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Shannon Technology and Energy Park

Information To Cover The COMAH Regulations 2015

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- Quantitative Risk Assessment
- Preliminary MATTE Assessment
- Oil and Hazardous and Noxious Substances Spill Plan
- EIAR Chapter 02 – Project Description
- Marine Navigation Risk Assessment
- EIAR Chapter 14 – Major Accidents and Disasters

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Vysus Group

Report for

Shannon LNG Limited

Shannon Technology Energy Park (STEP) Land Use Planning QRA

Summary

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Executive summary

A comprehensive quantitative risk assessment (QRA) of the proposed Shannon Technology and Energy Park (STEP) Liquefied Natural Gas (LNG) Terminal, Power Plant and Above Ground Installation (AGI) has been performed. The analysis has been conducted in accordance with the current HSA Technical Land-use Planning (LUP) Advice.

The QRA has used the suite of models incorporated into the DNV Safeti software (version 8.4). Safeti is a comprehensive hazard and risk analysis software tool for all stages of design and operation.

The QRA has considered hazards from Liquefied Natural Gas (LNG) and natural gas associated with operation of:

- Onshore pipelines and equipment at the terminal;
- The Above Ground Installation (AGI);
- 600 MW Power plant and associated Battery Energy Storage System and onsite 220 KV substation;
- The Floating Storage and Regassification Unit (FSRU); and,
- Transfer of LNG to the FSRU from a Liquefied Natural Gas Carrier (LNGC).

The following results have been obtained:

- Individual risk of fatality contours;
- The individual risk at the nearest residential property;
- Societal risk FN curves for members of the public; and,
- The Societal risk Expectation Value (EV) for members of the public.

The conclusions drawn from the results are as follows:

- Comparing the QRA results against land use planning criteria shows there are no incompatible land uses in any of the three LUP zones;
- Comparison with the individual risk at the nearest residential property with the criterion value of 1 x 10^{-6}/y shows that the result is well below the criterion value;
- The FN curve representing societal risk to members of the public for the proposed STEP is within the ‘Broadly Acceptable’ region.
- The Expectation Value for members of the public is 13 which is a very low value and indicative of operation in the ‘Broadly Acceptable’ Region.

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Glossary

Abbreviation	Description
AGI	Above Ground Installation
BESS	Battery Energy Storage Facility
BGE	Bord Gáis Eireann
BOG	Boil Off Gas
CCGT	Combined Cycle Gas Turbines
CHP	Combined Heat and Power
cpm	chances per million years
CRU	Commission for Energy Regulation
ESDV	Emergency Shutdown Valve
EV	Expectation Value
FN	Frequency of N or more fatalities
FRED	Failure Rate and Event Data
FSRU	Floating Storage and Regasification Unit
HRD	Hydrocarbon Release Database
HSA	Health and Safety Authority
IDLH	Immediately Dangerous to Life or Health
IMO	International Maritime Organization
GLA	Gas Unloading Arm
GNI	Gas Networks Ireland
LFL	Lower Flammability Level
LNG	Liquified Natural Gas
LNGC	Liquified Natural Gas Carrier
PERC	Powered Emergency Release Coupling
QRA	Quantitative Risk Assessment
RO	Recognised Organisation

RPT	Rapid Phase Transition
RSO	Recognised Security Organisation
TSR	Temporary Safe Refuge
VSD	Vessel Separation Device

1. Introduction

1.1 Project Background

The Shannon Technology and Energy Park (STEP) consists of a Liquefied Natural Gas (LNG) Terminal, Power Plant and Above Ground Installation (AGI). The STEP addresses Ireland's significant security of supply policy goals and provides additional flexible power generation capacity to support intermittent renewable generation and resolve a predicted generation capacity shortfall.

Ireland's Climate Action Plan[1], sets a target of 70% of electricity to be generated from renewable sources by 2030. It also commits to an early and complete phase-out of coal and peat-fired electricity generation. This leaves natural gas as being the only back up for intermittent wind generation at that point.

But despite its reliance on natural gas for renewable energy support, Ireland has very limited supply sources of natural gas. The country's sole gas field, Corrib, is rapidly declining by about 20% per year, resulting in a growing reliance on UK imports to meet its gas demand. Ireland currently imports over 50% of its gas needs from the UK via a single supply point and these imports will grow to over 80% by 2025 and 90% by 2030. The impact of losing this single gas supply from the UK has been assessed[2] by the Commission for Energy Regulation (CRU) as being *"disastrous"* for electricity production in Ireland.

Recently[3], the Minister for the Environment, Climate and Communications has also noted "*the UK has left the European Union which will lead, at the end of the withdrawal period, to difficulties for Ireland in meeting the requirements of EU law in relation to gas security of supply including potential challenges for future compliance with EU law including the "N-1" infrastructure standard and the supply standard*"

Consequently, Government polices clearly support the urgent need for the development. For example, the *National Energy & Climate Plan (NECP) 2021-2030* contains a policy goal to support natural gas infrastructure projects, such as the STEP, that enhance Ireland's security of supply. Eirgrid's *All-Island Generation capacity Statement 2020-2029* confirms the need for additional conventional power plants. The new power generators at STEP will have the ability to transition to future technologies, such as hydrogen as an alternative fuel source, in the medium to long term.

The STEP addresses Ireland's significant gas security of supply concerns and provides additional flexible power generation capacity to support intermittent renewable generation and resolve a predicted generation capacity shortfall.

The Shannon Estuary comprises 500 km^2 of navigable water extending from Loop Head, in County Clare, and Kerry Head, in County Kerry, eastwards to the city of Limerick, a distance of 100 km. The naturally occurring deep and sheltered waters of the estuary are connected to the Atlantic Ocean and are accessible to large ocean-going vessels of varying types and sizes of up to 185,000 deadweight tonnes (dwt).

The Proposed Development will be comprised of two main components:

1. A Power Plant; and,
2. An LNG Terminal.

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1 Climate Action Plan 2019. Department of the Environment, Climate and Communications. 17th June 2019
2 Identification of National Electricity Crisis Scenarios for Ireland. CRU/20/138. Commission for energy regulation. 20/11/2020
3 Request for Tenders dated 2 November 2020 for the provision of Consultancy Services to undertake a Technical Analysis to inform a Review of the Security of Energy Supply of Ireland's Electricity and Natural Gas Systems

LNG is natural gas that has been cooled to approximately minus 160 degrees centigrade, at which point it becomes a liquid at atmospheric pressure. As a liquid, the volume of natural gas is approximately 600 times less than the volume of the equivalent amount in the gaseous stage, making it more manageable for storage and ocean transportation. LNG is stored and transported in insulated tanks operating at pressures slightly above normal atmospheric pressure.

LNG is produced primarily in locations with large gas reserves which are too distant from market areas to be transported economically by pipeline. The natural gas from these fields is gathered and brought by pipeline to liquefaction plants where it is liquefied, pumped into LNG storage tanks and then loaded onto LNG ships and transported to the market areas of the world. Ireland is one of very few countries in Western Europe with a national gas distribution network that does not have an LNG import terminal. Once the LNG is delivered to the regasification terminal, the liquid is unloaded into the storage tanks, converted back into gas and transmitted via the gas pipeline system.

The previously consented 26 km 30” Shannon Pipeline (planning reference: PL08.GA0003), once constructed, will facilitate transport of the natural gas from the Proposed Development site to the national gas network at Foynes.

The Power Plant will generate power for its own needs and for the LNG Terminal, and for sale to the market via the national electricity grid exported via a 220 kV connection, which will be subject to a separate planning application. An application to connect to the national electrical transmission system via this 220 kV connection was submitted to EirGrid in September 2020. An offer has yet to be received. Once the connection offer is made, this 220 kV connection will be subject to a separate planning application.

The Proposed Development has a flexible design that will be able to accommodate alternative low carbon fuels in future. The location of the Proposed Development site will provide access to future offshore renewable projects around the world, combined with facilities for the production and landing of hydrogen. This would contribute to the decarbonisation of Ireland’s energy system by providing long term hydrogen energy storage (produced onsite or into the national gas transmission system), renewable energy storage (through the BESS) and direct electricity generation at the Power Plant. The modular Power Plant offers flexibility to incorporate alternative fuels, and the modern nature of the LNG Terminal will ensure it can easily be adapted in future. Refer to New Fortress Energy Inc.’s ‘A Step Towards a Zero Carbon Future’ policy for further details.

The LNG Terminal could also be operational before the Power Plant and the 220 kV grid connection are completed. Therefore, a medium voltage (10/ 20 kV) connection to supply power to the LNG Terminal in the absence of the 600 MW Power Plant will be required. This medium voltage connection will also be subject to a separate planning application.

The Masterplan for STEP will integrate the Proposed Development and a (future) Data Centre Campus. The Data Centre Campus is not included in this application and will therefore be subject to a separate planning application. The Data Centre Campus, the 220 kV and the medium voltage (10/ 20 kV) cables have been considered as part of the cumulative impact assessment.

Planning consents were previously granted by ABP for the development of an LNG Terminal (2007) and a Combined Heat and Power Plant (CHP) (2012) on the Proposed Development site. The current application is a new Strategic Infrastructure Development (SID) application and does not rely on any of the previous planning applications. A Site Selection Assessment has been undertaken by AECOM in 2021 and a report prepared. The report concluded that Ballylongford / Tarbert landbank is the most suitable location to accommodate and safely operate the Proposed Development.

The location offers the following:

- A large unoccupied landbank on the coast which is zoned for industrial purposes adjacent to the foreshore;
- Access to water depth greater than 13 m;
- A navigational channel of uniform cross-sectional depth suitable for LNG carriers including the largest vessel;
- Turning circle for LNG ships that provide adequate turning space of up to approximately 690 m;
- Space outside the main navigation channel for a marine control zone around the LNGC and FSRU;
- Protection from swell waves from the Atlantic and is only subject to locally generated wind waves;
- Access to high-capacity gas transmission system that can receive up to 800 mmscf/d;
- The ability to get a high voltage export grid connection offer within the generation capacity shortfall time window[4]; and
- Access to high-capacity electricity grid (220 kV or higher) that can export 600 MW without undue system constraint.

4 Shannon LNG Limited made a successful high voltage grid application under Enduring Connection Policy (ECP2.1)

1.2 Location and Surroundings

As stated above, STEP is planned for the south bank of the Shannon estuary between Tarbert and Ballylongford in County Kerry, Ireland; this location is shown in Figure 1-1 (marked in red).

The STEP is to be located on a circa 200 acre site on the Shannon Estuary at Ralappane, between Tarbert and Ballylongford in Co. Kerry and accessed off the existing L-1010 (Coast Road).

The *Kerry County Development Plan 2015-2021* has zoned the site 'Industry' as part of the Tarbert/Ballylongford Land Bank, and more specifically for marine related industry and compatible industries requiring deep water access.

Figure 1-1 Site Location

Figure 1-2 provides an overview of the site.

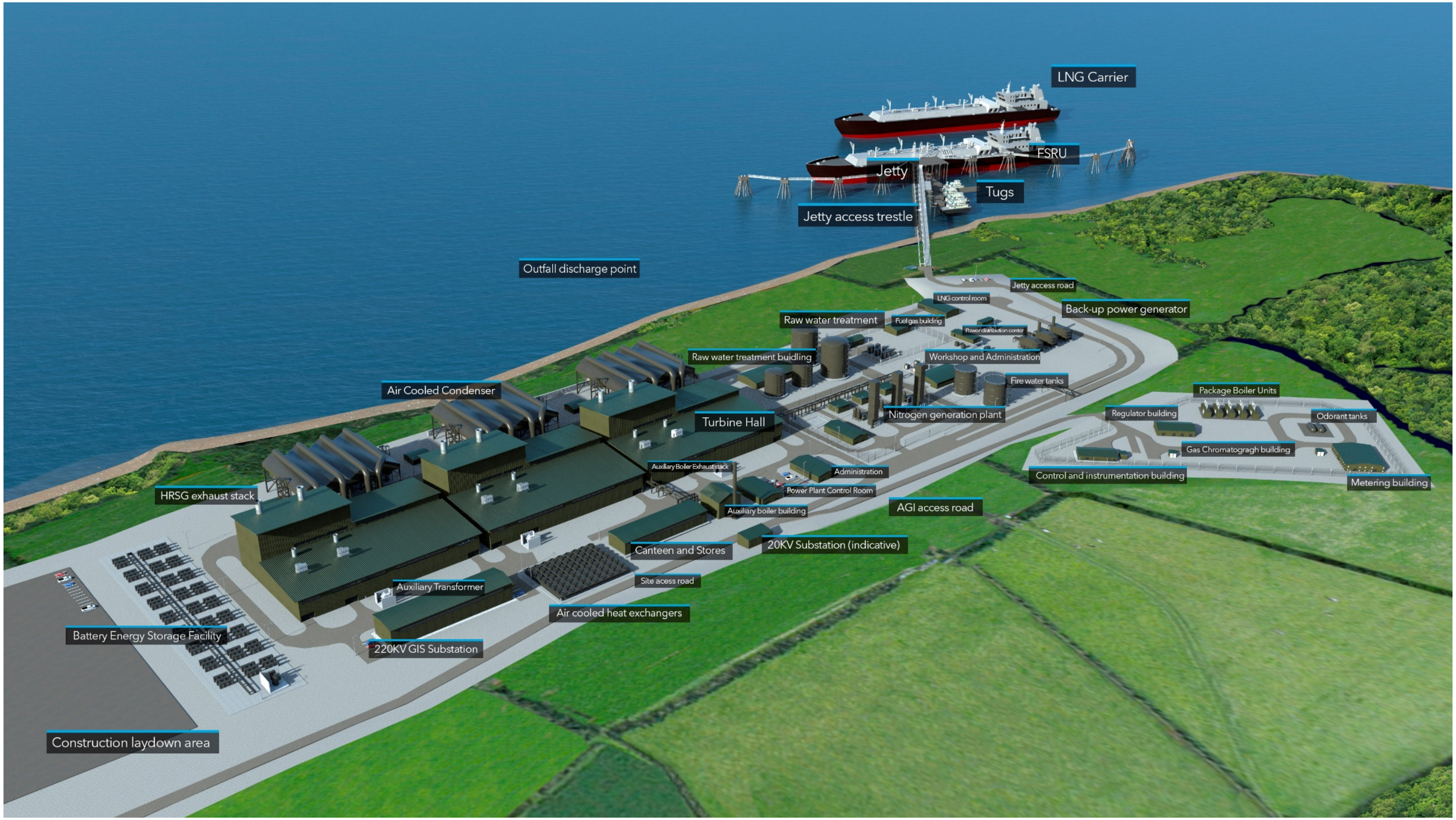


Figure 1-2 Proposed Site Overview

1.3 STEP Summary

The STEP consists of two main components:

1. LNG Terminal
2. Power Plant.

The proposed LNG Terminal will comprise of:

- A floating storage regasification unit (FSRU), which will have an LNG storage capacity of up to 180,000 m^3. The LNG vaporisation process equipment to regasify the LNG to natural gas shall be on-board the FSRU. The heat for LNG regasification shall be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. Loading of LNG onto the FSRU shall be via a ship to ship transfer from another LNG carrier (LNGC) berthed alongside.
- Jetty and access trestle, with the jetty comprising of an unloading platform, mooring dolphins and breasting dolphins.
- Four tugboats moored on the proposed jetty for FSRU and LNG carrier mooring operations.
- Onshore facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, fire water system.
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, gas metering and pressure control equipment. The AGI facilitates the connection of the LNG terminal to the consented 26 km Shannon Pipeline.

The proposed Power Plant will comprise of:

- A flexible modular power plant design with up to three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of circa 200 MW for a total installed capacity of up to 600 MW. The multishaft arrangement of the power plant provides fast acting response with very low minimum stable generation and is ideally suited to support increased intermittent renewable generation.
- Each block shall comprise of two (2) gas turbine generators, two (2) heat recovery steam generator and one (1) steam turbine generator and an air-cooled condenser.
- A 120 MW for 1 hour (120 MWhr) Battery energy storage facility (BESS). Due to its very fast response, the BESS supports intermittent renewable generation.

The STEP will supply up to 22.6 MMscm/d (800 MMscf/d) of natural gas to the Irish gas transmission system via the previously consented 26 km Shannon Pipeline.

An application to connect to the national electrical transmission system via a 220 kV connection was submitted to EirGrid in September 2020. An offer has yet to be received. It is expected that the connection will run 5 km east under the L-1010 road to the Eirgrid Killpaddogue 220 kV substation. Once the connection offer is made, this 220 kV connection will be subject to a separate planning design and planning application.

1.4 Properties of LNG and Natural Gas

LNG is a mixture of low molecular weight (typically ≤ C4) hydrocarbons (predominantly liquid methane), held at cryogenic temperatures. Physical properties for methane, ethane and propane (the principal constituents of LNG) are provided in Table 1-1 [4].

Table 1-1 Properties of LNG Constituents

Substance	Methane	Ethane	Propane
Chemical Formula	CH_4	C_2H_6	C_3H_8
CAS Number	74-82-8	74-84-0	74-98-6
Appearance at 20°C	Colourless Gas	Colourless Gas	Colourless Gas
Atmospheric Boiling Point (°C)	-161.5	-88.6	-42.1
Melting Point (°C)	-182.5	-183.3	-187.7
Liquid Specific Gravity	0.422	0.546	0.59
Vapour Density (air = 1)	0.55	1.1	1.5
Lower Flammable Limit (vol %)	5	3	2.1
Upper Flammable Limit (vol %)	15	12	9.5
Flash Point (°C)	-188	-135	-104
Auto Ignition Temperature (°C)	595	504	450
Long Term Exposure Limit	N/A	N/A	N/A
LD_{50}	N/A	N/A	N/A
Eco-toxicity	Unlikely to cause adverse effects	Unlikely to cause adverse effects	Unlikely to cause adverse effects
Degradability	Disperses rapidly	Disperses rapidly	Disperses rapidly

1.5 Hazards of LNG and Natural Gas

LNG's principal hazards result from its:

- cryogenic temperature (of -162ºC);
- flammability; and,
- vapour dispersion characteristics.

LNG which does not meet Irish gas quality specifications will be ballasted with nitrogen (adding nitrogen into the gas stream up to 2.5 mol% nitrogen) to lower heating value and/or Wobbe Index value to meet Bord Gáis Eireann (BGE) specifications.

1.5.1 Cryogenic Burns

As a cryogenic liquid, LNG can cause burns to personnel if it comes in contact with the skin. A second cryogenic hazard is associated with LNG vapours; breathing cold vapours from LNG evaporation or boiling can damage the lungs. Whilst methane does not chemically react with the lungs, the cold vapour can cause 'frosting of the lungs'. The severity of damage is directly related to the severity of exposure.

Typically process equipment in LNG duty is thermally insulated to prevent injury to personnel during normal operation.

1.5.2 Toxicity and Asphyxiation

Methane, or natural gas, is not toxic or a carcinogen. There is no immediately dangerous to life or health ("IDLH") value for methane in the United States **[5]**. The relevant HSA guidance **[6]** notes that methane is an asphyxiant. Such materials are described as:

> *"Gaseous chemical substances which may not produce significant physiological effects in the exposed employee, but when present in high concentrations will act as simple asphyxiants."*

The danger of asphyxiation is increased in LNG facilities due to the absence of an odourant in the gas. However, asphyxiation requires a relatively high concentration of gas in air and such effects are only important close to a release of LNG.

1.5.3 Fire Hazards

LNG vaporises quickly as it absorbs heat from the environment, and the resulting vapour is flammable when mixed in air at concentrations from 5 to 15% (volume basis). LNG vapour at its normal boiling point of -162ºC is 1.5 times denser than air at 25ºC. On release of LNG it evaporates and as the LNG cloud drifts, it mixes with the surrounding, warmer air, is diluted and becomes less dense.

1.5.3.1 Pool Fire

When LNG is released from a storage tank or piping, a liquid pool may form. As the pool forms, some of the liquid will evaporate and, if flammable vapour finds an ignition source, the flame can travel back to the spill, resulting in a pool fire. A pool fire involves burning of vapour above the liquid pool as it evaporates from the pool and mixes with air.

1.5.3.2 Jet Fire

If compressed or liquefied gases are released from storage tanks, piping or equipment under pressure, the material discharging through the hole will form a gas jet that entrains and mixes with the ambient air. If the material encounters an ignition source while it is in the flammable range, a jet fire may occur. For LNG at low pressure as a liquid, this type of fire is unlikely. Larger jet fires could occur during unloading or transfer operations when pressures are increased by pumping, or from ignited releases from the high pressure (89 barg) piping. Such fires could cause severe damage, but associated consequences are highly dependent on the direction of release (i.e. not omni-directional).

1.5.3.3 Flash Fire

When a volatile, flammable material is released to the atmosphere, a vapour cloud forms and disperses (mixing with air as it does so). If the resultant vapour cloud is ignited before the cloud is diluted below its LFL, a flash fire may occur. The combustion normally occurs within only portions of the vapour cloud (where mixed with air in flammable concentrations), rather than the entire cloud. A flash fire may burn back to the release point, resulting in a pool or jet fire but is unlikely to generate damaging overpressures (explode) when unconfined.

1.5.3.4 Explosions

As discussed in the previous section, a flash fire can occur if LNG is released into the atmosphere and ignited. If ignited in open (unconfined) areas, pure methane is not known to generate damaging overpressures (explode). However, if some confinement of the vapour cloud is present, methane can produce damaging overpressures. Areas congested with equipment and structures can facilitate damaging overpressures if a vapour cloud is ignited within such an area. For example, if a vapour cloud infiltrates a process plant area with various vessels, structures, and piping and the cloud ignites, the portion of the cloud within that congested area may generate damaging overpressures. A larger volume fraction of heavier hydrocarbons in the LNG reduces the minimum ignition energy required for detonation and increases the specific gravity of the hydrocarbon mixture (and hence reduces the tendency to rapidly disperse). Both of these effects increase the likelihood of generation of damaging overpressures.

For the purpose of this study LNG has been modelled as methane (the practice within UK HSE) as only a very small fraction of the product stream will be heavier hydrocarbons. The onshore plant layout is relatively open and the degree of congestion is low. The potential for vapour cloud explosion (VCE) on site have therefore judged to be insignificant.

1.5.3.5 Rapid Phase Transition (RPT)

RPT is the term used to describe a phenomenon recognised in some LNG release experiments involving the nearly instantaneous transition from the liquid to vapour phase and an associated rapid pressure increase. When LNG forms a pool on water, the heat from the water rapidly vaporises the LNG; however, this boiling is not the phenomenon referred to as RPT. In an RPT, a portion of the spilled LNG changes from liquid to gas virtually instantaneously. Although the physical mechanism is not completely understood, RPT is attributed to the superheating of the LNG due to the lack of nucleation sites (sites that help with the formation of gas bubbles and promote boiling). An RPT may result in two types of effects:

1. overpressure resulting from the rapid phase change; and,
2. dispersion of the ‘puff’ of LNG expelled into the atmosphere.

Rapid phase changes have not resulted in any known major incidents involving LNG. In view of this and the fact that the jetty structure for the proposed facility is relative open, not involving any solid walls against the side of the ship, RPTs have not been modelled within the QRA.

2. Facility Description

The proposed LNG Terminal will comprise of the following systems which are relevant to the QRA:

- A floating storage regasification unit (FSRU), which will have an LNG storage capacity of up to 180,000 m^3. The LNG vaporisation process equipment to regasify the LNG to natural gas shall be on-board the FSRU. The heat for LNG regasification shall be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. Loading of LNG onto the FSRU shall be via a ship to ship transfer from another LNG carrier (LNGC) berthed alongside.
- Jetty and access trestle, with the jetty comprising of an unloading platform, mooring dolphins and breasting dolphins.
- Onshore facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, fire water system.
- Gas supply to the 600 MW Power plant.
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, gas metering and pressure control equipment. The AGI facilitates the connection of the LNG terminal to the consented 26km Shannon Pipeline.

2.1 FSRU

A Floating Storage Regassification Unit (FSRU) shall be berthed at the jetty. The FSRU shall be an ocean-going vessel with a full crew operating under the same national and international permitting and controls as all other shipping traffic in the estuary.

The FSRU shall be typically, but not permanently, moored at the jetty and shall depart the jetty as necessary. Loading of LNG onto the FSRU shall be via a ship to ship transfer from another LNG ship berthed alongside. The FSRU shall have an LNG storage capacity of between 130,000 m^3 to 180,000 m^3. While in the Shannon Estuary, the FSRU shall be governed by the Shannon Foynes Port Company.

The FSRU shall be approximately between 250 to 300 metres long and between 40 to 55 metres wide with a draft of approximately 13 metres (the distance between the surface of the water and the lowest point of the vessel). The height of the vessel shall be approximately 50 metres above the sea surface to the top of the exhaust stack.

The FSRU shall be a double-hulled ocean-going vessel with four cargo tanks suitable for storing LNG at very low temperatures (-163ºC). The cargo tanks are lined with specialised membranes to allow the storage of chilled LNG. The cold temperature and insulation keeps the LNG cargo in a liquid state until it is required for regasification.

The FSRU has the capability to receive LNG from an LNG carrier (LNGC), return the LNG to a gaseous state using the onboard regasification unit (‘regasification’), and transfer the gas into gas unloading arms on the jetty. Tugboats shall typically be used to moor the LNG carrier safely next to the FSRU.

The LNG carriers shall typically tether next to the FSRU while LNG is transferred into the cargo tanks of the FSRU. Purpose-built flexible cryogenic hoses would be used to transfer the LNG from the LNG carriers to the FSRU. Once the transfer of LNG is complete, LNG carriers would depart from alongside the FSRU with the assistance of tugboats.

The LNG vaporisation process equipment to regasify the LNG shall be on board the FSRU. The vaporisation process shall have a send-out capacity of up to 22.6 MMscm/d (800 MMscf/d).

The FSRU ship will be self-sufficient in terms of producing the necessary electricity and heat. The FSRU will use electric power for pumps and regasification equipment, for auxiliary systems and for staff accommodation. Generators will be powered by dual-fuel diesel engines which will use boil off natural gas from the LNG storage tanks (BOG) as main fuel. As a pilot fuel, engines use a small amount of marine diesel oil (MDO). The estimated amount of required diesel fuel is up to 1 m^3/day at maximum operation of the FSRU terminal.

As a security solution in emergency situations, the jetty is equipped with quick release systems that allow automated release of the FSRU's mooring lines and the separation of the natural gas transport system under pressure. In this way it is possible to quickly sail the FSRU ship to a safe area.

At the time of drafting this report, a charter agreement for a specific FSRU has not been executed. Therefore, the exact characteristics, specific locations and technical systems which will be integral part of the FSRU vessel's equipment are not clarified. For the purposes of this QRA a study of vessels from various FSRU suppliers has been carried out and the QRA has been based on a typical design.

The FSRU ship must meet all conditions of international navigation, i.e. conditions that have been established by the SOLAS Convention and other international conventions accepted within the International Maritime Organization (IMO). The FSRU vessel must possess valid ship certificates and documents required for such a ship type in accordance with the aforementioned international conventions whose list is consolidated and updated in the Maritime Safety Committee of the International Maritime Organization's "List of Certificates and Documents Required to be Carried on Board Ships" document.

The FSRU ship must also comply with all safety requirements prescribed by the regulations of the ship's registries and the flag State which the vessel is flying, the recognized organizations (RO) and the recognized security organization (RSO).

In addition, the FSRU ship as a vessel for the transport and storage of liquefied natural gas should meet the requirements of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), as amended.

LNG vaporisation process equipment to regasify the LNG shall be on-board the FSRU. The heat required for LNG vaporisation will be primarily via seawater, supplemented by gas fired heaters when the seawater temperature is inadequate. When seawater temperatures are insufficient to provide all the heat required for regasification, the FSRU would provide supplementary heat for regasification. The supplementary heat will be provided by the combustion of BOG in gas fired heaters.

Considering the sea temperature at the location of the LNG Terminal, it is predicted that supplementary gas fired heaters will be utilised from about the middle of November to early May, when the temperature is lower than 12°C. The exact times will be dependent on seasonal variability.

2.2 LNG Carrier Ships

The LNG Carriers (LNGCs) deliver the LNG, berthing at the LNG Terminal and unloading the LNG to the FSRU for storage until it is regasified.

All LNG carriers in the world are of double hull construction with the LNG containment systems, equipment and insulation installed within the inner hull. LNG is carried in specially designed cargo tanks in liquid form at -163 C at atmospheric pressure. The tanks are surrounded completely by two insulation spaces which are designed to reduce 'heating of the cargo' through external ambient conditions. The insulation spaces are filled with nitrogen to provide an inert blanket around the tanks whilst also supporting the most modern gas detection systems installed to continuously monitor the cargo.

The Proposed Development is designed to accommodate a range of LNGC sizes from 130,000 m^3 LNG capacity to 265,000m^3 capacity (Q-Max). As of February 2021, the 551 LNGC in service, only 14 are of the Q-Max vessels in service throughout the world. The majority of LNGC calling at Shannon will be in the 130,000 to 173,000m^3.

Unloading the cargo will be enabled by means of flexible hoses for cryogenic fluid transfer which will be installed after berthing. Flexible hoses will also be used to transport BOG from the FSRU storage tank to the LNGC storage tanks so to prevent forming of overpressure in the FSRU tanks and under pressure in FSRU storage tanks due to BOG formation during LNG transfer.

Up to 60 visits of LNGC per year are expected. LNG unloading from the LNGC to the FSRU via ship-to-ship transfer is estimated to take on average 35 hours. An additional 25 hours in total is required to moor, berth, unmoor and unberth. Ship passage time from the mouth of the Estuary to Ardmore point is estimated at 4 hours.

It is envisaged that the port side of the FSRU will be moored to the jetty, and the LNGC will be berthed by the port side to the FSRU. The main reason for such an arrangement is to point the bow of both vessels to the open sea during the stay on berth so that fast departure of vessels is possible in case of extraordinary circumstances, even without tugs.

2.3 Jetty and Access Trestle

The Jetty shall be capable of receiving and providing secure berthing for a FSRU up to 180,000 m^3. Its main purposes are for the mooring of the FSRU ship and for the accommodation of the high-pressure gas platform.

The infrastructure to be installed on the Jetty includes:

- Two gas unloading arms (GLAs) on the unloading platform; and,
- A 30" (750 mm) fully welded gas pipeline. The gas piping would run from the unloading arm on the platform along a pipe rack on the western side of the trestle.

The FSRU shall discharge into the GLAs at a pressure range from 48 to 98 Barg at flowrate up to 800 MMscf/d.

2.4 Onshore Receiving Facilities

The onshore receiving facility receives the natural gas from the FSRU via the jetty piping before it connects in to the AGI.

If the gas received from the FSRU has a heating value which does not meet the Gas Network Ireland (GNIs) requirements, nitrogen would be injected into the gas stream so that it meets the required specification. This is the main purpose of the nitrogen generation facility. Nitrogen will also be used for purging and inerting of various items of equipment and piping, during operation and maintenance activities. All compressed air for instrument use and for service and maintenance use will also be generated onsite.

2.5 Above Ground Installation

The configuration of the Above Ground Installation (AGI) is based on information provided by Gas Networks Ireland (GNI). It shall be typical of existing GNI AGIs on the national gas network. It shall contain filters, meters, heaters, pressure regulators, a flow control system and an odorisation system.

The AGI shall accommodate the valves and control equipment to facilitate the connection to the proposed 26 km Shannon pipeline. It will facilitate in metering and controlling the gas flow and the transfer of custody of gas to GNI and will allow GNI to receive the gas into the national gas network.

It is standard practice for safety reasons to add odorant to natural gas, which has little or no smell. The odorisation tanks, associated pipework, and control systems will be provided to inject carefully controlled volumes of odorant into the natural gas. The gas is odorised so that any gas leaks are detectable by human beings. Odorant will be injected at a rate to ensure compliance with GNI and statutory requirements (typically 6 milligrams per cubic metre).

A bidirectional pig-trap (and associated equipment) is to launch (or retrieve) a 'pig' which is propelled through the pipeline. Pigs are used for two purposes: initially during the gassing-up/commissioning to clean and dewater the pipeline, and later, when the pipeline is operational, an intelligent pig is sent through the pipeline to monitor pipeline conditions such as the wall thickness of the pipeline.

The function of pressure reduction/flow control equipment, which is to be included in a 16 m x 13 m building, is to reduce the pressure of the gas. GNI has indicated that it may wish to control the flow rate or reduce the pressure before injection into the national gas network.

GNI has indicated that it may wish to provide gas heating at the site due to the operation of pressure reduction or flow control equipment as described above. Pressure reduction of a natural gas stream normally is accompanied by a drop in temperature, as the gas throttling process cools the gas (the Joules-Thompson effect). To counter this effect, if low temperatures are anticipated, the gas will be heated by sending it through heat exchangers, where it is heated by hot water.

The water is heated before being pumped through the heat exchangers. Water heaters, where deemed necessary, are normally conventional gas-fired boilers. The water heating system is similar to that used in a domestic gas-fired central heating system. The heaters are normally housed in individual package boiler units (PBU) buildings (13m x 4m).

The AGI will also include an instrument and control building (20 m x 10 m), gas chromatograph (3.5 m x 3.5 m) building, gas filters, and fiscal gas metering. Most of the equipment, including most of the valves and pipework, will be below ground level. A short section of pipe will extend above ground level to provide the connection for the permanent pig launcher and receiver, which will be required on an occasional basis to allow internal cleaning or inspection of the pipeline. The pipeline exporting gas to an AGI at Foynes was subject to a separate QRA in 2008 [11].

2.6 Liquid Natural Gas Terminal

The LNG Terminal will operate 24 hours per day using a rotating shift schedule. The actual shift schedule has yet to be determined however it is anticipated that the following manpower levels will be provided:

- It is anticipated the FSRU vessel will have a crew of approximately 35 persons comprising of Master, 4 deck officers, cargo engineer, Chief Engineer and 4 engineering officers, with the balance of the complement being crew working on deck, in the engine room and catering. Length of service on board for the officers is generally 3 months on and 3 months off, while the crew typically serve 6 months on board and 6 months off. All crew are on board for the full time of their contract.
- Tugboats will normally have a crew of 4 onboard. Tugboat 1's crew will be permanently onboard for immediate response. Tug's 2 crew will always be available within 30 minutes. The crew for tugs 3 and 4 will be within 2 hours' notice of the site.

- Excluding FSRU and tugboat crews, the onshore receiving facility will have 20 day staff/ contractors (09:00 - 17:30);
- 24 shift staff/ contractors - 3 shifts of 3 employees (08:00 - 16:00; 16:00 - 00:00; 00:00 – 08:00); and,
- The AGI will be normally unmanned.

2.7 Power Plant

The power plant is a flexible multi-shaft design with three blocks of CCGT with up to three blocks of Combined Cycle Gas Turbines, each block with a capacity of circa 200 MW for a total installed capacity of up to 600 MW. The multishaft arrangement of the power plant provides fast acting response with very low minimum stable generation and is ideally suited to support increased intermittent renewable generation. Each block shall comprise of two gas turbine generators, two heat recovery steam generator and one steam turbine generator and an air-cooled condenser.

The gas used to fuel the power plant will be supplied at pressures suitable for the specific gas turbine equipment selected. This gas will pass through gas conditioning equipment that will likely be comprised of:

- filter separator,
- dew point heater/boiler unit,
- pressure control station, and,
- gas quantity and quality measurement as required for performance management and environmental protection monitoring.

3. Overview of QRA Methodology

3.1 Introduction

Essentially a risk assessment seeks to provide answers to the following questions:

- What can go wrong?
- If things go wrong, what would the consequences be?
- What is the likelihood of things going wrong?
- Does action need to be taken?

Risk assessment is a structured method for obtaining answers to these, and other related questions. As the name suggests, quantitative risk assessment (QRA) is used to state the likelihood, consequence and risk results in numerical terms. A QRA flowchart is presented in Figure 3-1, showing the major steps in the process. Each of the major steps is then described in the remaining Sections of this Chapter.

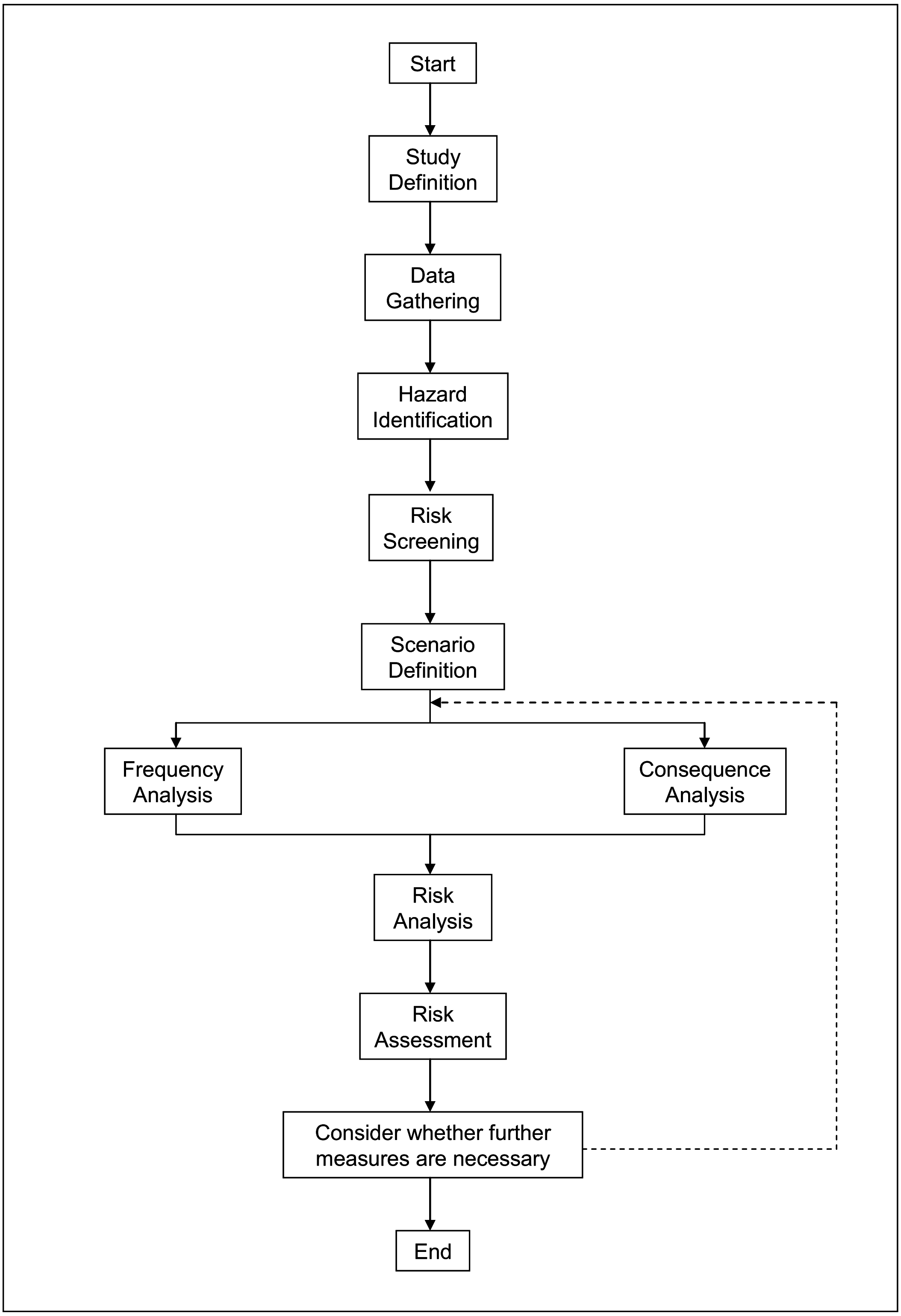


Figure 3-1 QRA Process Flowchart

3.2 Study Definition

It is important to define the scope and objectives of the study at the outset, since these will influence the breadth, depth and the output of the analysis. Study definition involves:

- Defining the system to be analysed (in terms of the types of process involved, the physical boundaries of the system, the nature of the surrounding environment / population, etc.);
- Describing the reasons for conducting the analysis (the objectives of the study, or the concerns that give rise to the need for the analysis); and,
- Identifying the decisions that will need to be made, using the analysis results as one input. The types of decision to be made influence the output required from the analysis.

3.3 Data Gathering

Depending on the purpose of the analysis and the size of the system under consideration, the quantity of data required to perform a QRA can be substantial. Typically, the data required include:

- Information about the system;
  - Process flow diagrams (PFDs);
  - Piping and instrumentation drawings (P&IDs);
  - Heat and mass balance data;
  - Process operating conditions;
  - Material properties;
  - Vessel capacities;
  - Details of shutdown / emergency systems;
  - Layout drawings; and,
- Information on potential ignition sources (on and off-site);
- Population data (for people on-site and / or off-site, depending on the purpose of the study); and,
- Meteorological data.

3.4 Hazard Identification

The purpose of the hazard identification step is to identify all of the relevant hazards which generate risk within the system, together with the way in which the hazards could be realised. The study definition step may limit the types of hazard of interest (e.g. a study may focus on potential major accidents to people or the environment). Methods for hazard identification include:

- Review of accident / incident data;
- Process Hazard Analysis (PHA);
- Hazard and Operability (HAZOP) studies;
- Failure Modes and Effects Analysis (FMEA);
- 'What-If' Analysis;
- The 'Methodical Rupture' approach (listing all of the potential leak sources from each equipment item within the system); and,
- Use of checklists.

The method used depends on the purpose of the study and the nature of the system under investigation.

3.5 Risk Screening

In some studies, a risk screening step is performed prior to the full analysis. The purpose of this step may be to:

- Review the list of hazards obtained at the hazard identification stage and remove any that are not relevant to the current study (e.g. because their effects would be too limited); and/or,
- Determine the level of detail that should be applied to the analysis of the hazards at later stages.

In relation to the second of these points, some safety regulators (including the Health and Safety Executive in the UK) apply a 'proportionality principle' when considering the level of detail that should be applied when analysing a given set of hazards. Essentially the proportionality principle states that those scenarios or groups of scenarios that present the greatest risk should receive more detailed analysis than scenarios that contribute relatively little to the risk. A risk screening process (i.e. a coarse, initial assessment of the risk) can be used to decide which scenarios should be subject to more detailed analysis at later stages.

3.6 Scenario Definition

Having determined which hazards will be included in the QRA, and the level of detail that should be applied, it is then necessary to develop the list of hazards into modelling scenarios. This involves describing the scenario in sufficient detail to proceed with the modelling. For example, the hazard identification may identify the following hazard:

'*Leak of hydrocarbon from pipe due to impact by object*.'

The scenario definition step adds further detail to this, including:

- The process conditions (temperature, pressure) within the pipe;
- The composition of the hydrocarbon;
- The size(s) of the leak that may occur;
- The location(s) at which the leak might occur;
- The volume of hydrocarbon available to feed the leak; and,
- The likely duration of the leak, given the volume of hydrocarbon and any action that might be possible to isolate the leak.

It is also common practice to group similar hazards together for the purposes of the subsequent analysis. Using the example above, the hazard identification study may identify a number of ways in which a leak of hydrocarbon from a pipe could result (such as internal corrosion, external corrosion, fatigue, etc.). All of those could be grouped together into a single 'pipe leak' scenario.

3.7 Consequence Analysis

The purpose of consequence analysis is to determine the potential outcome (or outcomes) of the various scenarios comprising the QRA. Consequence analysis may be broken down into the following steps:

- Source term modelling;
- Physical effects modelling; and,
- Impact modelling.

Depending on the tools used by the analyst to perform the QRA, these steps may be performed using separate models, or in a single model that automatically proceeds from one step to the next.

3.7.1 Source Term Modelling

Source term modelling determines the behaviour of the material upon leakage, in terms of:

- Release rate and / or quantity;
- The velocity of the material;
- The phase of the material (liquid, gas / vapour or two-phase); and,
- The conditions within the material upon release (temperature, density, etc.).

Where the material forms a pool of liquid, it will also be necessary to model the pool spreading and rate of vaporisation of material from the pool.

3.7.2 Physical Effects Modelling

Modelling of physical effects predicts the behaviour of the material once it has been released, using the source term modelling results as inputs. The types of physical effects considered may include:

- Gas or vapour dispersion;
- Fire dimensions and heat output (for ignited releases of flammable material); and,
- Size and strength of explosions (for ignited flammable clouds in congested / confined regions).

Since some of the calculations performed can be quite complex, and the number of calculations required in a QRA study can be large, software packages are usually employed to perform the modelling.

3.7.3 Impact Modelling

Impact modelling determines the impact that the various physical phenomena have upon receptors of interest (i.e. people, environmental features or assets, depending on the objectives of the study). For people, the relationship between exposure to a potentially harmful agent (such as toxic gas, thermal radiation or blast overpressure) and the probability of fatality is often expressed using a probit equation. Probit relationships take the form:

$$Y = A + B.\ln(D)$$

Where:

Y = probit value

A and B are constants that are specific to the harmful agent.

D is the harmful dose received by the receptor. This is a function of the concentration (or intensity) of the harmful agent and the exposure duration. For toxic substances:

$$D = C^N.t$$

Where:

C = gas concentration (ppm)

N = substance-specific constant

T = exposure duration (minutes)

In the case of thermal radiation:

$$D = Q^{4/3}.t$$

Where:

Q = incident thermal radiation flux ($W.m^{-2}$)

t = exposure duration (s)

The probit value is related to the probability of fatality by the following expression:

$$P = 0.5 \times \left[1 + erf\left(\frac{Y-5}{\sqrt{2}} \right) \right]$$

Where:

P = probability of fatality

Probit values are available in standard tables. For example, a fatality probability of 0.1 corresponds to a probit value of 4.16.

3.8 Frequency Analysis

In general terms, frequency analysis is used to calculate:

- The likelihood of a given release of dangerous material occurring – this is usually expressed as a frequency (e.g. 1×10^{-3} per year, or once in a thousand years);
- Given that a release has occurred, the probability that a given type of physical effect follows – for example, for releases of flammable material, the type of effect may depend on whether the material is ignited soon after the release begins, or at some time later; and,
- Given that a certain type of physical effects results, the probability of an undesired outcome – this may depend on the wind direction, the probability that a person is present within the hazard range, and the probability of successful emergency action.

Frequency analysis approaches fall into three categories:

- Use of relevant historical data;
- Use of analytical or simulation techniques (such as fault tree analysis or event tree analysis); and,
- Use of expert judgment.

Historical data may relate to the frequency of releases of varying sizes from different types of equipment (e.g., the frequency of small leaks from flanges), or to the frequency of accidents on facilities of interest (e.g., the frequency of large fires on refinery crude distillation units).

3.9 Risk Analysis

In simple terms, risk is the chance of an undesired outcome. The chance is usually expressed as a frequency; the undesired outcome may be fatality, environmental damage or financial loss. In terms of risks to people, there are different types of risk outputs that may be calculated using QRA:

- Risk indices (such as Fatal Accident Rate);
- Individual risk usually expressed as the risk of harming a hypothetical person with a defined set of characteristics. Individual risk results may be expressed as a point value (the individual risk to a hypothetical person at a given geographical location), as a graph of individual risk versus distance (a risk transect) or as contours overlaid on a map;
- Societal risk, which expresses the frequency with which different numbers of people could be affected by an accident. It is usually presented as an ‘FN curve’, where F is the frequency with which N or more people are affected.

3.10 Risk Assessment and Risk Reduction

Once the risk analysis results have been obtained, it is necessary to assess their significance. This often involves comparison of the results with criteria. Risk criteria may be established by regulators or set internally by the company. Risk criteria usually define:

- The level of risk which is deemed unacceptable (except perhaps in extraordinary circumstances); and,
- The level of risk which is considered so low that further efforts to reduce the risk are unnecessary.

Between these two levels is a region in which the risk may be considered tolerable, on condition that all appropriate measures have been taken to control the risk.

The risk analysis results may indicate a need to consider the implementation of further measures to reduce the risk. The analysis outputs may then be interrogated to determine whether there are any particular scenarios which dominate the risk profile. Where such key risk contributors can be identified, it is prudent to focus efforts to reduce the risk on these scenarios.

Once potential risk reduction measures have been postulated, their effectiveness may be evaluated by modifying the analysis inputs to include them and re-calculating the results. The final decision about whether or not to implement a given risk reduction option depends on:

- The magnitude of the initial risk – if the risk is high relative to the relevant criteria, this will provide a stronger driver for taking action;
- The size of the risk reduction that would be achieved if the measure were to be introduced; and,
- The cost of implementing the measure.

It should be noted that consideration of the costs and benefits of implementing a risk reduction measure is usually weighted in favour of safety, such that the costs have to be much greater than the benefits before a measure can be ruled out.

4. Report Structure

The remaining sections of this report are set out as follows:

- Section 5 details the overall process details used as the basis for the QRA.
- Section 6 describes how the potential major accident scenarios included in the QRA were identified;
- Section 7 presents the methods and data used in the calculation of the frequency of potential major accidents;
- Section 8 details the approach for defining possible ignition sources;
- Section 9 describes criteria used for assessing harm to people;
- Section 10 details the analysis of the consequences of potential major accidents;
- Section 11 describes populations on and around the terminal;
- Section 12 describes risk criteria as used by the HSA;
- Section 13 presents the risk analysis and results making comparisons with the risk criteria described in Section 12.
- Section 14 presents the study conclusions; and,
- References used are listed in Section 15.

5. QRA Basis

The systems and process conditions used as the basis for the QRA (i.e. those systems containing LNG, natural gas or odorant) are summarised in the following sub-sections.

5.1 Onshore Facilities

The onshore systems within the STEP comprise of:

- Gas arms connection to the FSRU;
- Gas pipeline running along the jetty and onshore to the AGI;
- Gas supply to three 8 MW back up power supply units;
- Gas supply to the power station units; and,
- Fuel gas supply to heaters.

For the purpose of this study LNG has been modelled as methane (the practice within UK HSE) as only a very small fraction of the product stream will be heavier hydrocarbons. The onshore plant layout is relatively open and the degree of congestion is low. The potential for vapour cloud explosion (VCE) on site have therefore judged to be insignificant.

From the process heat and mass balance for the installation [8] operating at maximum throughput the following basis has been used for modelling:

- 810 MMSCFD (million standard cubic feet per day) export gas flow from the FSRU to site ~752,800 kg/h = 209.11 kg/s;
- 89 barg export pressure from the FSRU; and,
- 4.5°C export temperature from the FSRU.

For modelling purposes the operating fraction for the onshore equipment is 1.0 (100%), continuous at the above flowrate. This is conservative as in practice the FSRU will be disconnected some of the time and the Gas flowrate to the AGI will not be 100% of full capacity continuously.

5.2 AGI (Natural Gas Systems)

The systems within the AGI comprise of:

- Inlet valve System;
- Filtering;
- Metering;
- Heat exchangers;
- Pressure reduction;
- Outlet valves;
- Pig trap;
- Fuel gas system;
- Interconnecting pipes between equipment (most buried);
- Odorant tanks; and,
- Road tankers that deliver odorant to the AGI.

From the process heat and mass balance for the installation [8] operating at maximum throughput the following basis has been used for modelling of natural gas within the AGI:

- Natural gas flow to the AGI: 672,250 kg/h = 186.74 kg/s;

- Pressure: 89 barg; and,
- Temperature: 4.5°C.

Again, it has been conservatively assumed that the AGI is operating at 100% Capacity.

5.3 AGI (Odorant)

GNI use a compound call Odorant New Blend. This compound consists of 21% Dimethyl Sulphide and 79% Tert-Butyl Mercaptan.

The odorant facilities comprise:

- Two 6,000 US gallon (22.7 m^3) horizontal, cylindrical odorant storage vessels located in a common bund;
- A road tanker off-loading point (with secondary containment); and,
- A small-bore pipe conveying odorant to the natural gas pipeline for injection.

Overall assumptions made for modelling of odorant are:

- Road tanker capacity 3,700 litres;
- Twelve odorant tanker deliveries per year;
- The odorant is stored under a natural gas blanket at a pressure of 2 barg and ambient temperature; and,
- Odorant tanks operating at 100% level.

5.4 FSRU

The project is at an early stage and as such details of a specific FSRU to be used are not available. A typical FSRU design has been adopted as the basis of the QRA, comprising of the following systems:

- Inlet piping to LNG storage tanks;
- LNG Storage Tanks;
- LNG vaporization system; and,
- Natural gas export system.

Process conditions and other assumptions made for the modelling of the FSRU are:

- Nominal LNG storage volume:180,000 m^3;
- LNG tanks: 4 x 45,000 m^3 tanks;
- Operating pressure range in the vapour space of the LNG tanks is 125 mbarg;
- Boil off gas (BOG) <= 0.15% per day of full capacity of tanks = 1.56 kg/s approx.;
- No of gas export arms: 2;
- Gas export rate: 752,800 kg/h split between two arms;
- Gas export pressure: 89 barg; and,
- Gas export temperature: 4.5°C.

5.5 LNGC

The project is at an early stage and as such details of specific LNGCs to be used are not available. A typical LNGC design has been adopted as the basis of the QRA, comprising of the following systems:

- LNG Storage Tanks;

- LNG transfer system; and,
- STS hoses.

Process conditions and other assumptions made for the modelling of the LNGC are:

- Nominal LNG storage volume:180,000 m^3;
- 4 x 45,000 m^3 LNG tanks;
- Operating pressure range in the vapour space of the LNG tanks is 125 mbarg;
- No. of STS liquid hoses: 4;
- STS transfer pressure: 4.5 barg;
- STS hose length: 18 m;
- STS hose diameter: 8" (200 mm);
- STS transfer temperature: -156°C;
- Discharge time: 35 hours per cargo maximum;
- Additional turnaround time for LNGC: 25 hours; and,
- No. of LNG STS Transfers per year: 60.

6. Release Cases

The approach used for the identification of release cases is the 'Methodical Rupture' approach (listing all of the potential leak sources from each equipment item within the system). This approach is appropriate for LNG/NG systems of this type as the piping and equipment designs are in no way novel and appropriate data for the frequencies of leaks is readily available.

For the purposes of the QRA, the plant has been broken down into a set of 'isolatable' inventories (i.e., sections of plant that could be isolated in the event of an accident, typically by the closure of emergency shutdown valves, ESDVs).

Scenarios for inclusion in the QRA have then been obtained by postulating releases of various sizes from each inventory within these isolatable sections. The sections of piping systems and equipment used for calculation of inventories are listed in Table 6-1, Table 6-2, Table 6-3 and Table 6-4 which detail the following overall process areas:

1. Onshore Installation: Natural gas pipeline from the FSRU on the jetty and onshore feeding natural gas to the AGI and the Power Station;
2. AGI – Conditioning of natural gas and connection to the Shannon Pipeline;
3. FSRU – Storage and vaporisation of LNG and supply of natural gas to the jetty;
4. LNGC – Transfer of LNG to the FSRU; and,

For each of the nodes defined in the tables a range of release scenarios have been developed ranging from small 'pinhole' holes typically of 3 or 4 mm diameter up to guillotine failure of pipelines and catastrophic vessel failure.

A description of the approach for selecting hole sizes, and frequencies of release for LNG and natural gas system release scenarios is included in Section 7.1.

Sections 7.2, 7.3 and 7.4 provide details on the approach used for assigning hole sizes and frequencies to specific failure cases such as releases of LNG from ship collisions, LNG hose failures, and natural gas arm failures.

Table 6-1 Node Definitions – Onshore Installation

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
SG-001A	NG Arms	400	16	20	Gas	4.5	89	
SG-002A	NG Arm 1 Connecting Pipework	400	16	5	Gas	4.5	89	
SG-002B	NG Arm 2 Connecting Pipework	400	16	5	Gas	4.5	89	
SG-003A	Jetty head pipework	750 400	30 16	36 20	Gas	4.5	89	
SG-004A	Jetty gas pipeline	750	30	394	Gas	4.5	89	
SG-005A	Onshore gas pipeline	750	30	280	Gas	4.5	89	Partially buried
SG-006A	Gas send out to AGI	750	30	249	Gas	4.5	89	Buried
SG-007A	Fuel Gas Line	100	4	14	Gas	4.5	89	Buried
SG-007B	Fuel Gas Line	100	4	12	Gas	4.5	89	
SG-008A	Backup fuel line	100	4	14	Gas	4.5	89	Buried
SG-008B	Backup fuel line	100	4	12	Gas	4.5	89	
SG-009A	Cold feed to Fuel Gas Generators	100	4	6	2-Phase	-37	23	
SG-009B	Cold feed to Fuel Gas Generators	100	4	71	2-Phase	-37	23	Buried

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
SG-010A	Fired Heaters and Heated feed to FG Generators	100	4	23	Gas	8	21	
SG-010B	Heated feed to Fuel Gas Generators Section 1	100	4	96	Gas	8	21	Buried
SG-010C	Heated feed to Fuel Gas Generators Section 2	100	4	62	Gas	8	21	
SG-010D	Heated feed to FG Generators Section 3	100	4	72	Gas	8	21	Buried
SG-011A	Feed to Fuel Gas Generator 1	50	2	12	Gas	8	21	
SG-011B	Feed to Fuel Gas Generator 2	50	2	12	Gas	8	21	
SG-011C	Feed to Fuel Gas Generator 3	50	2	12	Gas	8	21	
CG-001A	Fuel supply to Power Plants	200	8	443	Gas	4.5	89	Buried
CG-002A	Fuel to CCGT 1	100	4	27	Gas	4.5	89	
CG-002B	Fuel to CCGT 2	100	4	27	Gas	4.5	89	
CG-002C	Fuel to CCGT 3	100		27	Gas	4.5	89	

Table 6-2 Node Definitions – AGI

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
PG-001A	Inlet Valve System	750	30	47	Gas	4.5	89	Buried
PG-002A	Pipeline to filtering	750	30	78	Gas	4.5	89	Buried
PG-003A	Filtering	450	18	74	Gas	4.5	89	
PG-004A	Pipeline to Metering	450	18	74	Gas	4.5	89	Buried
PG-005A	Metering	200 500	4 20	59 59	Gas	4.5	89	
PG-006A	Pipeline to Heat Exchangers	450	18	128	Gas	4.5	89	Buried
PG-007A	Heat Exchangers	450	18	60	Gas	2	89	
PG-008A	Pipeline to Pressure Reduction	300 450	12 18	34 138	Gas	2	89	Buried
PG-009A	Pressure Reduction	150 400	6 16	28 41	Gas	2	89	
PG-010A	Pressure Reduction Outlet Pipeline	150 400 750	6 16 30	8 25 69	Gas	1	85	Buried
PG-011A	Outlet Valves	750	30	47	Gas	1	85	Buried
PG-012A	Pig Trap	750	30	7	Gas	1	85	
PG-013A	AGI Outlet	750	30	64	Gas	1	85	Buried
PG-014A	Fuel Gas System	50	2	51	Gas	4.5	89	

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
		80	3	13				
		150	6	13				
ML-001A	Odorant Tank A	-		-	Liquid	15	2	Includes BLEVE scenario
ML-001B	Odorant Tank B	-		-	Liquid	15	2	Includes BLEVE scenario
ML-002	Odorant Tanker hose failure	50		15	Liquid	15	5	

Table 6-3 Node Definitions – FSRU

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
FL001A	LNGC to FSRU manifold A	400 25		1.9 1	Liquid	-163	12	
FL001B	LNGC to FSRU manifold B	400 25		1.9 1	Liquid	-163	12	
FL001C	LNGC to FSRU manifold C	400 25		1.9 1	Liquid	-163	12	
FL001D	LNGC to FSRU manifold D	400 25		1.9 1	Liquid	-163	12	
FL002	FSRU to Liquid Manifold	600 500 400 100 75		130 95 150 5 85	Liquid	-163	12	
FL003A	Liquid Manifold to Tank No.1	400		10	Liquid	-163	12	
FL003B	Liquid Manifold to Tank No. 2	400		10	Liquid	-163	12	
FL003C	Liquid Manifold to Tank No. 3	400		10	Liquid	-163	12	
FL003D	Liquid Manifold to Tank No. 4	400		10	Liquid	-163	12	
FL004	LNG Storage Tanks	-		-	Liquid	-161	0.25	Ship Collision Scenario
FL005	Liquid Line to LNG Daily tank	150		25	Liquid	-161	6	

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
		37.5		3				
FL006	LNG Daily Tank	-		-	Liquid	-161	6	
FL007A	LNG Daily Tank to Pump Suction Pot No. 1 / 2	75		15	Liquid	-148.8	1.57	
FL007B	LNG Daily Tank to Pump Suction Pot No. 3 / 4	75		15	Liquid	-148.8	1.57	
FL008A	Inlet pipework to LNG Booster Pump No. 1	75		2	Liquid	-148.8	1.57	
FL008B	Inlet pipework to LNG Booster Pump No. 2	75		2	Liquid	-148.8	1.57	
FL008C	Inlet pipework to LNG Booster Pump No. 3	75		2	Liquid	-148.8	1.57	
FL009A	LNG Booster Pump (P1)	75		4	Liquid	-148.3	89	
FL009B	LNG Booster Pump (P2)	75		4	Liquid	-148.3	89	
FL009C	LNG Booster Pump (P3)	75		4	Liquid	-148.3	89	
FL010	LNG Booster Pump to R/Cycle Line	75		36	Liquid	-148.3	89	
FL011	LNG Booster Pump Discharge	75		50	Liquid	-148.3	89	
FL012A-1	Inlet header to Vaporisers Skid 1	75 50		15 10	Liquid	-148.3	89	
FL012A-2	Inlet header to Vaporisers Skid 2	75		15	Liquid	-148.3	89	

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
		50		10				
FL013A-1	No.1 Vaporiser Shell / Tube HX and associated pipework (Regas skid 1)	50		5	Liquid	-148.3	89	
FL013B-1	No.2 Vaporiser Shell / Tube HX and associated pipework (Regas skid 1)	50		5	Liquid	-148.3	89	
FL013A-2	No.1 Vaporiser Shell / Tube HX and associated pipework (Regas skid 2)	50		5	Liquid	-148.3	89	
FL013B-2	No.2 Vaporiser Shell / Tube HX and associated pipework (Regas skid 2)	50		5	Liquid	-148.3	89	
FG013A-1	Skid 1, No.1 Vaporiser Outlet	200		7.5	Gas	4.5	89	
FG013A-2	Skid 1, No.2 Vaporiser Outlet	200		7.5	Gas	4.5	89	
FG013B-1	Skid 2, No.1 Vaporiser Outlet	200		7.5	Gas	4.5	89	
FG013B-2	Skid 2, No.2 Vaporiser Outlet	200		7.5	Gas	4.5	89	
FG014-1	Inlet to Buffer Tank 1	250 200		5 7.5	Gas	4.5	89	
FG014-2	Inlet to Buffer Tank 2	250 200		5 7.5	Gas	4.5	89	
FG015-1	Buffer Tank 1	-		-	Gas	25	89	

Node ID	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
FG015-2	Buffer Tank 2	-		-	Gas	25	89	
FG016	Common outlet from Buffer Tank (fuel gas)	400 250 200 150 50		15 16 36 10 65	Gas	25	89	
FG018	Fuel Gas Line	150		30	Gas	25	89	
FG020	FSRU Main Vapour Line	600 500 450 400 350 250 200		25 150 20 20 80 50 15	Gas	-120	0.1	
FG028	Connection to jetty gas arms	400 250 25		15 20 5	Gas	4.5	89	

Table 6-4 Node Definitions – LNGC

LNGC	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
LL001A	LNG Storage Tanks	-		-	Liquid	-163	0.25	Ship Collision Scenario
LL002A	LNG Cargo Pumps	400 50 25		10 40 12	Liquid	-163	4.5	
LL003	LNG Cargo Delivery Header	600 500 450 300 200 100 75 50 37.5		193 100 131.5 20 20 142.5 383 8.5 50	Liquid	-163	4.5	
LL004A	Bunker Station A	400 37.5 25		5 2 4	Liquid	-163	4.5	
LL004B	Bunker Station B	400 37.5 25		5 2 4	Liquid	-163	4.5	
LL004C	Bunker Station C	400 37.5 25		5 2 4	Liquid	-163	4.5	
LL004D	Bunker Station D	400		5	Liquid	-163	4.5	

LNGC	Description	Nominal Diameter (mm)	Diameter (inches)	Length (m)	Phase	Temperature (°C)	Pressure (barg)	Notes
		37.5 25		2 4				
LL005A	Flexible Hose A	250		18	Liquid	-163	4.5	LNG transfer (Ship to Ship) Scenario
LL005B	Flexible Hose B	250		18	Liquid	-163	4.5	
LL005C	Flexible Hose C	250		18	Liquid	-163	4.5	
LL005D	Flexible Hose D	250		18	Liquid	-163	4.5	
LG001A	Vapour Return Manifold	400 25		4 4	Gas	-140	0.25	
LG001B	Vapour Hose	250		20	Gas	-140	0.25	
LG002	Bunker St to Vapour Main (including Vapour Return)	750 600 400 300 250 150 25		58 190 205 170 70 60 22	Gas	-140	0.25	

7. Frequency Analysis

7.1 Piping and Equipment Release Frequencies

The frequency of releases from equipment has been determined by parts counting and application of generic frequency data. The parts count was performed using preliminary Process Flow Diagrams (PFDs). The majority of frequency data have been taken from the HSE Failure Rate and Event Data (FRED), contained within their Planning Case Assessment Guide [12]. This data is presented in Table 7-3.

The FRED data is used by HSE for QRA studies of onshore major hazard facilities and is therefore considered an appropriate source for this study. However, the FRED data has certain limitations in terms of the types of equipment addressed. Where there were no data within FRED for a given equipment item, reference was made to the HSE Hydrocarbon Release Database (HRD). The HRD is compiled from information submitted by operators of offshore oil and gas installations in the UK Sector of the North Sea. The environmental conditions in the North Sea may be more severe than those at the STEP, potentially leading to a conservative estimate of release frequency for the relevant equipment items.

It should be noted that these data sources are generic and do not necessarily reflect LNG experience (which generally gives lower failure rates).

Frequencies calculated for each scenario are presented in Appendix A.

7.2 Gas Arm Failure Frequencies

The frequency of failure of natural gas unloading arms has also been taken from FRED. The data and supporting notes are presented in Table 7-1 and are for liquified gasses such as LNG. The use of this data is assumed to be conservative for natural gas.

Table 7-1 Gas Arm Failure Frequencies

Cause of Failure **(Note 1)**	**Failure Frequencies (per transfer operation)**		
	Guillotine break	**Hole equivalent to 10% of pipe cross sectional area**	**Two simultaneous guillotine breaks**
Connection failures (Note 2)			
Arm	3.4×10^{-7}	3.1×10^{-6}	
Coupler (Note 3)	5.1×10^{-6}	-	
Operator error (Note 4)	5.4×10^{-7}	4.9×10^{-6}	
Sub-total per arm	**6.0×10^{-6}**	**8.0×10^{-6}**	
Ranging failures (Note 5)			
Mooring fault	6.0×10^{-7}	-	
Passing ships (Note 6)	2.0×10^{-7}	-	

Cause of Failure (Note 1)	Failure Frequencies (per transfer operation)		
	Guillotine break	**Hole equivalent to 10% of pipe cross sectional area**	**Two simultaneous guillotine breaks**
Sub-total per system	**8.0×10^{-7}**	**-**	**8.0×10^{-8} when multiple arms used**
Total of failures when one arm used	7.0×10^{-6}	8.0×10^{-6}	-
Total of failures when two arms used	1.3×10^{-5}	1.6×10^{-5}	1.0×10^{-7}
Total of failures when three arms used	1.9×10^{-5}	2.4×10^{-5}	1.0×10^{-7}

Notes:

1. The table does not include failures on the ship itself e.g. pipes, pumps, valves, flanges. Incidents of overfilling of the ship during transfers to a ship are not included. Some of the failure frequencies are dependent on the length of transfer time and a 12-hour transfer time has been assumed.
2. Connection failures apply to every unloading arm that is used during the transfer operation. Failure may lead to flow from both ends of the disconnected arm.
3. It is assumed that all unloading arms handling liquefied gases have emergency release couplings (ERC) designed to achieve a quick release with a minimum of spillage. The coupler failures specified here are events where the ERC parts without the valves in the coupling closing. Incidents where the coupling parts correctly will lead to minimal spillage.
4. This includes not making a connection correctly, opening the wrong valve or at the wrong time, or spilling cargo when disconnecting or venting.
5. Ranging failures are due to gross movement of the ship at the jetty and might simultaneously affect more than one connection where multiple hard arms are in use. When ranging incidents occur where multiple hard arms are connected it is assumed that 10% of the failures will lead to flow from two of the connections. It is assumed that the unloading system is fitted with ranging alarms. (Absence of ranging alarms increases the failure frequency due to Mooring faults by a factor of 5 and absence of ERC couplings would increase the Passing ships frequency by a factor of 5).
6. The failure frequency due to passing ships assumes 10 passing ships during offloading.

The values shown above have been used to calculate failure frequencies for two of the jetty natural gas arms with adjustments being made to account for the estimated number of arm disconnections per year, frequency of passing ships and operational durations.

Frequencies calculated for the gas arm failures at the jetty are shown in Table 7-2.

Table 7-2 Gas Arm Failure Frequencies used

Release Size	Hole Diameter (mm)	Frequency (/y)
Guillotine break	400	6.24×10^{-4}
Break (10% CSA)	126	2.27×10^{-4}
Two Guillotine Breaks	400	4.38×10^{-5}

Table 7-3 Piping and Equipment Release Frequencies

Source	Equipment Description		Frequency (per item year) by hole size (mm)												
	Primary	Secondary	3	4	6	10	13	25	50	75	100	300	1000	1/3 Pipe Dia.	Rupture
Data from HSE FRED	Piping (not including fittings)	1.00E-05					5.00E-06							1.00E-06	1.00E-05
		2"-5"	2.00E-06					1.00E-06							5.00E-07
		6"-11"		1.00E-06				7.00E-07						4.00E-07	2.00E-07
		12"-19"		8.00E-07				5.00E-07						2.00E-07	7.00E-08
		20"-40"		7.00E-07				4.00E-07						1.00E-07	4.00E-08
	Vessel				4.00E-05		1.00E-05	5.00E-06							2.00E-06
	Pump						5.00E-05								3.00E-05
	Flange						5.00E-06								
	Tank											2.50E-03	1.00E-04		5.00E-06
Data from HSE HRD	Compressor	Centrifugal					1.20E-02		2.70E-04		2.90E-06				2.90E-06
		Reciprocating					8.60E-02		3.30E-03		1.40E-05				1.40E-05
	Fin-fan coolers					3.84E-03									
	Heat Exchanger	Plate				9.68E-03		1.42E-03	2.85E-04	2.85E-04					
		HC in Shell				4.15E-03		4.88E-04	2.44E-04						
		HC in Tube				2.81E-03		5.36E-04							1.34E-04

7.3 Ship to Ship LNG Transfer Failure Frequencies

Data for failure of cryogenic hoses used for Ship to Ship (STS) transfer has been taken from FRED [11] for multi safety system facilities:

- 5 mm diameter hole: 6 x 10^{-6} per hose per transfer;
- 15 mm diameter hole: 0.4 x 10^{-7} per hose per transfer; and,
- Guillotine failure: 2 x 10^{-7} per hose per transfer.

The resulting hose failure rates in Table 7-5 have been used, based on four hoses and 60 STS transfers per year.

Table 7-4 Ship to Ship Hose Failure Frequency

Release Size	Total Frequency (per year)
5 mm diameter	1.44 x 10^{-3}
15 mm diameter	9.60 x 10^{-6}
Guillotine	4.80 x 10^{-5}

7.4 Ship Collision

The frequency of collisions with either the FSRU or LNGC giving rise to a spill of LNG has been calculated using the method presented in the Dutch 'Purple Book' [30]. It has been assumed that when the LNGC is present, such collisions will affect the LNGC rather than the FSRU.

For the type of vessel of interest (FSRU / LNGC), the release frequencies are calculated as follows:

Frequency of small spill:

$$F_{small} = 0.00012 \times f_o$$

Frequency of large spill:

$$F_{large} = 0.025 \times f_o$$

Where f_o is the base failure rate and is given by:

$$f_o = 6.7 \times 10^{-11} \times T \times t \times N$$

Where:

T = total number of ships per year on transport route (river/estuary)

t = average number of hours unloading per transfer operation (hours)

N = number of transfers per year

The following assumptions have been made:

- The LNGC is present 41% of the time;
- That the FSRU is present all year;
- When the LNGC is present it is the LNGC which will receive the impact and not the FSRU; and,
- There is an average of 830 large ships per year passing the Terminal.

This gives the failure frequencies shown in Table 7-5. It should be noted that within the QRA the spill sizes associated with large spills are based on the results of the Sandia studies and not on the Purple Book, as described in Section 10.3.

Table 7-5 Ship Collision Release Frequencies

Release Size	Frequency for FSU (per year)	Frequency for LNGC (per year)
Large	1.04×10^{-5}	1.10×10^{-7}
Small	5.01×10^{-8}	5.28×10^{-10}

7.5 BLEVE Frequencies

The two odorant tanks located within the AGI are pressurised vessels containing flammable hydrocarbons. If engulfed in fire, there is a possibility that these vessels may rupture resulting in a BLEVE.

The frequency for a BLEVE of each of these vessels has been taken from FRED and is assumed to be equivalent to that for an LPG Pressure Vessel: 1×10^{-5} /y.

7.6 Release Outcome Frequency

A given release of flammable material may ultimately result in a variety of outcomes, depending on a number of factors, including whether automatic isolation is successful, whether ignition of the release occurs immediately or whether it is delayed. Event outcome frequencies have been calculated using a simplified event tree, as displayed in Figure 7-1 .

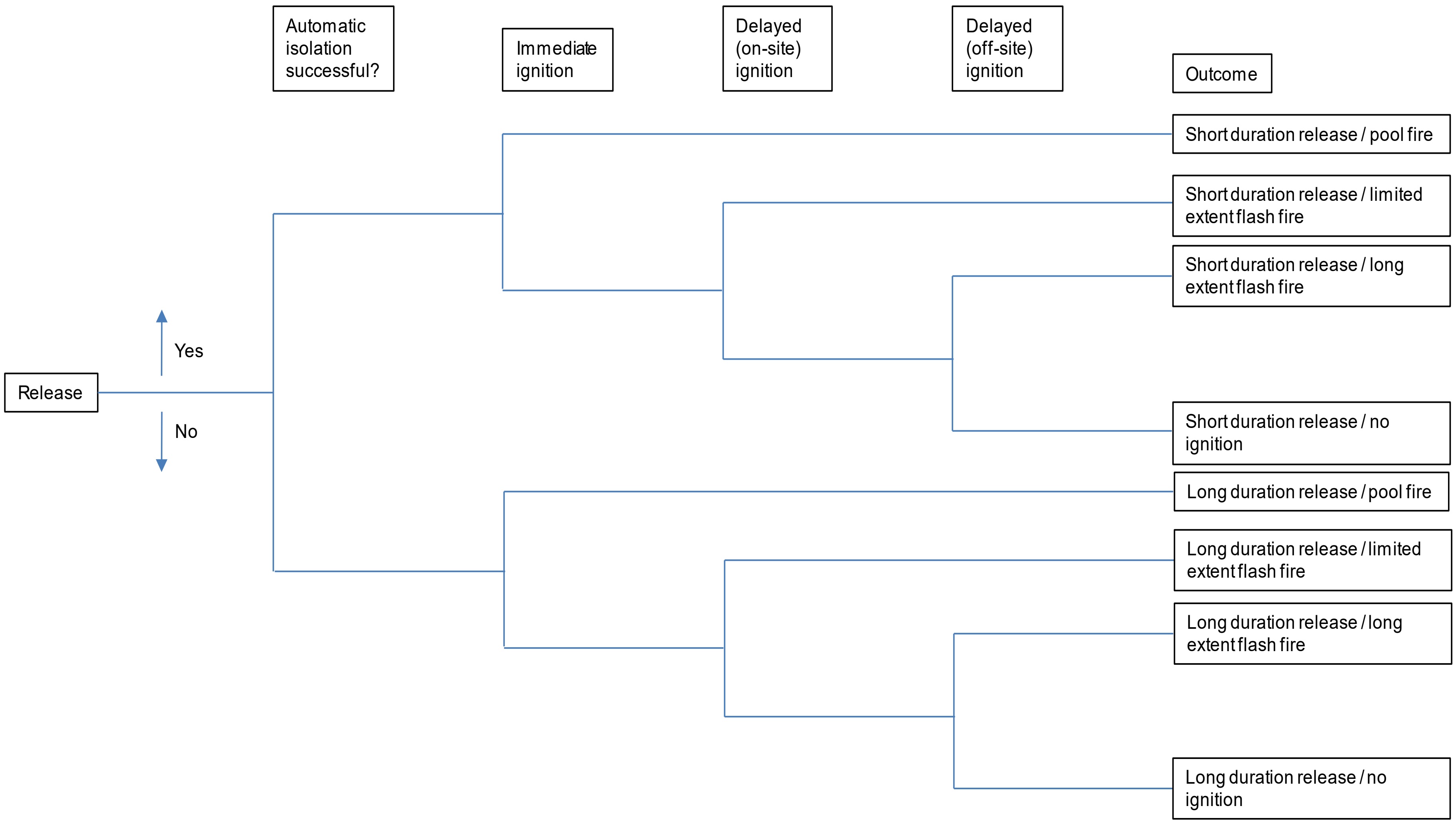


Figure 7-1 Simplified Event Tree

Where provided, the probability of successful leak detection and automatic isolation has been taken as 0.99, consistent with the value given in FRED.

8. Ignitions

Within the Safeti software, the user defines the immediate ignition probabilities for each scenario and the characteristics of potential ignition sources in the surrounding area that may cause delayed ignition. Immediate ignition probabilities are discussed further in Section 8.1. Definition of sources that may cause delayed ignition is described in Section 8.2.

8.1 Immediate Ignition

In determining immediate ignition probabilities, a number of public domain sources have been consulted.

Cox, Lees and Ang [14] present ignition probabilities for flammable gases and liquids that are based partly on a review of values used in published studies, and partly on historical experience. The ignition probability varies with the size of the release, as shown in Table 8-1. Note that these figures are for overall probability of ignition, combining both immediate and delayed cases.

Table 8-1 Ignition Probability according to Cox, Lees and Ang

Failure Type	Ignition Probability – Gases	Ignition Probability – Liquids	Release Rate (kg/s)
Minor	0.01	0.01	<1
Major	0.07	0.03	1-50
Massive	0.3	0.08	>50

The methodology outlined in the TNO 'Purple Book' [15] distinguishes between gases of different reactivity, specifying the values shown in Table 8-2.

Table 8-2 Immediate Ignition Probabilities according to 'Purple Book'

Source Type		Ignition Probability for Gas Type (see Note)	
Release Rate for Continuous Source (kg/s)	Mass released for Instantaneous Source	Low Reactivity	Average / High Reactivity
<10	<1,000	0.02	0.2
10-100	1,000 – 10,000	0.04	0.5
>100	>10,000	0.09	0.7
Note: the Purple Book classifies methane as 'low' reactivity			

In comparison, the HSE's PCAG [9] document reports that immediate ignition probability values used in assessments vary between 0.1 (no readily identifiable ignition source) and 0.9 (release near to strong, continuously present ignition sources such as direct-fired equipment).

From a review of the information presented above it can be seen that:

- Most authors indicate that immediate ignition probability increases as a function of the size of the release;
- For the smallest releases the ignition probability may be as low as 1-2%; and,
- The 'Purple Book' considers methane to be of low reactivity, with correspondingly lower ignition probability.

In addition, it is necessary to account for the type of equipment that will be used in parts of the facility and the ways in which it might fail. The use of buried pipelines on the AGI means that severe loads would be required to cause a guillotine failure, similarly the energy required to penetrate a ships double hull in the event of a collision is very high. In view of the energies required to cause such failures, it is considered likely that application of such loads would be likely to result in immediate ignition of the contents. Hence ruptures of buried pipelines and ship collision events have been considered to be associated with a higher immediate ignition probability than most other events.

It is also important to note that use of a low immediate ignition probability results in a more conservative estimate of off-site risk, since a larger proportion of releases are allowed to develop into flammable vapour clouds. On this basis, the immediate ignition probabilities displayed in Table 8-3 have been used for the QRA.

Table 8-3 Immediate Ignition Probabilities for LNG

Failure Type	Immediate Ignition Probability	Vapour Release Rate (i.e. from pool) kg/s
Minor	0.01	<1
Small	0.02	1 – 10
Large	0.1	>10
Severe loading event (Note 1)	0.5	As calculated
Note 1: Severe loading events are ship collision and buried pipe guillotines		

These probabilities are slightly more conservative than those specified by the 'Purple Book' (Table 8-2). For small releases they are considerably more conservative than those used by HSE; for larger releases they are consistent with the HSE value that corresponds with 'no readily identifiable ignition sources'. This is considered to be representative of the proposed STEP, where hazardous area classification will be implemented together with appropriate standards of intrinsically safe equipment, together with control of vehicle movements and other potential ignition sources (smoking materials, mobile telephones). The values are consistent with the overall ignition probabilities reported by Cox, Lees and Ang (Table 8-1).

8.2 Delayed Ignition Probability

The Safeti software implements the delayed ignition calculation method defined in the 'Purple Book' [15]. This method deals with delayed on-site ignition and delayed off-site ignition within the same framework. Two different approaches to delayed ignition are described.

The first approach involves definition of the specific locations of known ignition sources both within and outside the establishment. The method takes account of the distribution of ignition sources, the likelihood of the source being present or active, and the strength of the source.

The second approach also involves definition of known ignition sources within the establishment. However, if the release is not ignited within the establishment, it is then assumed that ignition takes place when the cloud is at its fullest extent.

The first approach is recommended for societal risk calculations; individual risk calculation may be performed using either approach.

Where a distribution of ignition sources is defined, the probability of ignition being caused by a given source is obtained from:

$$P(t) = P_{present}(1 - e^{-\omega t})$$

Where:

P(t) = probability of ignition in time interval t

$P_{present}$ = the probability that the ignition source is present when the cloud passes

ω = the ignition effectiveness (s^{-1})

T = time (s)

The ignition effectiveness can be calculated if the ignition probability for a specified time period is known. The 'Purple Book' gives some guidance on appropriate values of the ignition probability for a time period of one minute, as shown in Table 8-4.

Table 8-4 Probability of Ignition for a One Minute Time Interval (Purple Book)

Source	Probability of ignition in one minute
Point Source	
Motor vehicle	0.4
Flare	1.0
Outdoor furnace	0.9
Indoor furnace	0.45
Outdoor boiler	0.45
Indoor boiler	0.23
Ship	0.5
Ship transporting flammable materials	0.3
Fishing vessel	0.2
Pleasure craft	0.1
Diesel train	0.4
Electric train	0.8
Line source	
Transmission line	0.2 per 100 m
Road	Note 1
Railway	Note 1
Area source	
Chemical plant	0.9 per site
Oil refinery	0.9 per site

Source	Probability of ignition in one minute
Heavy industry	0.7 per site
Light industrial warehousing	As for population
Population source	
Residential	0.01 per person
Employment force	0.01 per person
Note 1: The ignition probability for a road or railway near the establishment under consideration is a function of the average traffic density.	

The HSE has published research reports [16] [17] describing a detailed, complex approach to ignition probability calculation. The methodology takes into account:

- The concentration of flammable gas as a function of time, both outdoors and inside buildings with specified ventilation rates;
- Whether sources are indoors or outdoors;
- The frequency and duration for which intermittent ignition sources are active;
- The strength of the ignition source; and,
- Different densities of ignition sources in different plant areas or in different off-site land uses (rural, urban, industrial).

In its fullest form the method requires a numerical solution of the relevant equations across a two-dimensional grid, although it is possible to simplify the approach so that it is practical to implement within a QRA.

The HSE approach is similar in certain respects to the 'Purple Book' method, but, for off-site ignition, uses typical ignition source densities for different land uses rather than specifying discrete ignition sources.

For the STEP project the Purple Book approach, as implemented in the Safeti software, has been used.

8.2.1 Delayed On-Site Ignition Sources

In identifying and characterising on-site ignition sources, reference has been made to one of the HSE Research Reports [17]. This reference has been used as a guide to determine the type, number and characteristics of ignition sources. The ignition parameters given in the research report have then been adapted for use with the Safeti / Purple Book model.

For the purposes of defining on-site ignition sources the following areas and point sources have been used:

Table 8-5 On Site Delayed Ignition Sources (Point and Area Sources)

Area / Item	Modelled as	Probability of ignition in one minute	Notes
STEP Site			
Overall Site	Chemical plant	0.9	

Area / Item	Modelled as	Probability of ignition in one minute	Notes
SUS Transformers	Indoor boiler	0.23	Operating probability fraction 0.99
Ships			
FSRU	Ship carrying flammable liquids	0.3	
LNGC	Ship carrying flammable liquids	0.3	
Tugs	Fishing vessel	0.2	
AGI			
Overall AGI Site	Ship carrying flammable liquids	0.3	Normally unoccupied site with hazardous area classification
AGI Boilers (5 of)	Indoor furnace	0.45	
Power Station			
Overall Power Station	Heavy industry	0.7	
Transformers (3 of)	Indoor boiler	0.23	Operating probability fraction 0.99
GIS Substation	Indoor boiler	0.23	Operating probability fraction 0.99
Water Treatment Site			
Overall site	Chemical plant	0.9	
Nitrogen Generation Site			
Overall site	Chemical plant	0.9	

For roadways on the site the traffic densities and speeds in Table 8-6 have been assumed. These are based on the numbers of personnel expected on site during weekdays and at other times (weekends and night time).

Table 8-6 On Site Roadways

Roadway	Probability of ignition in one minute	Traffic Density (/h)	Average Speed (mph)
L1010 to site entrance	0.4	Week Day: 7.2 Other times: 1.9	30
Site entrance to jetty car park	0.4	Week Day: 0.8 Other times: 0.4	5
Site entrance to water treatment car park	0.4	Week Day: 0.1 Other times: 0	5

Roadway	Probability of ignition in one minute	Traffic Density (/h)	Average Speed (mph)
Site entrance to power plant car park 1	0.4	Week Day: 4.3 Other times: 0	5
Site entrance to power plant car park 2	0.4	Week Day: 1.6 Other times: 0.9	5
Site entrance to terminal control room	0.4	Week Day: 0.2 Other times: 0.2	5

8.2.2 Delayed Off-Site Ignition Sources

The following off-site ignition sources have been identified:

- Traffic using the coast road (L1010);
- Shipping moving along the Shannon river; and,
- Moneypoint power station.

In addition, population has also been defined as a potential ignition source, using the parameters defined in Table 8-4.

Coast Road L1010

The average annual daily traffic for the L1010 was taken to be 263 vehicles per day during the operational phase of the terminal. It is assumed that:

- 80% of this traffic occurs during the day;
- Average vehicle speed is 60 km/h; and,
- The ignition strength of a motor vehicle is 0.4 in 60 s (in line withTable 8-4).

Shipping

The 2020 Navigational Risk Estimate for the site [19] gives the current traffic along the Shannon as between 1089 and 1129 movements per year (i.e. between 900 and 1029 vessels per year). A value of 1129 movements per year is assumed. The ignition strength of ships is taken as 0.5 in 60s (in line with Table 8-4), and a ship speed of 15 kts (7.717 m/s) is assumed.

Moneypoint

The Moneypoint power station is treated as a 'Heavy Industry' area with an ignition strength of 0.7 in 60s (Table 8-4).

9. Fatality Probability

The 2010 HSA guidance [3] uses a probit equation for calculating the fatality probability for persons exposed to thermal radiation. This approach has been adopted in this study.

Probit relationships take the form:

$$Y = A + B.ln(D)$$

Where:

Y = probit value

A and B are constants that are specific to the harmful agent.

D is the harmful dose received by the receptor. This is a function of the intensity (or concentration) of the harmful agent and the exposure duration.

The probit value is related to the probability of fatality by the following expression:

$$P = 0.5 \times \left[1 + erf\left(\frac{Y-5}{\sqrt{2}}\right)\right]$$

Where:

P = probability of fatality

For example, a fatality probability of 0.1 corresponds to a probit value of 4.16. Probit values are available in standard tables.

9.1 Fatality Probability – People Outdoors

For people outdoors exposed to thermal radiation, the 2010 guidance specified the use the probit equation published by Eisenberg et al. [20]:

$$Y = -14.9 + 2.56\ln\left(I^{1.33}.t\right)$$

Where:

I = incident thermal radiation flux (kW/m^2)

T = exposure time (s)

The probit equation parameters were set accordingly in Safeti.

9.2 Fatality Probability – People Indoors

The 2010 guidance recognises that people indoors may be offered some protection from the effects of thermal radiation and gives the set of assumptions presented in Table 9-1.

Table 9-1 Fatality Probability for People Indoors

Thermal Radiation Flux (kW/m^2)	Fatality Probability
>25.6	Building conservatively assumed to catch fire quickly and so fatality probability is 1.
12.7 – 25.6	People are assumed to escape outdoors, and so have a risk of fatality corresponding to that outdoors (i.e. the probit equation is used).
<12.7	People are assumed to be protected, so fatality probability is 0.

The Safeti model was configured to use these assumptions for people indoors onshore.

9.3 Fatality Probability due to Flash Fires

The 2010 guidance does not specify an approach for flash fires. It has been assumed that people outdoors within the flash fire envelope (the lower flammable limit, LFL, contour) will be fatalities.

Building occupants are protected from the direct effects of a flash fire outside, unless the flash fire causes secondary fires at the building (as a result of flame contact). Should secondary fires occur, these may harm the occupants or cause them to seek escape and then be exposed to the burning vapour.

The HSE has published research on the effects of flash fires on building occupants [21]. This work indicated that the probability of fatality for occupants of a building engulfed by a flash fire could be as high as 21.5% (for occupants of a dwelling where multi-point ignition of the building occurs as a result of engulfment of the building by a flash fire at night). Therefore, it is assumed that the fatality probability for people indoors from flash fires is 0.25, to account for the protection afforded by the building.

9.4 Fatality Probability within The FSRU and LNGC

FSRUs and LNGCs have protection against the effects of thermal radiation, in the form of construction from metal and the addition of passive fire protection. FSRUs and LNGCs also have fire and smoke detection systems, fire alarms and emergency evacuation procedures. These all reduce the risk to personnel onboard.

The mandatory IGC code for ships carrying flammable materials is quite specific on the safeguards required for protecting crew against flammable hazards. Through compliance with this standard, design features for an FSRU and LNGC include:

- Accommodation block designed and constructed such that it or part of it can be used as a Temporary Safe Refuge (TSR) for the maximum number of personnel on board;
- The TSR is designed to be able to withstand impairment from the hazards on the installation for a minimum of one hour and be fully protected on all sides by A60 rated fire walls, bulkheads, floors and ceilings; and,
- The forward bulkhead of the accommodation block, and also the lifeboats, are protected from jet fire or explosion on the process deck or cargo deck by means of a fire/blastwall.

By following the IGC requirements personnel within the vessel are afforded a very high level of protection.

The Chemicals Industry Association (CIA) [27] provides guidance on the assessment of risk to personnel in buildings onshore. Where buildings are designed to withstand flammable hazards to an extent that allows safe evacuation the risks of fatality are also considered to be very low.

It can be seen that guidance and standards for both offshore and onshore buildings or TR’s recognise that through good design the risks to personnel in these areas is very low. It should be noted that actual data presenting risk reduction factors has not been identified as the approach taken by the IMO and CIA is aimed at making the buildings ‘safe’ rather than using a measure for risk reduction.

On this basis personnel within the FSRU or LNGC are at very low risk of harm. It has therefore been assumed that personnel vulnerability within the LNGC or FSRU structure is 10% of that for a standard onshore building, which is considered to be conservative.

10. Consequence Modelling

10.1 Modelling Software

The Shannon LNG QRA has used the suite of models incorporated into the DNV Safeti software (version 8.4). Safeti is a comprehensive hazard and risk analysis software tool for all stages of design and operation.

Safeti examines the progress of a potential incident from the initial release to far-field dispersion including modelling of pool spreading and evaporation, and flammable and toxic effects.

Safeti contains models tailored for hazard analysis of offshore and onshore industrial installations. These include:

- Discharge and dispersion models, including a Unified Dispersion Model (UDM).
- Flammable models, including resulting radiation effects, for jet fires, pool fires and boiling liquid expanding vapour explosions (BLEVEs).
- Explosion models, to calculate overpressure and impulse effects.

The consequence models in Safeti have been validated specifically by DNV for LNG modelling [22]. This validation exercise simulated the modelling of methane as opposed to a mixture of hydrocarbons. The study concluded that the vaporisation fraction of a mixture would be predominantly methane in the early stages of an event with the maximum distance to LFL being the result of early vaporisation.

Results from consequence modelling for each scenario considered are presented in Appendix B.

10.2 Release Durations

10.2.1 Releases from Pipes

These estimated release durations are based on judgements around the closing time of emergency valves. The detection systems to be provided at the facility would enable leaks to be detected rapidly.

Releases from pipes containing LNG have been assumed to continue for:

- One minute plus the time taken to empty the contents of the inventory for isolated cases; and,
- 10 minutes plus the time taken to empty the contents of the inventory for unisolated cases.

It is conservatively assumed that the LNG release rate from the pipe after isolation will continue at the same rate that it did before isolation with the complete inventory of the pipe being released. In reality the release rate will fall rapidly after isolation with the flow being dependant on release position, size and orientation.

The durations of releases from pipes containing natural gas have been modelled in two ways, depending on the release rate and gas flow through the process.

Where the release rate from a rupture is lower than the gas flow through the pipe it is assumed that the release rate is constant at the initial release rate (the pipe does not depressurise). On isolation the release rate will fall as the pipe depressurises and this has been modelled as a varying rate release, continuing until the pipe pressure reaches atmospheric pressure.

In cases where the release rate is greater than the process flow it is assumed that the pipe will rapidly depressurise as its contents are released and following this initial surge the release continues at the normal gas process flowrate until isolation occurs.

10.2.2 Releases from Tanks / Vessels

The duration of a release from tanks or vessels have been assumed to be equal to the time taken to empty the tank/vessel contents.

10.2.3 Releases during Ship to Ship Transfer

For releases during ship to ship transfer the following durations for isolated releases have been assumed

- Small Releases: 345 seconds;
- Medium Releases: 125 seconds; and,
- Large Releases: 105 seconds.

The above tines are based on typical detection times for an offshore installation plus 45 seconds for isolation and blowdown. These durations are considered to be conservative.

Unisolated releases are assumed to have 600 seconds.

10.3 Release Following Vessel Collision

In extreme cases, a release of LNG from the LNGC or FSRU could result from collision with another vessel. The frequencies of such events are very low.

Marine accidents of this type have been subjected to detailed analysis by the Sandia National Laboratories in the USA [28]. The study considered accidental and deliberate (i.e. due to terrorist attack) breaches of LNGC cargo tanks. Finite element modelling was used to calculate breach sizes. Note that intentional breaches fall outside the scope of this risk assessment. This analysis indicated that the effective size of breaches in an LNG vessel due to accidental events would be in the range 0.5 m^2 to 1.5 m^2.

Sandia performed a re-assessment of this study in 2008, to account for the largest LNG carriers that were then coming into service [29]. The 2008 study did not result in any changes to the breach sizes for accidental cases; and focussed on intentional breaches. However, the sizes of spills were increased to allow for the observed increases in tanker sizes.

For large spills resulting from collisions with either the FSRU or LNGC the following have been assumed:

- Effective release diameter 1200 mm (i.e. an area of 1.1 m^2; within the range calculated by Sandia);
- Available volume 41,000 m^3; and,
- Liquid head 20 m.

It should be noted that these values represent the largest vessels in service and therefore provide an upper bound to the likely consequences. The assumptions are also highly conservative compared to the assumptions stated in the Dutch 'Purple Book' [30] for such events, where a 'large' spill has a volume of only 126 m^3. In view of the Sandia studies the Purple Book large spill size is not considered to be a good representation of releases from vessel collision events of the type considered in this analysis. A large spill case based on the Sandia reports has therefore been considered in the QRA.

For small spills a size of 32 m^3 released over 1800 seconds for a semi-gas (refrigerated) tanker has been used, as given in the Purple Book.

10.4 Effect of Impoundment

Releases of LNG on the FSRU and LNGC are assumed to be unrestricted, i.e. no bunds or secondary containment systems are present.

The odorant used at the AGI is stored in a bunded area and this has been accounted for in the assessment.

10.5 Effect of Topography

At the proposed location, on travelling south from the river bank the land rises to a height of approximately 30 m, before sloping gently downwards again. The Shannon facility will be constructed on 'plateaux' cut into the hillside sloping down to the river.

It has been assumed that topography has no effect on dispersion of natural gas.

10.6 Releases onto Land and Water

It is assumed that releases from the FSRU, LNGC and jetty are released over water and all other releases are over land.

10.7 Dispersion Modelling

Dispersion of natural methane is dependent on several parameters, including: surface roughness, averaging time, material properties, wind speed and weather conditions. The weather data used in the study are discussed in Section 10.10.

10.8 Surface Roughness Parameter

Table 10-1 shows examples of roughness parameters that should be used in dispersion calculations over different types of terrain. A surface roughness parameter of 0.1 has been used in the study for dispersion over land as this provides pessimistic dispersion conditions that best represent the local topography of the terminal location and the surrounding terrain. A surface roughness height of 5 mm has been used for the dispersion of spills onto water to represent spills on to a "deep river".

Table 10-1 Typical Surface Roughness Parameter Values

Terrain	Roughness Parameter
Smooth ice	1×10^{-5}
Sea (any state)	1×10^{-4}
Sandy desert	1×10^{-3}
Closely mown grass	1×10^{-3}
Short grass	1×10^{-3}
Long grass	0.03
Root crops	0.1
Parkland with trees	0.3
Open suburbia	0.5
City centres / forests	1

10.9 Averaging Time

When using gas dispersion models the 'averaging time' is a description of the time over which a gas concentration is averaged. At a particular point in space the concentration of a plume at equilibrium will vary for two reasons. Firstly, as the wind direction is not perfectly constant the plume will meander about a mean value. Secondly there are 'in-cloud' fluctuations due to the turbulence inherent in the atmosphere. As dispersion models aim to show a 'time averaged' concentration at a particular point, this average will depend on the length of time over which the concentration was 'sampled'. The situation is made more complicated because the different types of dispersion model assume different definitions of 'averaging time'.

The use of a short averaging time will maximise the recorded concentration at a given point, whereas a longer averaging time will give a lower value. This is because the use of a short averaging time captures the concentration 'peaks' at a location.

In this study an averaging time of 18.75 s has been used (this is the SAFETI default value for flammable gases).

For releases over land and water the concentration of interest for gas dispersion outputs is 2.5% v/v methane in air; corresponding to the lower flammable limit (LFL).

10.10 Weather Data

Within a risk assessment, weather conditions are usually described as a combination of a letter with a number, such as 'F2'. The letter denotes the Pasquill stability class and the number gives the wind speed in metres per second.

The Pasquill stability classes describe the amount of turbulence present in the atmosphere and range from A to F. Stability class A corresponds to 'unstable' weather, with a high degree of atmospheric turbulence, as would be found on a bright sunny day. Stability class D describes 'neutral' conditions, corresponding to an overcast sky with moderate wind. A clear night with little wind would be considered to represent 'stable' conditions, denoted by stability class F.

Wind speeds range from light (1-2 m/s) through moderate (around 5 m/s) to strong (10 m/s or more). The probability of the wind blowing from a particular direction is commonly displayed graphically as a 'wind rose'. Weather data for Shannon Airport have been obtained from Met Éireann. The data present Pasquill stability classes based on hourly measurements between 2015 and 2019.

Shannon Airport is the nearest weather station to the Terminal location near Ballylongford and is therefore the most representative data source to be used in the QRA.

In order to provide a robust basis for calculating the risk to hypothetical house residents (see Section 13.1), a detailed analysis of the weather data during day and night has been performed for this study.

The fraction of time considered to be 'day' was calculated by assigning day and night hours to different months of the year, then calculating the number of daytime hours. Note that 'day' and 'night' were defined according to hypothetical resident behaviour (i.e. on when people may typically get up and go to bed, and not sunrise and sunset). Within the weather calculation, this has been defined as a 14 hour period during summer (defined as the period from April to the end of October, when daylight saving time operates) from 07:00 GMT (06:00 DST) until 21:00 GMT (20:00 DST); and a 12 hour period during winter (all months not defined as summer) from 06:00 GMT to 18:00 GMT.

The data were then processed to obtain wind direction probabilities (i.e. ‘wind rose’ data) and the proportion of time for which D5 and F2 weather conditions occurred. The results are shown in Table 10-2.

Table 10-2 – Weather Data

Day

Stability Class	Wind Sector															
	348.75 - 11.25	11.25 - 33.75	33.75 - 56.25	56.25 - 78.75	78.75 - 101.25	101.25 - 123.75	123.75 - 146.25	146.25 - 168.75	168.75 - 191.25	191.25 - 213.75	213.75 - 236.25	236.25 - 258.75	258.75 - 281.25	281.25 - 303.75	303.75 - 326.25	326.25 - 348.75
D5	0.01946	0.01905	0.01118	0.02441	0.05997	0.06020	0.03500	0.04689	0.10023	0.06150	0.03480	0.03000	0.01946	0.01905	0.01118	0.02441
F2	0.00043	0.00073	0.00031	0.00027	0.00079	0.00082	0.00045	0.00052	0.00182	0.00232	0.00159	0.00132	0.00043	0.00073	0.00031	0.00027

Night

Stability Class	Wind Sector															
	348.75 - 11.25	11.25 - 33.75	33.75 - 56.25	56.25 - 78.75	78.75 - 101.25	101.25 - 123.75	123.75 - 146.25	146.25 - 168.75	168.75 - 191.25	191.25 - 213.75	213.75 - 236.25	236.25 - 258.75	258.75 - 281.25	281.25 - 303.75	303.75 - 326.25	326.25 - 348.75
D5	0.00577	0.00974	0.00764	0.01825	0.04317	0.05041	0.028	0.03080	0.05748	0.03190	0.01351	0.01134	0.00577	0.00974	0.00764	0.01825
F2	0.01262	0.01218	0.00816	0.00960	0.01837	0.01291	0.00988	0.01134	0.02015	0.02033	0.02047	0.02154	0.01262	0.01218	0.00816	0.00960

11. Populations

11.1 Onsite Personnel

Onsite personnel and off site population numbers used in the assessment are described in Table 11-1. Populations on the LNGC and FSRU are based on those identified during previous QRA studies, involving the types of vessels being assessed, and the remaining populations are based on anticipated numbers of personnel that will be normally present onshore.

11.2 Offsite Populations

The following offsite populations have been used; these are taken from the QRA for the site undertaken in 2013 [31] plus a 2% increase in population identified from reports from The Central statistics Office [32].

Table 10-1 Offsite Populations

Area / Location	No. People	Fraction indoor Day	Fraction Indoor Night
Individual residences within 2 km	4 per residence	0.9	0.99
Ballylongford	426	0.9	0.99
Tarbert	562	0.9	0.99
Kilrush	2749	0.9	0.99
Money Point Power Station	313	0.5	0.7
Background (/km^2)	31.57	0.9	0.99

11.3 Hypothetical House Residents

In the event of a major accident, the likelihood of harm to a person indoors differs from that for a person outdoors (see Section 9). Therefore, it is common practice for QRA studies to consider the proportion of time individuals may spend indoors and outdoors.

To account for time spent indoors and outdoors, the previous QRA study [23] employed the concept of a ‘hypothetical house resident’ originally developed by the UK HSE [24]. The hypothetical house resident is present all of the time at their dwelling, spending 90% of their time indoors during the day and 99% of their time indoors at night. The HSA guidance [3] is based on the ‘hypothetical house resident’ concept.

Table 11-2 – Onsite Populations

Location	Week Day		Week Night		Weekend Day		Weekend Night		Notes
	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	
FSRU									
FSRU - Accommodation	33		33		33		33		
FSRU - Fore Deck		1		1		1		1	
FSRU - Aft Deck		1		1		1		1	
LNGC									
LNGC - Accommodation	33		33		33		33		LNGC will be at location 60 times per year, for 60 hours each time
LNGC - Fore Deck		1		1		1		1	
LNGC - Aft Deck		1		1		1		1	
Jetty									
Tug 1	3.6	0.4	3.6	0.4	3.6	0.4	3.6	0.4	4 personnel, 90 % of the time inside
Tugs 2, 3 and 4 (per tug)	3.6	0.4	3.6	0.4	3.6	0.4	3.6	0.4	Tugs 2, 3 and 4 occupied During manoeuvring of the LNGC. Unoccupied at other times.
Jetty Structure		0.76		0.76		0.76		0.75	
STEP									
Control Room	2		2		2		2		
Admin / Workshop	17								
Site		1		1		1		1	
AGI									
Control Room									AGI Site Normally Unoccupied
Site									
Power Plant									

Location	Week Day		Week Night		Weekend Day		Weekend Night		Notes
Administration Building	20								
Control Room	1		1		1		1		
Storage/Workshop/Canteen	6								
Turbine Hall 1	1		1		1		1		
Turbine Hall 2	1		1		1		1		
Turbine Hall 3	1		1		1		1		
Condenser Area 1		1		1		1		1	
Condenser Area 2		1		1		1		1	
Condenser Area 3		1		1		1		1	
Auxiliary Control Room 1	1		1		1		1		
Auxiliary Control Room 2	1		1		1		1		
Auxiliary Control Room 3	1		1		1		1		
Nitrogen Plant									
Control Room	0.9								
Site		0.1							
Water Treatment Plant									
Control Room	0.9								
Site		0.1							

Note that where a population is described as being less than 1, e.g. 0.9 for the Nitrogen Plant Control Room this means that one person will be present in the control room for 90% of the time.

12. Risk Criteria

12.1 Individual Risk

The current HSA criteria [3] are stated in terms of risk of fatality. Use of probit equations is prescribed for calculation of the probability of fatality given exposure to a dose of a harmful agent (such as thermal radiation, overpressure or toxic gas).

The land use planning zone boundaries in the HSA guidance are defined as:

- Zone 1 (inner): within the 1 x 10^{-5} /y individual risk of fatality contour;
- Zone 2 (middle): between the 1 x 10^{-5} /y and 1 x 10^{-6} /y individual risk of fatality contours; and,
- Zone 3 (outer): between the 1 x 10^{-6} /y and 1 x 10^{-7} /y individual risk of fatality contours.

The criteria for new establishments found in the HSA guidance are:

- The individual risk of fatality at the nearest residential property should not exceed 1 x 10^{-6} /y; and,
- There should be no incompatible land uses existing within any of the three zones.

Land uses are assigned to one of four 'Sensitivity Levels', using a classification developed by the UK HSE [9], as summarised in Table 12-1.

Table 12-1 Acceptable Land Uses in Risk Zones

Sensitivity Level and Description	Zone 1	Zone 2	Zone 3
1. People at work, parking	DAA	DAA	DAA
2. Developments for use by the general public (including housing)	AA	DAA	DAA
3. Developments for use by vulnerable people	AA	AA	DAA
4. Very large and sensitive developments	AA	AA	AA
Notes AA – Advise Against. DAA – Don't Advise Against			

12.2 Societal Risk – FN Curve

Societal risk results are commonly presented as an 'F-N' curve, which shows the cumulative frequency with which N or more fatalities are experienced.

For siting of new facilities where the societal risk is presented as a 'F-N' curve, the HSA guidance defines two criterion points:

- an upper societal risk value of 1 in 5000 years for 50 fatalities represents the boundary of the intolerable region (i.e. a societal risk above this value would be considered intolerable); and,
- a lower societal risk value of 1 in 100,000 years for 10 fatalities represents the boundary of the broadly acceptable region (i.e. a societal risk below this value would be considered broadly acceptable).

Where the societal risk is in the intolerable region, then the HSA should advise against the proposed facility. Where the societal risk is in the broadly acceptable region, the HSA should not advise against. If the societal risk falls between these two values (i.e. in the ‘significant’ region), then the HSA should advise the planning authority of that fact and the need for the planning authority to weigh this into their planning decision.

For the purposes of this study, the HSA criterion points have been plotted on the F-N graph and criterion lines extrapolated through them. This results in the F-N criteria lines shown in Figure 12-1.

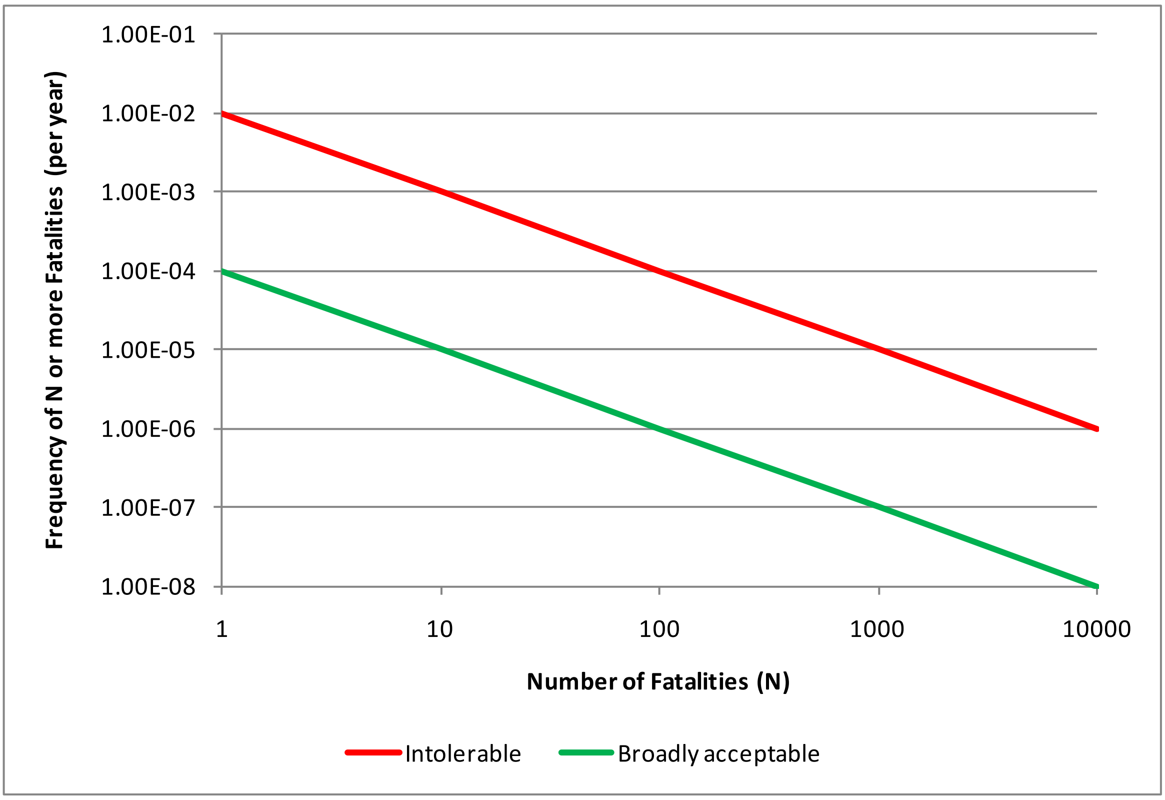


Figure 12-1 HSA Criterion Points

12.3 Expectation Value (EV)

The EV is the calculated number of fatalities per year. For example, a major accident that could result in 100 fatalities with a frequency of 1 in 1,000 years (i.e. 1×10^{-3} /y) would have an EV of:

$$EV = 100 \times 1 \times 10^{-3} = 0.1 \text{ fatalities per year.}$$

In practice, the EV is the sum of all (frequency x number of fatality) pairs for every accident scenario modelled for the facility under consideration.

The current HSA guidance does not contain EV criteria values. However a consultation document issued by the HSA in 2021 [34] included EV criteria in terms of cpm (chances per million years) with the following acceptance criteria:

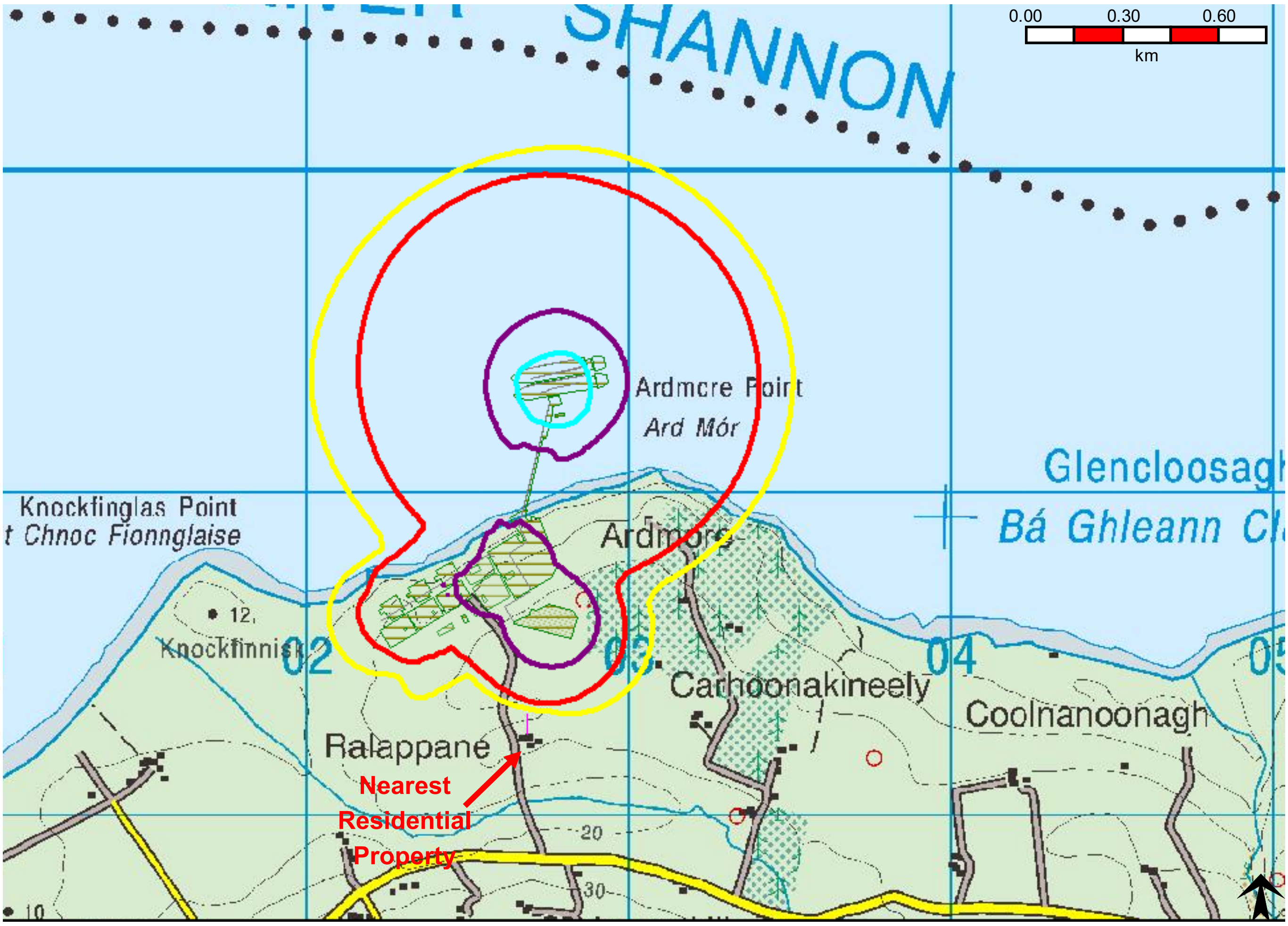
- EV greater than 10,000 - LUP advice to the planning authority will always be ‘Advises Against’.
- EV between 100 and 10,000 - it should be demonstrated that all practicable efforts have been made to reduce the risk to a level that is as low as reasonably practicable.

13. Risk Calculation Results

Individual risk of fatality calculations have been performed using the DNV Safeti software (version 8.4).

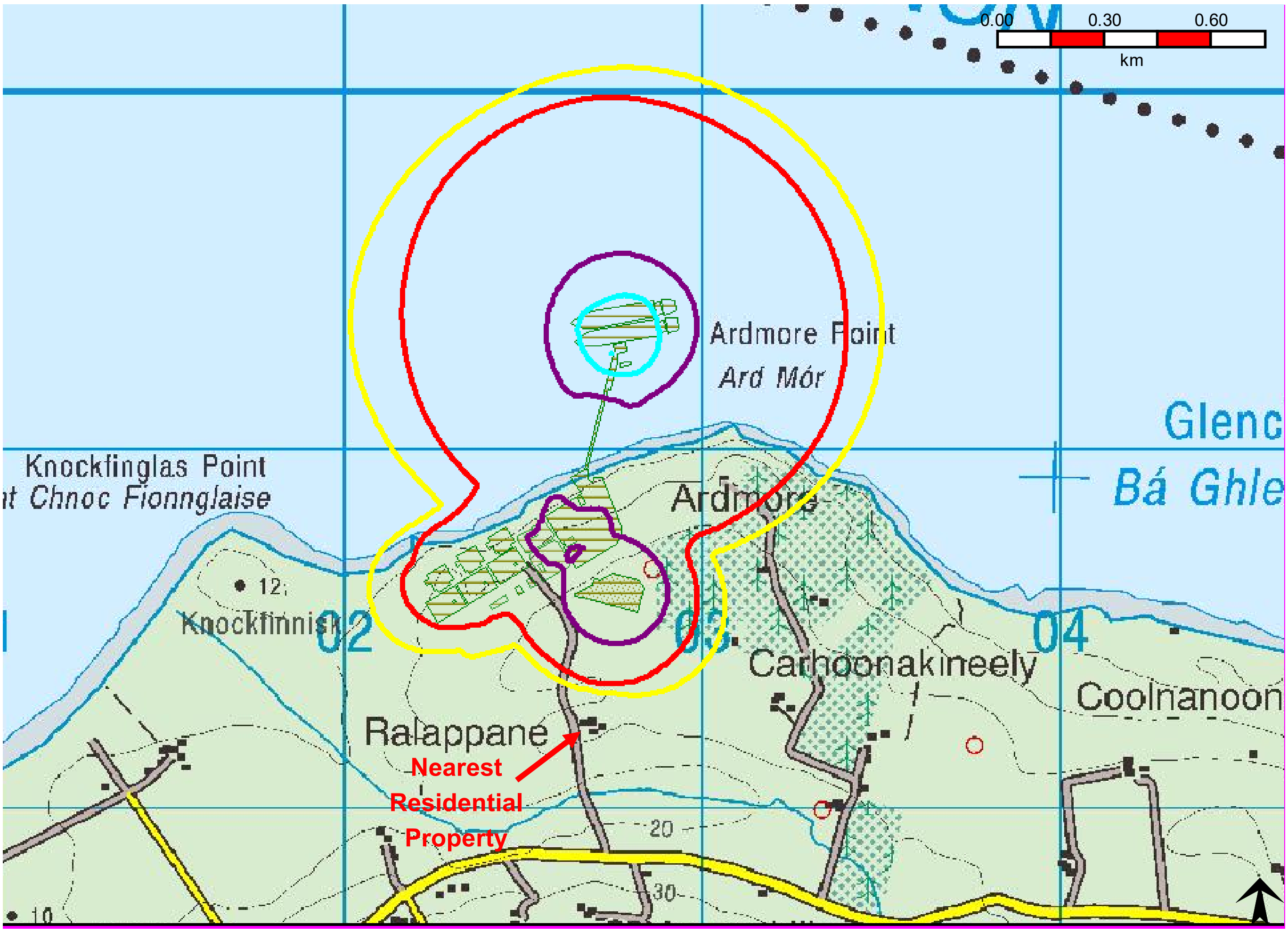
13.1 Individual Risk

The individual risk contours for people outdoors in the area of the LNG terminal are presented in Figure 13-1, contours for people indoors are presented in Figure 13-2.



Key: Light Blue: 1 x 10^{-4}/y; Purple: 1 x 10^{-5}/y; Red: 1 x 10^{-6}/y; Yellow: 1 x 10^{-7}/y

Figure 13-1 Outdoors Individual Risk Contours



Key: Light Blue: 1 x 10^{-4}/y; Purple: 1 x 10^{-5}/y; Red: 1 x 10^{-6}/y; Yellow: 1 x 10^{-7}/y

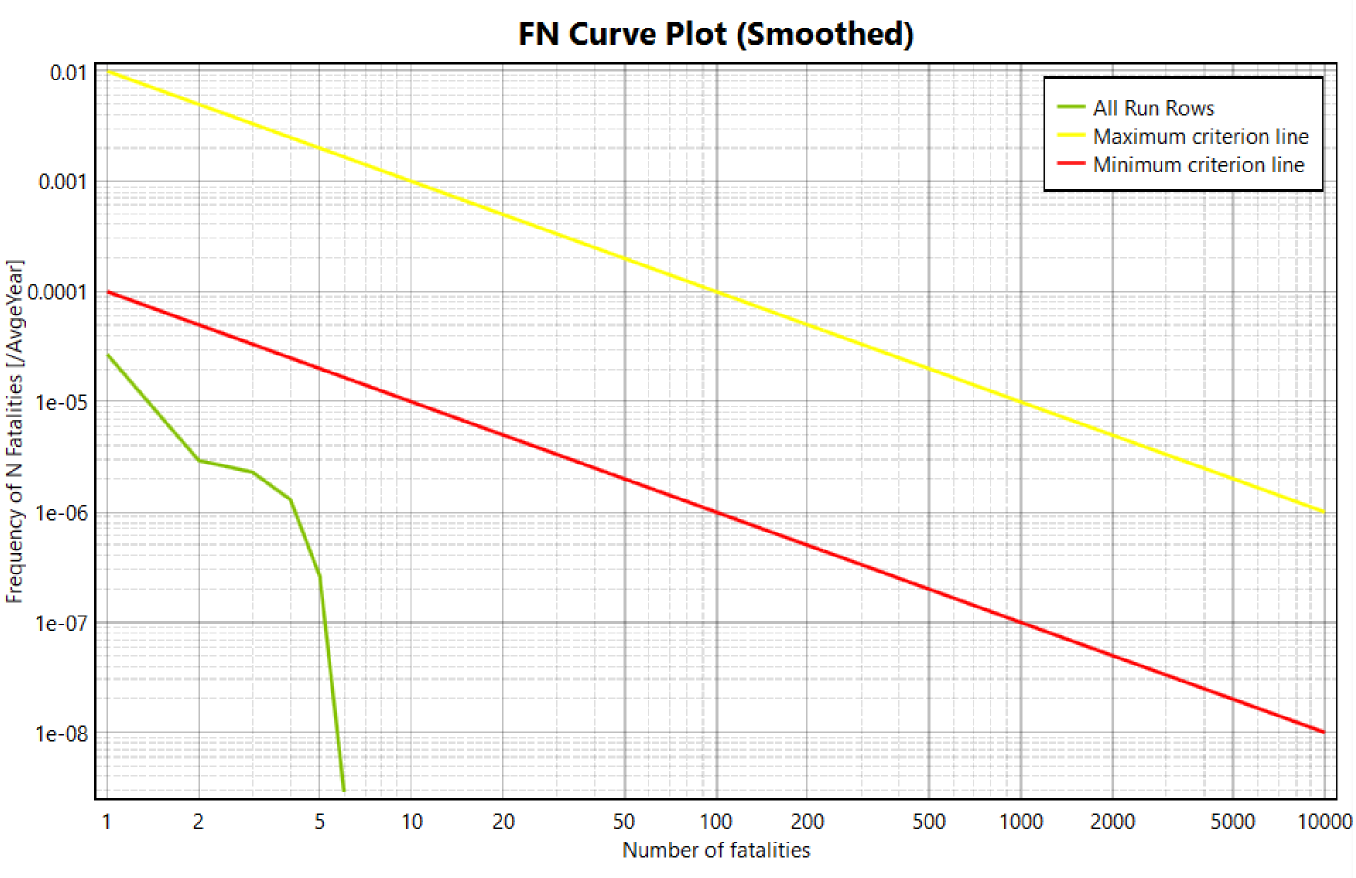
Figure 13-2 Indoor Individual Risk Contours

The Individual Risk calculated at the nearest residential property is very low:

- Outdoor: 7.3 x 10^{-9}/y; and,
- Indoor: 1.8 x 10^{-9}/y.

13.2 Societal Risk

The societal risk F-N curve members of the public in the area around the STEP is displayed in Figure 13-3.



Key: Yellow: intolerable risk above this line; Red: broadly acceptable risk below this line; Green: STEP FN Curve.

Figure 13-3 STEP Offsite Societal Risk F-N Curve

13.3 Expectation Value

The Expectation Value (EV) for the offsite area has been calculated in accordance with the requirements of the HSA TULP Consultation Document [33].

The calculated value for the total offsite area is 13 chances per million (cpm), which is a very low EV.

13.4 Hypothetical House Resident

As detailed in Section 11.2 a hypothetical house resident is present all of the time at their dwelling, spending 90% of their time indoors during the day and 99% of their time indoors at night. A detailed calculation for hypothetical house residents has not been undertaken as it can be seen from Figure 13-1 and Figure 13-2 that both indoor and outdoor risks are much lower than 1×10^{-7}/y and consequently the hypothetical house risk will also be much lower than 1×10^{-7}/y.

13.5 Discussion

The results for the LNG Terminal presented above have been compared with the HSA's risk criteria in Section 12.1.

Comparing individual risk contours shown in Figure 13-1 and Figure 13-2 against the criteria for Land use planning shows:

- There are no incompatible land uses in any of the three LUP zones;
- The highest risk individual risk contour onshore is 1 x 10^{-5}/y around the main site area and AGI;
- The highest risk individual risk contour offshore is 1 x 10^{-4}/y around sections of the LNGC, FSRU and Jetty;
- Individual risk at the nearest residential property is 7.3 x 10^{-9}/y during daytime and 1.8 x 10^{-9}/y during nightime. Comparison against with the criterion value of 1 x 10^{-6}/y shows that the result is well below the criterion value;
- It can be seen from Figure 13-3 that the FN curve for the STEP is well within the ‘Broadly Acceptable” Region.
- The Expectation Value has been calculated as 13 cpm, which is well below the HSA EV Criteria of 100, above which an ALARP demonstration is required.

14. Conclusions

A comprehensive quantitative risk assessment (QRA) of the proposed STEP has been performed. The analysis has been conducted in accordance with the current HSA guidance [3]. The following results have been obtained:

- Individual risk of fatality contours;
- The individual risk at the nearest residential property;
- Societal risk FN curves; and,
- Societal risk Expectation Values (EVs).

The conclusions drawn from the results are as follows:

- Comparing the QRA results against land use planning criteria shows there are no incompatible land uses in any of the three LUP zones;
- Comparison with the individual risk at the nearest residential property with the criterion value of 1×10^{-6}/y shows that the result is well below the criterion value;
- The FN curve representing societal risk to members of the public for the proposed STEP is within the ‘Broadly Acceptable’ region.
- The Expectation Value for members of the public is 13, which is a very low value and indicative of operation in the ‘Broadly Acceptable’ Region.

15. References

[1] Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015. SI No. 209 of 2015.

[2] HSA (2006). Land-use Planning Advice for Kilkenny County Council in relation to Grassland Fertilisers (Kilkenny) Ltd at Palmerstown.

[3] HSA (2010). Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning.

[4] Hazardous Chemicals Data Book, Second Edition1986. G. Weiss

[5] NTIS Publication No. PB-94-195047: Documentation for Immediately Dangerous to Life or Health Concentrations (IDLH): NIOSH Chemical Listing and Documentation of Revised IDLH Values

[6] HSA (2011). Code of Practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations 2001.

[7] Shannon Heat and mass balance, Black & Veatch, Document 198291-REFF-002 Rev. D, January 2021

[8] HSE (2003). Risk Assessment Methodology for Storage of Refrigerated Flammable Liquids. Planning Case Assessment Guide, Chapter 6N

[9] IS328 (2003) Code of Practice for Gas Transmission Pipelines and Installations.

[10] ERM (2008). Natural Gas Pipeline QRA. Report 0083107-R01.

[11] HSE (2012). Failure Rate and Event Data for use within Risk Assessments. Planning Case Assessment Guide, Chapter 6K (version 12).

[12] W S Atkins (2001). Effects of Secondary Containment on Source Term Modelling. HSE CRR 324/2001.

[13] AW Cox, FP Lees and ML Ang (1990) Classification of Hazardous Locations.

[14] VROM (2005). Publication Series on Dangerous Substances (PGS 3). Guideline for quantitative risk assessment 'Purple book' CPR 18E.

[15] Spencer H, Daycock J and Rew P J (1998). A model for the ignition probability of flammable gases. HSE CRR 203/1998.

[16] Daycock J and Rew P J (2004). Development of a model for the determination of on-site ignition probabilities. HSE RR 226.

[17] Arup Consulting Engineers (on behalf of Shannon LNG) (2007). Shannon LNG Terminal Environmental Impact Statement. Revision: Issue for planning.

[18] MARICO Marine (2020). Shannon Foynes Port Company, Shannon LNG Terminal NRA Update. Report 18UK1448 Issue No. 1, 21-07-2020.

[19] Eisenberg N A et al. (1975). Vulnerability Model. A Simulation System for Assessing Damage Resulting from Marine Spills. NTIS report AD-A015-245.

[20] Ashe BSW and Rew PJ (2003). Effect of flash fires on building occupants. HSE Research Report 084.

[21] Pitblado, R M et al, (2004). Consequence of LNG Marine Incidents. CCPS Conference Orlando 2004.

[22] ERM (2007). Land Use Planning QRA Studies of the Proposed Shannon LNG Terminal. Report 0059890-R02 Issue 1.

[23] HSE (1989). Risk criteria for land use planning in the vicinity of major industrial hazards. HMSO Books C30.

[24] RIVM (2009). Reference Manual BEVI Risk Assessments. Version 3.2.

[25] Chemical Industries Association, Guidance for the location and design of occupied buildings on chemical manufacturing sites. 2011.

[26] Hightower M, et al. (2004). Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water. Sandia National Laboratories Report SAND2004-6258.

[27] Luketa A, et al. (2008). Breach and Safety Analysis of Spills Over Water from Large Liquefied Natural Gas Carriers. Sandia National Laboratories Report SAND2008-3153.

[28] Publication Series on Dangerous Substances (PGS 3). Guideline for quantitative risk assessment 'Purple book' CPR 18E, VROM, 2005.

[29] BS EN 13766:2018+A1:2020: Thermoplastic multi-layer (non-vulcanized) hoses and hose assemblies for the transfer of liquid petroleum gas and liquefied natural gas.

[30] BS EN 1474-2:2008: Installation and equipment for liquefied natural gas. Design and testing of marine transfer systems. Design and testing of transfer hoses.

[31] Land -Use Planning QRA of Alterations to Shannon LNG Terminal and addition of a CHP Plant. Scandpower Risk Management. Lloyd's Register. Report No 50102216 R01 Rev 03. 6/3/2013.

[32] An Phiromh Staidrimh; Census - CSO - Central Statistics Office

[33] Guidance on Technical Land-use Planning Advice for Planning Authorities and Operators of Establishments under the COMAH Regulations. Health and Safety Authority – TULP Consultation.

Appendix A Release Frequencies

Piping and equipment release frequencies are presented for each scenario defined in Section 6.

Onshore

Full Case Tag	Outcome Frequency (per y)
SG-001A-A-0126L-IS	1.19E-04
SG-001A-A-0400-IS	5.66E-04
SG-001A-A-0013L-UN	4.00E-06
SG-001A-A-0126-UN	1.20E-06
SG-001A-A-0400-UN	5.72E-06
SG-002A-A-0004L-IS	3.96E-06
SG-002A-A-0013L-IS	4.95E-06
SG-002A-A-0025L-IS	2.48E-06
SG-002A-A-0134L-IS	9.90E-07
SG-002A-A-0400R-IS	3.47E-07
SG-002A-A-0004L-UN	4.00E-08
SG-002A-A-0013L-UN	5.00E-08
SG-002A-A-0025L-UN	2.50E-08
SG-002A-A-0134L-UN	1.00E-08
SG-002A-A-0400R-UN	3.50E-09
SG-001B-A-0013L-IS	3.96E-04
SG-001B-A-0126-IS	1.19E-04
SG-001B-A-0400-IS	5.66E-04
SG-001B-A-0013L-UN	4.00E-06
SG-001B-A-0126-UN	1.20E-06
SG-001B-A-0400-UN	5.72E-06
SG-002B-A-0004L-IS	3.96E-06
SG-002B-A-0013L-IS	4.95E-06
SG-002B-A-0025L-IS	2.48E-06
SG-002B-A-0134L-IS	9.90E-07
SG-002B-A-0400R-IS	3.47E-07
SG-002B-A-0004L-UN	4.00E-08
SG-002B-A-0013L-UN	5.00E-08
SG-002B-A-0025L-UN	2.50E-08
SG-002B-A-0134L-UN	1.00E-08
SG-002B-A-0400R-UN	3.50E-09
SG-003A-A-0004L-IS	4.08E-05
SG-003A-A-0013L-IS	7.33E-05
SG-003A-A-0025L-IS	2.42E-05
SG-003A-A-0134L-IS	3.96E-06
SG-003A-A-0250L-IS	3.56E-06
SG-003A-A-0400L-IS	1.39E-06
SG-003A-A-0750R-IS	1.43E-06
SG-003A-A-0004L-UN	4.12E-07
SG-003A-A-0013L-UN	7.40E-07
SG-003A-A-0025L-UN	2.44E-07
SG-003A-A-0134L-UN	4.00E-08
SG-003A-A-0250L-UN	3.60E-08

Full Case Tag	Outcome Frequency (per y)
SG-003A-A-0400L-UN	1.40E-08
SG-003A-A-0750R-UN	1.44E-08
SG-004A-A-0004L-IS	2.73E-04
SG-004A-A-0013L-IS	5.85E-04
SG-004A-A-0025L-IS	1.56E-04
SG-004A-A-0250L-IS	3.90E-05
SG-004A-A-0750R-IS	1.56E-05
SG-004A-A-0004L-UN	2.76E-06
SG-004A-A-0013L-UN	5.91E-06
SG-004A-A-0025L-UN	1.58E-06
SG-004A-A-0250L-UN	3.94E-07
SG-004A-A-0750R-UN	1.58E-07
SG-005A-A-0004L-IS	1.94E-04
SG-005A-A-0013L-IS	4.16E-04
SG-005A-A-0025L-IS	1.11E-04
SG-005A-A-0250L-IS	2.77E-05
SG-005A-A-0750R-IS	1.11E-05
SG-005A-A-0004L-UN	1.96E-06
SG-005A-A-0013L-UN	4.20E-06
SG-005A-A-0025L-UN	1.12E-06
SG-005A-A-0250L-UN	2.80E-07
SG-005A-A-0750R-UN	1.12E-07
SG-006A-A-0004L-IS	1.73E-04
SG-006A-A-0013L-IS	3.70E-04
SG-006A-A-0025L-IS	9.86E-05
SG-006A-A-0250L-IS	2.47E-05
SG-006A-A-0750R-IS	9.86E-06
SG-006A-A-0004L-UN	1.74E-06
SG-006A-A-0013L-UN	3.74E-06
SG-006A-A-0025L-UN	9.96E-07
SG-006A-A-0250L-UN	2.49E-07
SG-006A-A-0750R-UN	9.96E-08
SG-007A-A-0003L-IS	2.77E-05
SG-007A-A-0013L-IS	2.08E-05
SG-007A-A-0025L-IS	1.39E-05
SG-007A-A-0100R-IS	6.93E-06
SG-007A-A-0003L-UN	2.80E-07
SG-007A-A-0013L-UN	2.10E-07
SG-007A-A-0025L-UN	1.40E-07
SG-007A-A-0100R-UN	7.00E-08
SG-007B-A-0003L-IS	2.38E-05
SG-007B-A-0013L-IS	1.78E-05
SG-007B-A-0025L-IS	1.19E-05

Full Case Tag	Outcome Frequency (per y)
SG-007B-A-0100R-IS	5.94E-06
SG-007B-A-0003L-UN	2.80E-07
SG-007B-A-0013L-UN	1.80E-07
SG-007B-A-0025L-UN	1.20E-07
SG-007B-A-0100R-UN	6.00E-08
SG-008A-A-0003L-IS	2.77E-05
SG-008A-A-0013L-IS	2.08E-05
SG-008A-A-0025L-IS	1.39E-05
SG-008A-A-0100R-IS	6.93E-06
SG-008A-A-0003L-UN	2.80E-07
SG-008A-A-0013L-UN	2.10E-07
SG-008A-A-0025L-UN	1.40E-07
SG-008A-A-0100R-UN	7.00E-08
SG-008B-A-0003L-IS	2.38E-05
SG-008B-A-0013L-IS	1.78E-05
SG-008B-A-0025L-IS	1.19E-05
SG-008B-A-0100R-IS	5.94E-06
SG-008B-A-0003L-UN	2.40E-07
SG-008B-A-0013L-UN	1.80E-07
SG-008B-A-0025L-UN	1.20E-07
SG-008B-A-0100R-UN	6.00E-08
SG-009A-A-0003L-IS	1.19E-05
SG-009A-A-0013L-IS	8.91E-06
SG-009A-A-0025L-IS	5.94E-06
SG-009A-A-0100R-IS	2.97E-06
SG-009A-A-0003L-UN	1.20E-07

Full Case Tag	Outcome Frequency (per y)
SG-009A-A-0013L-UN	9.00E-08
SG-009A-A-0025L-UN	6.00E-08
SG-009A-A-0100R-UN	3.00E-08
SG-009B-A-0003L-IS	1.41E-04
SG-009B-A-0013L-IS	1.05E-04
SG-009B-A-0025L-IS	7.03E-05
SG-009B-A-0100R-IS	3.51E-05
SG-009B-A-0003L-UN	4.60E-07
SG-009B-A-0013L-UN	1.24E-04
SG-009B-A-0025L-UN	3.95E-07
SG-009B-A-0100R-UN	1.49E-05
SG-010A-A-0003L-IS	4.55E-05
SG-010A-A-0010L-IS	1.23E-02
SG-010A-A-0013L-IS	3.91E-05
SG-010A-A-0025L-IS	1.47E-03
SG-010A-A-0050L-IS	7.25E-04
SG-010A-A-0100R-IS	1.14E-05
SG-010A-A-0003L-UN	4.60E-07
SG-010A-A-0010L-UN	1.24E-04
SG-010A-A-0013L-UN	3.95E-07
SG-010A-A-0025L-UN	1.49E-05
SG-010A-A-0050L-UN	7.32E-06
SG-010A-A-0100R-UN	1.15E-07
SG-010B-A-0003L-IS	1.90E-04
SG-010B-A-0013L-IS	1.43E-04

AGI

Full Case Tag	Outcome Frequency (per y)
PG-001A-A-0004L-IS	3.29E-05
PG-001A-A-0025L-IS	1.88E-05
PG-001A-A-0250L-IS	4.70E-06
PG-001A-A-0750R-IS	1.88E-06
PG-001A-A-0004L-UN	3.32E-07
PG-001A-A-0025L-UN	1.90E-07
PG-001A-A-0250L-UN	4.75E-08
PG-001A-A-0750R-UN	1.90E-08
PG-002A-A-0004L-IS	5.41E-05
PG-002A-A-0025L-IS	3.09E-05
PG-002A-A-0250L-IS	7.72E-06
PG-002A-A-0750R-IS	3.09E-06
PG-002A-A-0004L-UN	5.46E-07
PG-002A-A-0025L-UN	3.12E-07
PG-002A-A-0250L-UN	7.80E-08
PG-002A-A-0750R-UN	3.12E-08
PG-003A-A-0004L-IS	6.31E-05
PG-003A-A-0025L-IS	3.94E-05
PG-003A-A-0150L-IS	1.57E-05
PG-003A-A-0450R-IS	5.51E-06
PG-003A-A-0004L-UN	6.37E-07
PG-003A-A-0025L-UN	3.98E-07
PG-003A-A-0150L-UN	1.59E-07
PG-003A-A-0450R-UN	5.57E-08
PG-004A-A-0004L-IS	5.83E-05
PG-004A-A-0025L-IS	3.64E-05
PG-004A-A-0150L-IS	1.46E-05
PG-004A-A-0450R-IS	5.10E-06
PG-004A-A-0004L-UN	5.89E-07
PG-004A-A-0025L-UN	3.68E-07
PG-004A-A-0150L-UN	1.47E-07
PG-004A-A-0450R-UN	5.15E-08
PG-005A-A-0004L-IS	1.00E-04
PG-005A-A-0025L-IS	6.44E-05
PG-005A-A-0067L-IS	2.35E-05
PG-005A-A-0167L-IS	5.86E-06
PG-005A-A-0200L-IS	1.17E-05
PG-005A-A-0500R-IS	2.35E-06
PG-005A-A-0004L-UN	1.01E-06
PG-005A-A-0025L-UN	6.51E-07
PG-005A-A-0067L-UN	2.37E-07
PG-005A-A-0167L-UN	5.92E-08
PG-005A-A-0200L-UN	1.18E-07

Full Case Tag	Outcome Frequency (per y)
PG-005A-A-0500R-UN	2.37E-08
PG-006A-A-0004L-IS	1.01E-04
PG-006A-A-0025L-IS	6.32E-05
PG-006A-A-0150L-IS	2.52E-05
PG-006A-A-0450R-IS	8.84E-06
PG-006A-A-0004L-UN	1.02E-06
PG-006A-A-0025L-UN	6.38E-07
PG-006A-A-0150L-UN	2.55E-07
PG-006A-A-0450R-UN	8.93E-08
PG-007A-A-0004L-IS	4.75E-05
PG-007A-A-0010L-IS	1.40E-02
PG-007A-A-0013L-IS	6.14E-03
PG-007A-A-0025L-IS	2.68E-03
PG-007A-A-0100L-IS	1.19E-05
PG-007A-A-0150L-IS	6.63E-04
PG-007A-A-0300R-IS	4.16E-06
PG-007A-A-0004L-UN	4.80E-07
PG-007A-A-0010L-UN	1.41E-04
PG-007A-A-0013L-UN	6.20E-05
PG-007A-A-0025L-UN	2.71E-05
PG-007A-A-0100L-UN	1.20E-07
PG-007A-A-0150L-UN	6.70E-06
PG-007A-A-0300R-UN	4.20E-08
PG-008A-A-0004L-IS	2.65E-05
PG-008A-A-0025L-IS	1.66E-05
PG-008A-A-0100L-IS	6.64E-06
PG-008A-A-0300R-IS	2.33E-06
PG-008A-A-0004L-UN	2.68E-07
PG-008A-A-0025L-UN	1.68E-07
PG-008A-A-0100L-UN	6.71E-08
PG-008A-A-0300R-UN	2.35E-08
PG-009A-A-0004L-IS	6.02E-05
PG-009A-A-0025L-IS	3.97E-05
PG-009A-A-0050L-IS	1.11E-05
PG-009A-A-0134L-IS	8.16E-06
PG-009A-A-0150L-IS	5.52E-06
PG-009A-A-0400R-IS	2.85E-06
PG-009A-A-0004L-UN	6.08E-07
PG-009A-A-0025L-UN	4.01E-07
PG-009A-A-0050L-UN	1.12E-07
PG-009A-A-0134L-UN	8.24E-08
PG-009A-A-0150L-UN	5.58E-08
PG-009A-A-0400R-UN	2.88E-08

Full Case Tag	Outcome Frequency (per y)
PG-010A-A-0004L-IS	1.85E-04
PG-010A-A-0025L-IS	1.14E-04
PG-010A-A-0050L-IS	3.26E-06
PG-010A-A-0134L-IS	4.89E-06
PG-010A-A-0150L-IS	2.90E-05
PG-010A-A-0250L-IS	6.86E-06
PG-010A-A-0400L-IS	1.71E-06
PG-010A-A-0450L-IS	9.57E-06
PG-010A-A-0750R-IS	2.74E-06
PG-010A-A-0004L-UN	1.87E-06
PG-010A-A-0025L-UN	1.15E-06
PG-010A-A-0050L-UN	3.29E-08
PG-010A-A-0134L-UN	4.94E-08
PG-010A-A-0150L-UN	2.93E-07
PG-010A-A-0250L-UN	6.93E-08
PG-010A-A-0400L-UN	1.73E-08
PG-010A-A-0750R-UN	2.77E-08
PG-011A-A-0004L-IS	3.25E-05
PG-011A-A-0025L-IS	1.86E-05
PG-011A-A-0250L-IS	4.64E-06
PG-011A-A-0750R-IS	1.86E-06
PG-011A-A-0004L-UN	3.28E-07
PG-011A-A-0025L-UN	1.88E-07
PG-011A-A-0250L-UN	4.69E-08
PG-011A-A-0750R-UN	1.88E-08
PG-012A-A-0004L-IS	4.50E-06
PG-012A-A-0025L-IS	2.57E-06

Full Case Tag	Outcome Frequency (per y)
PG-012A-A-0250L-IS	6.44E-07
PG-012A-A-0750R-IS	2.57E-07
PG-012A-A-0004L-UN	4.55E-08
PG-012A-A-0025L-UN	2.60E-08
PG-012A-A-0250L-UN	6.50E-09
PG-012A-A-0750R-UN	2.60E-09
PG-013A-A-0004L-IS	4.45E-05
PG-013A-A-0025L-IS	2.53E-05
PG-013A-A-0250L-IS	6.35E-06
PG-013A-A-0750R-IS	2.53E-06
PG-013A-A-0004L-UN	4.49E-07
PG-013A-A-0025L-UN	2.56E-07
PG-013A-A-0250L-UN	6.41E-08
PG-013A-A-0750R-UN	2.56E-08
PG-014A-A-0003L-IS	8.75E-05
PG-014A-A-0004L-IS	1.29E-05
PG-014A-A-0025L-IS	5.28E-05
PG-014A-A-0050L-IS	2.06E-05
PG-014A-A-0075L-IS	6.44E-06
PG-014A-A-0150R-IS	2.57E-06
PG-014A-A-0003L-UN	8.84E-07
PG-014A-A-0004L-UN	1.30E-07
PG-014A-A-0025L-UN	5.33E-07
PG-014A-A-0050L-UN	2.08E-07
PG-014A-A-0075L-UN	6.50E-08
PG-014A-A-0150R-UN	2.60E-08

FSRU

Full Case Tag	Outcome Frequency (per y)
FL001A-0003L-IS	1.09E-05
FL001A-0004L-IS	1.66E-06
FL001A-0013L-IS	3.70E-06
FL001A-0025L-IS	7.57E-06
FL001A-0134L-IS	4.14E-07
FL001A-0400R-IS	1.45E-07
FL001A-0003L-UN	1.10E-07
FL001A-0004L-UN	1.67E-08
FL001A-0013L-UN	3.74E-08
FL001A-0025L-UN	7.65E-08
FL001A-0134L-UN	4.18E-09
FL001A-0400R-UN	1.46E-09
FL001B-0003L-IS	1.09E-05
FL001B-0004L-IS	1.66E-06
FL001B-0013L-IS	3.70E-06
FL001B-0025L-IS	7.57E-06
FL001B-0134L-IS	4.14E-07
FL001B-0400R-IS	1.45E-07
FL001B-0003L-UN	1.10E-07
FL001B-0004L-UN	1.67E-08
FL001B-0013L-UN	3.74E-08
FL001B-0025L-UN	7.65E-08
FL001B-0134L-UN	4.18E-09
FL001B-0400R-UN	1.46E-09
FL001C-0003L-IS	1.09E-05
FL001C-0004L-IS	1.66E-06
FL001C-0013L-IS	3.70E-06
FL001C-0025L-IS	7.57E-06
FL001C-0134L-IS	4.14E-07
FL001C-0400R-IS	1.45E-07
FL001C-0003L-UN	1.10E-07
FL001C-0004L-UN	1.67E-08
FL001C-0013L-UN	3.74E-08
FL001C-0025L-UN	7.65E-08
FL001C-0134L-UN	4.18E-09
FL001C-0400R-UN	1.46E-09

Full Case Tag	Outcome Frequency (per y)
FL001D-0003L-IS	1.09E-05
FL001D-0004L-IS	1.66E-06
FL001D-0013L-IS	3.70E-06
FL001D-0025L-IS	7.57E-06
FL001D-0134L-IS	4.14E-07
FL001D-0400R-IS	1.45E-07
FL001D-0003L-UN	1.10E-07
FL001D-0004L-UN	1.67E-08
FL001D-0013L-UN	3.74E-08
FL001D-0025L-UN	7.65E-08
FL001D-0134L-UN	4.18E-09
FL001D-0400R-UN	1.46E-09
FL002-0003L-IS	1.96E-04
FL002-0004L-IS	3.02E-04
FL002-0013L-IS	6.78E-04
FL002-0025L-IS	2.78E-04
FL002-0075L-IS	4.63E-05
FL002-0100L-IS	2.72E-06
FL002-0134L-IS	3.27E-05
FL002-0167L-IS	1.03E-05
FL002-0200L-IS	1.42E-05
FL002-0400L-IS	1.14E-05
FL002-0500L-IS	4.14E-06
FL002-0600R-IS	5.66E-06
FL002-0003L-UN	1.98E-06
FL002-0004L-UN	3.05E-06
FL002-0013L-UN	6.85E-06
FL002-0025L-UN	2.81E-06
FL002-0075L-UN	4.68E-07
FL002-0100L-UN	2.75E-08
FL002-0134L-UN	3.30E-07
FL002-0167L-UN	1.05E-07
FL002-0200L-UN	1.43E-07
FL002-0400L-UN	1.16E-07
FL002-0500L-UN	4.18E-08
FL002-0600R-UN	5.72E-08

Full Case Tag	Outcome Frequency (per y)
FL003A-0004L-IS	8.71E-06
FL003A-0013L-IS	1.09E-05
FL003A-0025L-IS	5.45E-06
FL003A-0134L-IS	2.18E-06
FL003A-0400R-IS	7.62E-07
FL003A-0004L-UN	8.80E-08
FL003A-0013L-UN	1.10E-07
FL003A-0025L-UN	5.50E-08
FL003A-0134L-UN	2.20E-08
FL003A-0400R-UN	7.70E-09
FL003B-0004L-IS	8.71E-06
FL003B-0013L-IS	1.09E-05
FL003B-0025L-IS	5.45E-06
FL003B-0134L-IS	2.18E-06
FL003B-0400R-IS	7.62E-07
FL003B-0004L-UN	8.80E-08
FL003B-0013L-UN	1.10E-07
FL003B-0025L-UN	5.50E-08
FL003B-0134L-UN	2.20E-08
FL003B-0400R-UN	7.70E-09
FL003C-0004L-IS	8.71E-06
FL003C-0013L-IS	1.09E-05
FL003C-0025L-IS	5.45E-06
FL003C-0134L-IS	2.18E-06
FL003C-0400R-IS	7.62E-07
FL003C-0004L-UN	8.80E-08
FL003C-0013L-UN	1.10E-07
FL003C-0025L-UN	5.50E-08
FL003C-0134L-UN	2.20E-08
FL003C-0400R-UN	7.70E-09
FL003D-0004L-IS	8.71E-06
FL003D-0013L-IS	1.09E-05
FL003D-0025L-IS	5.45E-06
FL003D-0134L-IS	2.18E-06
FL003D-0400R-IS	7.62E-07
FL003D-0004L-UN	8.80E-08
FL003D-0013L-UN	1.10E-07
FL003D-0025L-UN	5.50E-08

Full Case Tag	Outcome Frequency (per y)
FL003D-0134L-UN	2.20E-08
FL003D-0400R-UN	7.70E-09
FL004A-0300L-NA	6.06E-09
FL004A-1200L-NA	1.26E-06
FL005-0003L-IS	3.27E-05
FL005-0004L-IS	2.72E-05
FL005-0013L-IS	3.21E-05
FL005-0025L-IS	3.54E-05
FL005-0038L-IS	3.27E-06
FL005-0050L-IS	1.09E-05
FL005-0150R-IS	5.45E-06
FL005-0003L-UN	3.30E-07
FL005-0004L-UN	2.75E-07
FL005-0013L-UN	3.25E-07
FL005-0025L-UN	3.58E-07
FL005-0038L-UN	3.30E-08
FL005-0050L-UN	1.10E-07
FL005-0150R-UN	5.50E-08
FL006-0006L-NA	4.00E-05
FL006-0013L-NA	1.00E-05
FL006-0025L-NA	5.00E-06
FL006-0050L-NA	5.00E-06
FL006-VCATC-NA	2.00E-06
FL007A-0003L-IS	3.27E-05
FL007A-0013L-IS	2.45E-05
FL007A-0025L-IS	1.63E-05
FL007A-0075R-IS	8.17E-06
FL007A-0003L-UN	3.30E-07
FL007A-0013L-UN	2.48E-07
FL007A-0025L-UN	1.65E-07
FL007A-0075R-UN	8.25E-08
FL007B-0003L-IS	3.27E-05
FL007B-0013L-IS	2.45E-05
FL007B-0025L-IS	1.63E-05
FL007B-0075R-IS	8.17E-06
FL007B-0003L-UN	3.30E-07
FL007B-0013L-UN	2.48E-07
FL007B-0025L-UN	1.65E-07

Full Case Tag	Outcome Frequency (per y)
FL007B-0075R-UN	8.25E-08
FL008A-0003L-IS	5.94E-06
FL008A-0013L-IS	4.46E-06
FL008A-0025L-IS	2.97E-06
FL008A-0075R-IS	1.49E-06
FL008A-0003L-UN	6.00E-08
FL008A-0013L-UN	4.50E-08
FL008A-0025L-UN	3.00E-08
FL008A-0075R-UN	1.50E-08
FL008B-0003L-IS	5.94E-06
FL008B-0013L-IS	4.46E-06
FL008B-0025L-IS	2.97E-06
FL008B-0075R-IS	1.49E-06
FL008B-0003L-UN	6.00E-08
FL008B-0013L-UN	4.50E-08
FL008B-0025L-UN	3.00E-08
FL008B-0075R-UN	1.50E-08
FL008C-0003L-IS	5.94E-06
FL008C-0013L-IS	4.46E-06
FL008C-0025L-IS	2.97E-06
FL008C-0075R-IS	1.49E-06
FL008C-0003L-UN	6.00E-08
FL008C-0013L-UN	4.50E-08
FL008C-0025L-UN	3.00E-08
FL008C-0075R-UN	1.50E-08
FL009A-0003L-IS	1.19E-05
FL009A-0013L-IS	5.84E-05
FL009A-0025L-IS	5.94E-06
FL009A-0075R-IS	2.97E-06
FL009A-0003L-UN	1.20E-07
FL009A-0013L-UN	5.90E-07
FL009A-0025L-UN	6.00E-08
FL009A-0075R-UN	3.00E-08
FL009B-0003L-IS	1.19E-05
FL009B-0013L-IS	5.84E-05
FL009B-0025L-IS	5.94E-06
FL009B-0075R-IS	2.97E-06
FL009B-0003L-UN	1.20E-07

Full Case Tag	Outcome Frequency (per y)
FL009B-0013L-UN	5.90E-07
FL009B-0025L-UN	6.00E-08
FL009B-0075R-UN	3.00E-08
FL009C-0003L-IS	1.19E-05
FL009C-0013L-IS	5.84E-05
FL009C-0025L-IS	5.94E-06
FL009C-0075R-IS	2.97E-06
FL009C-0003L-UN	1.20E-07
FL009C-0013L-UN	5.90E-07
FL009C-0025L-UN	6.00E-08
FL009C-0075R-UN	3.00E-08
FL010-0003L-IS	1.07E-04
FL010-0013L-IS	8.02E-05
FL010-0025L-IS	5.35E-05
FL010-0075L-IS	1.93E-05
FL010-0100R-IS	7.43E-06
FL010-0003L-UN	1.08E-06
FL010-0013L-UN	8.10E-07
FL010-0025L-UN	5.40E-07
FL010-0075L-UN	1.95E-07
FL010-0100R-UN	7.50E-08
FL011-0003L-IS	1.49E-04
FL011-0013L-IS	1.11E-04
FL011-0025L-IS	7.43E-05
FL011-0075R-IS	3.71E-05
FL011-0003L-UN	1.50E-06
FL011-0013L-UN	1.13E-06
FL011-0025L-UN	7.50E-07
FL011-0075R-UN	3.75E-07
FL012A-1-0003L-IS	7.43E-05
FL012A-1-0013L-IS	5.57E-05
FL012A-1-0025L-IS	3.71E-05
FL012A-1-0050L-IS	7.43E-06
FL012A-1-0075R-IS	1.11E-05
FL012A-1-0003L-UN	7.50E-07
FL012A-1-0013L-UN	5.63E-07
FL012A-1-0025L-UN	3.75E-07
FL012A-1-0050L-UN	7.50E-08

Full Case Tag	Outcome Frequency (per y)
FL012A-1-0075R-UN	1.13E-07
FL012A-2-0003L-IS	7.43E-05
FL012A-2-0013L-IS	5.57E-05
FL012A-2-0025L-IS	3.71E-05
FL012A-2-0050L-IS	7.43E-06
FL012A-2-0075R-IS	1.11E-05
FL012A-2-0003L-UN	7.50E-07
FL012A-2-0013L-UN	5.63E-07
FL012A-2-0025L-UN	3.75E-07
FL012A-2-0050L-UN	7.50E-08
FL012A-2-0075R-UN	1.13E-07
FL013A-1-0003L-IS	1.49E-05
FL013A-1-0013L-IS	1.11E-05
FL013A-1-0025L-IS	4.91E-04
FL013A-1-0050R-IS	2.45E-04
FL013A-1-0003L-UN	1.50E-07
FL013A-1-0013L-UN	1.13E-07
FL013A-1-0025L-UN	4.96E-06
FL013A-1-0050R-UN	2.48E-06
FL013B-1-0003L-IS	1.49E-05
FL013B-1-0013L-IS	1.11E-05
FL013B-1-0025L-IS	4.91E-04
FL013B-1-0050R-IS	2.45E-04
FL013B-1-0003L-UN	1.50E-07
FL013B-1-0013L-UN	1.13E-07
FL013B-1-0025L-UN	4.96E-06
FL013B-1-0050R-UN	2.48E-06
FL013A-2-0003L-IS	1.49E-05
FL013A-2-0013L-IS	1.11E-05
FL013A-2-0025L-IS	4.91E-04
FL013A-2-0050R-IS	2.45E-04
FL013A-2-0003L-UN	1.50E-07
FL013A-2-0013L-UN	1.13E-07
FL013A-2-0025L-UN	4.96E-06
FL013A-2-0050R-UN	2.48E-06
FL013B-2-0003L-IS	1.49E-05
FL013B-2-0013L-IS	1.11E-05
FL013B-2-0025L-IS	4.91E-04

Full Case Tag	Outcome Frequency (per y)
FL013B-2-0050R-IS	2.45E-04
FL013B-2-0003L-UN	1.50E-07
FL013B-2-0013L-UN	1.13E-07
FL013B-2-0025L-UN	4.96E-06
FL013B-2-0050R-UN	2.48E-06
FG013A-1-0004L-IS	1.11E-05
FG013A-1-0010L-IS	4.11E-03
FG013A-1-0013L-IS	1.11E-05
FG013A-1-0025L-IS	4.91E-04
FG013A-1-0050L-IS	2.42E-04
FG013A-1-0067L-IS	4.46E-06
FG013A-1-0200R-IS	2.23E-06
FG013A-1-0004L-UN	1.13E-07
FG013A-1-0010L-UN	4.15E-05
FG013A-1-0013L-UN	1.13E-07
FG013A-1-0025L-UN	4.96E-06
FG013A-1-0050L-UN	2.44E-06
FG013A-1-0067L-UN	4.50E-08
FG013A-1-0200R-UN	2.25E-08
FG013A-2-0004L-IS	1.11E-05
FG013A-2-0010L-IS	4.11E-03
FG013A-2-0013L-IS	1.11E-05
FG013A-2-0025L-IS	4.91E-04
FG013A-2-0050L-IS	2.42E-04
FG013A-2-0067L-IS	4.46E-06
FG013A-2-0200R-IS	2.23E-06
FG013A-2-0004L-UN	1.13E-07
FG013A-2-0010L-UN	4.15E-05
FG013A-2-0013L-UN	1.13E-07
FG013A-2-0025L-UN	4.96E-06
FG013A-2-0050L-UN	2.44E-06
FG013A-2-0067L-UN	4.50E-08
FG013A-2-0200R-UN	2.25E-08
FG013B-1-0004L-IS	1.11E-05
FG013B-1-0010L-IS	4.11E-03
FG013B-1-0013L-IS	1.11E-05
FG013B-1-0025L-IS	4.91E-04
FG013B-1-0050L-IS	2.42E-04

Full Case Tag	Outcome Frequency (per y)
FG013B-1-0067L-IS	4.46E-06
FG013B-1-0200R-IS	2.23E-06
FG013B-1-0004L-UN	1.13E-07
FG013B-1-0010L-UN	4.15E-05
FG013B-1-0013L-UN	1.13E-07
FG013B-1-0025L-UN	4.96E-06
FG013B-1-0050L-UN	2.44E-06
FG013B-1-0067L-UN	4.50E-08
FG013B-1-0200R-UN	2.25E-08
FG013B-2-0004L-IS	1.11E-05
FG013B-2-0010L-IS	4.11E-03
FG013B-2-0013L-IS	1.11E-05
FG013B-2-0025L-IS	4.91E-04
FG013B-2-0050L-IS	2.42E-04
FG013B-2-0067L-IS	4.46E-06
FG013B-2-0200R-IS	2.23E-06
FG013B-2-0004L-UN	1.13E-07
FG013B-2-0010L-UN	4.15E-05
FG013B-2-0013L-UN	1.13E-07
FG013B-2-0025L-UN	4.96E-06
FG013B-2-0050L-UN	2.44E-06
FG013B-2-0067L-UN	4.50E-08
FG013B-2-0200R-UN	2.25E-08
FG014-1-0004L-IS	1.86E-05
FG014-1-0013L-IS	1.86E-05
FG014-1-0025L-IS	1.30E-05
FG014-1-0067L-IS	4.46E-06
FG014-1-0084L-IS	2.97E-06
FG014-1-0200L-IS	2.23E-06
FG014-1-0250R-IS	1.49E-06
FG014-1-0004L-UN	1.88E-07
FG014-1-0013L-UN	1.88E-07
FG014-1-0025L-UN	1.31E-07
FG014-1-0067L-UN	4.50E-08
FG014-1-0084L-UN	3.00E-08
FG014-1-0200L-UN	2.25E-08
FG014-1-0250R-UN	1.50E-08
FG014-2-0004L-IS	1.86E-05

Full Case Tag	Outcome Frequency (per y)
FG014-2-0013L-IS	1.86E-05
FG014-2-0025L-IS	1.30E-05
FG014-2-0067L-IS	4.46E-06
FG014-2-0084L-IS	2.97E-06
FG014-2-0200L-IS	2.23E-06
FG014-2-0250R-IS	1.49E-06
FG014-2-0004L-UN	1.88E-07
FG014-2-0013L-UN	1.88E-07
FG014-2-0025L-UN	1.31E-07
FG014-2-0067L-UN	4.50E-08
FG014-2-0084L-UN	3.00E-08
FG014-2-0200L-UN	2.25E-08
FG014-2-0250R-UN	1.50E-08
FG015-1-0006L-NA	4.00E-05
FG015-1-0013L-NA	1.00E-05
FG015-1-0025L-NA	5.00E-06
FG015-1-0050L-NA	5.00E-06
FG015-1-VCATC-NA	2.00E-06
FG015-2-0006L-NA	4.00E-05
FG015-2-0013L-NA	1.00E-05
FG015-2-0025L-NA	5.00E-06
FG015-2-0050L-NA	5.00E-06
FG015-2-VCATC-NA	2.00E-06
FG016-0003L-IS	1.93E-04
FG016-0004L-IS	1.10E-04
FG016-0013L-IS	2.59E-04
FG016-0025L-IS	1.72E-04
FG016-0050L-IS	5.42E-05
FG016-0067L-IS	2.14E-05
FG016-0084L-IS	9.50E-06
FG016-0134L-IS	4.46E-06
FG016-0150L-IS	2.97E-06
FG016-0200L-IS	1.07E-05
FG016-0250L-IS	4.75E-06
FG016-0400R-IS	1.56E-06
FG016-0003L-UN	1.95E-06
FG016-0004L-UN	1.11E-06
FG016-0013L-UN	2.62E-06

Full Case Tag	Outcome Frequency (per y)
FG016-0025L-UN	1.74E-06
FG016-0050L-UN	5.48E-07
FG016-0067L-UN	2.16E-07
FG016-0084L-UN	9.60E-08
FG016-0134L-UN	4.50E-08
FG016-0150L-UN	3.00E-08
FG016-0200L-UN	1.08E-07
FG016-0250L-UN	4.80E-08
FG016-0400R-UN	1.58E-08
FG018-0004L-IS	4.46E-05
FG018-0013L-IS	4.46E-05
FG018-0025L-IS	3.12E-05
FG018-0050L-IS	1.78E-05
FG018-0150R-IS	8.91E-06
FG018-0004L-UN	4.50E-07
FG018-0013L-UN	4.50E-07
FG018-0025L-UN	3.15E-07
FG018-0050L-UN	1.80E-07
FG018-0150R-UN	9.00E-08
FG020-0004L-IS	4.21E-04
FG020-0006L-IS	3.96E-05
FG020-0013L-IS	6.74E-04
FG020-0025L-IS	2.66E-04
FG020-0050L-IS	4.95E-06
FG020-0067L-IS	8.91E-06
FG020-0084L-IS	2.97E-05
FG020-0117L-IS	2.38E-05
FG020-0134L-IS	5.94E-06
FG020-0150L-IS	5.94E-06
FG020-0167L-IS	2.23E-05
FG020-0200L-IS	8.17E-06
FG020-0250L-IS	1.49E-05
FG020-0350L-IS	8.32E-06
FG020-0400L-IS	2.08E-06
FG020-0450L-IS	2.08E-06
FG020-0500L-IS	8.91E-06
FG020-0600L-IS	1.49E-06

Full Case Tag	Outcome Frequency (per y)
FG020-VCATC-IS	1.98E-06
FG020-0004L-UN	4.25E-06
FG020-0006L-UN	4.00E-07
FG020-0013L-UN	6.81E-06
FG020-0025L-UN	2.68E-06
FG020-0050L-UN	5.00E-08
FG020-0067L-UN	9.00E-08
FG020-0084L-UN	3.00E-07
FG020-0117L-UN	2.40E-07
FG020-0134L-UN	6.00E-08
FG020-0150L-UN	6.00E-08
FG020-0167L-UN	2.25E-07
FG020-0200L-UN	8.25E-08
FG020-0250L-UN	1.50E-07
FG020-0350L-UN	8.40E-08
FG020-0400L-UN	2.10E-08
FG020-0450L-UN	2.10E-08
FG020-0500L-UN	9.00E-08
FG020-0600L-UN	1.50E-08
FG020-VCATC-UN	2.00E-08
FG028-0003L-IS	7.43E-05
FG028-0004L-IS	4.75E-05
FG028-0013L-IS	6.31E-05
FG028-0025L-IS	7.65E-05
FG028-0084L-IS	1.19E-05
FG028-0134L-IS	4.46E-06
FG028-0250L-IS	5.94E-06
FG028-0400R-IS	1.56E-06
FG028-0003L-UN	7.50E-07
FG028-0004L-UN	4.80E-07
FG028-0013L-UN	6.38E-07
FG028-0025L-UN	7.73E-07
FG028-0084L-UN	1.20E-07
FG028-0134L-UN	4.50E-08
FG028-0250L-UN	6.00E-08
FG028-0400R-UN	1.58E-08

LNGC

Full Case Tag	Outcome Frequency (per y)
LL001-0300L-NA	5.05E-11
LL001-1200L-NA	1.01E-08
LL002-1-0003L-IS	2.18E-04
LL002-1-0004L-IS	8.71E-06
LL002-1-0013L-IS	9.58E-05
LL002-1-0025L-IS	1.27E-04
LL002-1-0050L-IS	2.18E-05
LL002-1-0134L-IS	2.18E-06
LL002-1-0400R-IS	7.62E-07
LL002-1-0003L-UN	2.20E-06
LL002-1-0004L-UN	8.80E-08
LL002-1-0013L-UN	9.68E-07
LL002-1-0025L-UN	1.29E-06
LL002-1-0050L-UN	2.20E-07
LL002-1-0134L-UN	2.20E-08
LL002-1-0400R-UN	7.70E-09
LL002-2-0003L-IS	2.18E-04
LL002-2-0004L-IS	8.71E-06
LL002-2-0013L-IS	9.58E-05
LL002-2-0025L-IS	1.27E-04
LL002-2-0050L-IS	2.18E-05
LL002-2-0134L-IS	2.18E-06
LL002-2-0400R-IS	7.62E-07
LL002-2-0003L-UN	2.20E-06
LL002-2-0004L-UN	8.80E-08
LL002-2-0013L-UN	9.68E-07
LL002-2-0025L-UN	1.29E-06
LL002-2-0050L-UN	2.20E-07
LL002-2-0134L-UN	2.20E-08
LL002-2-0400R-UN	7.70E-09
LL002-3-0003L-IS	2.18E-04
LL002-3-0004L-IS	8.71E-06
LL002-3-0013L-IS	9.58E-05
LL002-3-0025L-IS	1.27E-04
LL002-3-0050L-IS	2.18E-05
LL002-3-0134L-IS	2.18E-06
LL002-3-0400R-IS	7.62E-07
LL002-3-0003L-UN	2.20E-06
LL002-3-0004L-UN	8.80E-08
LL002-3-0013L-UN	9.68E-07
LL002-3-0025L-UN	1.29E-06
LL002-3-0050L-UN	2.20E-07
LL002-3-0134L-UN	2.20E-08

Full Case Tag	Outcome Frequency (per y)
LL002-3-0400R-UN	7.70E-09
LL002-4-0003L-IS	2.18E-04
LL002-4-0004L-IS	8.71E-06
LL002-4-0013L-IS	9.58E-05
LL002-4-0025L-IS	1.27E-04
LL002-4-0050L-IS	2.18E-05
LL002-4-0134L-IS	2.18E-06
LL002-4-0400R-IS	7.62E-07
LL002-4-0003L-UN	2.20E-06
LL002-4-0004L-UN	8.80E-08
LL002-4-0013L-UN	9.68E-07
LL002-4-0025L-UN	1.29E-06
LL002-4-0050L-UN	2.20E-07
LL002-4-0134L-UN	2.20E-08
LL002-4-0400R-UN	7.70E-09
LL003-0003L-IS	1.71E-03
LL003-0004L-IS	3.77E-04
LL003-0013L-IS	1.62E-03
LL003-0025L-IS	1.08E-03
LL003-0038L-IS	5.45E-05
LL003-0050L-IS	4.63E-06
LL003-0067L-IS	8.71E-06
LL003-0075L-IS	2.09E-04
LL003-0100L-IS	8.19E-05
LL003-0150L-IS	2.86E-05
LL003-0167L-IS	1.09E-05
LL003-0200L-IS	2.54E-05
LL003-0300L-IS	1.52E-06
LL003-0450L-IS	1.00E-05
LL003-0500L-IS	4.36E-06
LL003-0600R-IS	8.41E-06
LL003-0003L-UN	1.72E-05
LL003-0004L-UN	3.81E-06
LL003-0013L-UN	1.64E-05
LL003-0025L-UN	1.09E-05
LL003-0038L-UN	5.50E-07
LL003-0050L-UN	4.68E-08
LL003-0067L-UN	8.80E-08
LL003-0075L-UN	2.11E-06
LL003-0100L-UN	8.28E-07
LL003-0150L-UN	2.89E-07
LL003-0167L-UN	1.10E-07
LL003-0200L-UN	2.56E-07

Full Case Tag	Outcome Frequency (per y)
LL003-0300L-UN	1.54E-08
LL003-0450L-UN	1.01E-07
LL003-0500L-UN	4.40E-08
LL003-0600R-UN	8.49E-08
LL004A-0003L-IS	4.79E-05
LL004A-0004L-IS	4.36E-06
LL004A-0013L-IS	1.52E-05
LL004A-0025L-IS	3.10E-05
LL004A-0050L-IS	1.09E-06
LL004A-0134L-IS	1.09E-06
LL004A-0400R-IS	3.81E-07
LL004A-0003L-UN	4.84E-07
LL004A-0004L-UN	4.40E-08
LL004A-0013L-UN	1.54E-07
LL004A-0025L-UN	3.14E-07
LL004A-0050L-UN	1.10E-08
LL004A-0134L-UN	1.10E-08
LL004A-0400R-UN	3.85E-09
LL004B-0003L-IS	4.79E-05
LL004B-0004L-IS	4.36E-06
LL004B-0013L-IS	1.52E-05
LL004B-0025L-IS	3.10E-05
LL004B-0050L-IS	1.09E-06
LL004B-0134L-IS	1.09E-06
LL004B-0400R-IS	3.81E-07
LL004B-0003L-UN	4.84E-07
LL004B-0004L-UN	4.40E-08
LL004B-0013L-UN	1.54E-07
LL004B-0025L-UN	3.14E-07
LL004B-0050L-UN	1.10E-08
LL004B-0134L-UN	1.10E-08
LL004B-0400R-UN	3.85E-09
LL004C-0003L-IS	4.79E-05
LL004C-0004L-IS	4.36E-06
LL004C-0013L-IS	1.52E-05
LL004C-0025L-IS	3.10E-05
LL004C-0050L-IS	1.09E-06
LL004C-0134L-IS	1.09E-06
LL004C-0400R-IS	3.81E-07
LL004C-0003L-UN	4.84E-07
LL004C-0004L-UN	4.40E-08
LL004C-0013L-UN	1.54E-07
LL004C-0025L-UN	3.14E-07
LL004C-0050L-UN	1.10E-08
LL004C-0134L-UN	1.10E-08

Full Case Tag	Outcome Frequency (per y)
LL004C-0400R-UN	3.85E-09
LL004D-0003L-IS	4.79E-05
LL004D-0004L-IS	4.36E-06
LL004D-0013L-IS	1.52E-05
LL004D-0025L-IS	3.10E-05
LL004D-0050L-IS	1.09E-06
LL004D-0134L-IS	1.09E-06
LL004D-0400R-IS	3.81E-07
LL004D-0003L-UN	4.84E-07
LL004D-0004L-UN	4.40E-08
LL004D-0013L-UN	1.54E-07
LL004D-0025L-UN	3.14E-07
LL004D-0050L-UN	1.10E-08
LL004D-0134L-UN	1.10E-08
LL004D-0400R-UN	3.85E-09
LL005A-0079L-IS	6.24E-04
LL005A-0250L-IS	8.06E-03
LL005A-0079L-UN	6.30E-06
LL005A-0250L-UN	8.14E-05
LL005B-0079L-IS	6.24E-04
LL005B-0250L-IS	8.06E-03
LL005B-0079L-UN	6.30E-06
LL005B-0250L-UN	8.14E-05
LL005C-0079L-IS	6.24E-04
LL005C-0250L-IS	8.06E-03
LL005C-0079L-UN	6.30E-06
LL005C-0250L-UN	8.14E-05
LL005D-0079L-IS	6.24E-04
LL005D-0250L-IS	8.06E-03
LL005D-0079L-UN	6.30E-06
LL005D-0250L-UN	8.14E-05
LG001A-0003L-IS	4.36E-05
LG001A-0004L-IS	3.48E-06
LG001A-0013L-IS	1.09E-05
LG001A-0025L-IS	2.83E-05
LG001A-0134L-IS	8.71E-07
LG001A-0400R-IS	3.05E-07
LG001A-0003L-UN	4.40E-07
LG001A-0004L-UN	3.52E-08
LG001A-0013L-UN	1.10E-07
LG001A-0025L-UN	2.86E-07
LG001A-0134L-UN	8.80E-09
LG001A-0400R-UN	3.08E-09
LG001B-0079L-IS	1.03E-02
LG001B-0250L-IS	1.03E-02

Full Case Tag	Outcome Frequency (per y)
LG001B-0079L-UN	1.04E-04
LG001B-0250L-UN	1.04E-04
LG002-0003L-IS	2.40E-04
LG002-0004L-IS	6.57E-04
LG002-0013L-IS	1.00E-03
LG002-0025L-IS	5.60E-04
LG002-0050L-IS	3.11E-05
LG002-0084L-IS	3.05E-05
LG002-0100L-IS	3.70E-05
LG002-0134L-IS	4.46E-05
LG002-0150L-IS	1.31E-05
LG002-0200L-IS	2.07E-05
LG002-0250L-IS	2.16E-05
LG002-0300L-IS	1.30E-05
LG002-0400L-IS	1.56E-05
LG002-0600L-IS	8.28E-06

Full Case Tag	Outcome Frequency (per y)
LG002-0750R-IS	2.53E-06
LG002-0003L-UN	2.42E-06
LG002-0004L-UN	6.64E-06
LG002-0013L-UN	1.01E-05
LG002-0025L-UN	5.66E-06
LG002-0050L-UN	3.14E-07
LG002-0084L-UN	3.08E-07
LG002-0100L-UN	3.74E-07
LG002-0134L-UN	4.51E-07
LG002-0150L-UN	1.32E-07
LG002-0200L-UN	2.09E-07
LG002-0250L-UN	2.18E-07
LG002-0300L-UN	1.31E-07
LG002-0400L-UN	1.58E-07
LG002-0600L-UN	8.36E-08
LG002-0750R-UN	2.55E-08

Appendix B Consequence Results

Onshore

Onshore - Release Flowrates

Scenario	Weather	Peak Flowrate [kg/s]
SG-001A-126L-IS	D5	196.2
	F2	196.2
SG-002A-4-IS	D5	0.198
	F2	0.198
SG-002A-13-IS	D5	2.088
	F2	2.088
SG-002A-25-IS	D5	7.723
	F2	7.723
SG-002B-4-IS	D5	0.198
	F2	0.198
SG-002B-13-IS	D5	2.088
	F2	2.088
SG-002B-25-IS	D5	7.723
	F2	7.723
SG-003A-4-IS	D5	0.198
	F2	0.198
SG-003A-13-IS	D5	2.088
	F2	2.088
SG-003A-25-IS	D5	7.723
	F2	7.723
SG-004A-4-IS	D5	0.198
	F2	0.198
SG-004A-13-IS	D5	2.088
	F2	2.088
SG-004A-25-IS	D5	7.723
	F2	7.723
SG-005A-4-IS	D5	0.198
	F2	0.198
SG-005A-13-IS	D5	2.088
	F2	2.088
SG-005A-25-IS	D5	7.723
	F2	7.723
SG-006A-4-IS	D5	0.198
	F2	0.198
SG-006A-13-IS	D5	2.088
	F2	2.088
SG-006A-25-IS	D5	7.723
	F2	7.723
SG-007A-4-IS	D5	0.198
	F2	0.198
SG-007A-13-IS	D5	2.088

Scenario	Weather	Peak Flowrate [kg/s]
	F2	2.088
SG-007A-25-IS	D5	7.723
	F2	7.723
SG-007A-100-IS	D5	123.6
	F2	123.6
SG-007B-4-IS	D5	0.198
	F2	0.198
SG-007B-13-IS	D5	2.088
	F2	2.088
SG-007B-25-IS	D5	7.723
	F2	7.723
SG-007B-100-IS	D5	123.6
	F2	123.6
SG-008A-4-IS	D5	0.198
	F2	0.198
SG-008A-13-IS	D5	2.088
	F2	2.088
SG-008A-25-IS	D5	7.723
	F2	7.723
SG-008A-100-IS	D5	123.6
	F2	123.6
SG-008B-4-IS	D5	0.198
	F2	0.198
SG-008B-13-IS	D5	2.088
	F2	2.088
SG-008B-25-IS	D5	7.723
	F2	7.723
SG-008B-100-IS	D5	123.6
	F2	123.6
SG-009A-3-IS	D5	0.03
	F2	0.03
SG-009A-13-IS	D5	0.56
	F2	0.56
SG-009A-25-IS	D5	2.071
	F2	2.071
SG-009A-100-IS	D5	33.13
	F2	33.13
SG-009B-3-IS	D5	0.03
	F2	0.03
SG-009B-13-IS	D5	0.56
	F2	0.56
SG-009B-25-IS	D5	2.071
	F2	2.071
SG-009B-100-IS	D5	33.13
	F2	33.13
SG-009B-3-IS	D5	0.024

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.024
SG-010A-10-IS	D5	0.271
	F2	0.271
SG-010A-13-IS	D5	0.457
	F2	0.457
SG-010A-25-IS	D5	1.691
	F2	1.691
SG-010A-50-IS	D5	6.765
	F2	6.765
SG-010A-100-IS	D5	27.06
	F2	27.06
SG-010B-3-IS	D5	0.024
	F2	0.024
SG-010B-13-IS	D5	0.457
	F2	0.457
SG-010B-25-IS	D5	1.691
	F2	1.691
SG-010B-100-IS	D5	27.06
	F2	27.06
SG-010C-3-IS	D5	0.024
	F2	0.024
SG-010C-13-IS	D5	0.457
	F2	0.457
SG-010C-25-IS	D5	1.691
	F2	1.691
SG-010C-100-IS	D5	27.06
	F2	27.06
SG-010D-3-IS	D5	0.024
	F2	0.024
SG-010D-13-IS	D5	0.457
	F2	0.457
SG-010D-25-IS	D5	1.691
	F2	1.691
SG-010D-100-IS	D5	27.06
	F2	27.06
SG-011A-3-IS	D5	0.024
	F2	0.024
SG-011A-13-IS	D5	0.457
	F2	0.457
SG-011A-25-IS	D5	1.691
	F2	1.691
SG-011A-50-IS	D5	6.765
	F2	6.765
SG-011B-3-IS	D5	0.024
	F2	0.024
SG-011B-13-IS	D5	0.457

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.457
SG-011B-25-IS	D5	1.691
	F2	1.691
SG-011B-50-IS	D5	6.765
	F2	6.765
SG-011C-3-IS	D5	0.024
	F2	0.024
SG-011C-13-IS	D5	0.457
	F2	0.457
SG-011C-25-IS	D5	1.691
	F2	1.691
SG-011C-100-IS	D5	27.06
	F2	27.06
CG-001-4-IS	D5	0.198
	F2	0.198
CG-001-13-IS	D5	2.088
	F2	2.088
CG-001-25-IS	D5	7.723
	F2	7.723
CG-001-67-IS	D5	55.47
	F2	55.47
CG-002A-3-IS	D5	0.111
	F2	0.111
CG-002A-13-IS	D5	2.088
	F2	2.088
CG-002A-25-IS	D5	7.723
	F2	7.723
CG-002A-100-IS	D5	123.6
	F2	123.6
CG-002B-3-IS	D5	0.111
	F2	0.111
CG-002B-13-IS	D5	2.088
	F2	2.088
CG-002B-25-IS	D5	7.723
	F2	7.723
CG-002B-100-IS	D5	123.6
	F2	123.6
CG-002C-3-IS	D5	0.111
	F2	0.111
CG-002C-13-IS	D5	2.088
	F2	2.088
CG-002C-25-IS	D5	7.723
	F2	7.723
CG-002C-100-IS	D5	123.6
	F2	123.6
SG-001A-126L-IS	D5	196.2

Scenario	Weather	Peak Flowrate [kg/s]
	F2	196.2
SG-002A-4-US	D5	0.198
	F2	0.198
SG-002A-13-US	D5	2.088
	F2	2.088
SG-002A-25-US	D5	7.723
	F2	7.723
SG-002B-4-US	D5	0.198
	F2	0.198
SG-002B-13-US	D5	2.088
	F2	2.088
SG-002B-25-US	D5	7.723
	F2	7.723
SG-003A-4-US	D5	0.198
	F2	0.198
SG-003A-13-US	D5	2.088
	F2	2.088
SG-003A-25-US	D5	7.723
	F2	7.723
SG-004A-4-US	D5	0.198
	F2	0.198
SG-004A-13-US	D5	2.088
	F2	2.088
SG-004A-25-US	D5	7.723
	F2	7.723
SG-005A-4-US	D5	0.198
	F2	0.198
SG-005A-13-US	D5	2.088
	F2	2.088
SG-005A-25-US	D5	7.723
	F2	7.723
SG-006A-4-US	D5	0.198
	F2	0.198
SG-006A-13-US	D5	2.088
	F2	2.088
SG-006A-25-US	D5	7.723
	F2	7.723
SG-007A-4-US	D5	0.198
	F2	0.198
SG-007A-13-US	D5	2.088
	F2	2.088
SG-007A-25-US	D5	7.723
	F2	7.723
SG-007A-100-US	D5	123.6
	F2	123.6
SG-007B-4-US	D5	0.198

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.198
SG-007B-13-US	D5	2.088
	F2	2.088
SG-007B-25-US	D5	7.723
	F2	7.723
SG-007B-100-US	D5	123.6
	F2	123.6
SG-008A-4-US	D5	0.198
	F2	0.198
SG-008A-13-US	D5	2.088
	F2	2.088
SG-008A-25-US	D5	7.723
	F2	7.723
SG-008A-100-US	D5	123.6
	F2	123.6
SG-008B-4-US	D5	0.198
	F2	0.198
SG-008B-13-US	D5	2.088
	F2	2.088
SG-008B-25-US	D5	7.723
	F2	7.723
SG-008B-100-US	D5	123.6
	F2	123.6
SG-009A-3-US	D5	0.03
	F2	0.03
SG-009A-13-US	D5	0.56
	F2	0.56
SG-009A-25-US	D5	2.071
	F2	2.071
SG-009A-100-US	D5	33.13
	F2	33.13
SG-009B-3-US	D5	0.03
	F2	0.03
SG-009B-13-US	D5	0.56
	F2	0.56
SG-009B-25-US	D5	2.071
	F2	2.071
SG-009B-100-US	D5	33.13
	F2	33.13
SG-009B-3-US	D5	0.024
	F2	0.024
SG-010A-10-US	D5	0.271
	F2	0.271
SG-010A-13-US	D5	0.457
	F2	0.457
SG-010A-25-US	D5	1.691

Scenario	Weather	Peak Flowrate [kg/s]
	F2	1.691
SG-010A-50-US	D5	6.765
	F2	6.765
SG-010A-100-US	D5	27.06
	F2	27.06
SG-010B-3-US	D5	0.024
	F2	0.024
SG-010B-13-US	D5	0.457
	F2	0.457
SG-010B-25-US	D5	1.691
	F2	1.691
SG-010B-100-US	D5	27.06
	F2	27.06
SG-010C-3-US	D5	0.024
	F2	0.024
SG-010C-13-US	D5	0.457
	F2	0.457
SG-010C-25-US	D5	1.691
	F2	1.691
SG-010C-100-US	D5	27.06
	F2	27.06
SG-010D-3-US	D5	0.024
	F2	0.024
SG-010D-13-US	D5	0.457
	F2	0.457
SG-010D-25-US	D5	1.691
	F2	1.691
SG-010D-100-US	D5	27.06
	F2	27.06
SG-011A-3-US	D5	0.024
	F2	0.024
SG-011A-13-US	D5	0.457
	F2	0.457
SG-011A-25-US	D5	1.691
	F2	1.691
SG-011A-50-US	D5	6.765
	F2	6.765
SG-011B-3-US	D5	0.024
	F2	0.024
SG-011B-13-US	D5	0.457
	F2	0.457
SG-011B-25-US	D5	1.691
	F2	1.691
SG-011B-50-US	D5	6.765
	F2	6.765
SG-011C-3-US	D5	0.024

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.024
SG-011C-13-US	D5	0.457
	F2	0.457
SG-011C-25-US	D5	1.691
	F2	1.691
SG-011C-100-US	D5	27.06
	F2	27.06
CG-001-4-US	D5	0.198
	F2	0.198
CG-001-13-US	D5	2.088
	F2	2.088
CG-001-25-US	D5	7.723
	F2	7.723
CG-001-67-US	D5	55.47
	F2	55.47
CG-002A-3-US	D5	0.111
	F2	0.111
CG-002A-13-US	D5	2.088
	F2	2.088
CG-002A-25-US	D5	7.723
	F2	7.723
CG-002A-100-US	D5	123.6
	F2	123.6
CG-002B-3-US	D5	0.111
	F2	0.111
CG-002B-13-US	D5	2.088
	F2	2.088
CG-002B-25-US	D5	7.723
	F2	7.723
CG-002B-100-US	D5	123.6
	F2	123.6
CG-002C-3-US	D5	0.111
	F2	0.111
CG-002C-13-US	D5	2.088
	F2	2.088
CG-002C-25-US	D5	7.723
	F2	7.723
CG-002C-100-US	D5	123.6
	F2	123.6

Onshore – Jet Fires

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-001A-126L-IS	D5	111.8	222.5	164.7	124.7
	F2	106.5	223	160.3	120.9
SG-001A-400R-IS	D5	114.6	229.1	169.4	128.2
	F2	109.2	229.7	164.9	124.5
SG-001A-400R2-IS	D5	114.6	229.2	169.4	128.3
	F2	109.3	229.8	164.9	124.5
SG-002A-4-IS	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a
SG-002A-13-IS	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-002A-25-IS	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-002A-134-IL	D5	114.6	228.7	170.1	129.4
	F2	109.2	229.8	166.1	125.9
SG-002A-400-IL	D5	114.9	229.5	170.7	129.8
	F2	109.5	230.6	166.7	126.3
SG-002B-4-IS	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a
SG-002B-13-IS	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-002B-25-IS	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-002B-134-IL	D5	114.6	228.8	170.1	129.4
	F2	109.2	229.8	166.1	125.9
SG-002B-400-IL	D5	114.9	229.5	170.7	129.8
	F2	109.5	230.6	166.7	126.3
SG-003A-4-IS	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a
SG-003A-13-IS	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-003A-25-IS	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-003A-134-IL	D5	116.8	233.8	173.7	132.1
	F2	111.3	235	169.7	128.6
SG-003A-250-IL	D5	185	401	290.2	222.1
	F2	178.5	405.4	285.5	220.2
SG-003A-400-IL	D5	125.8	255.2	188.7	143.2
	F2	120.2	256.9	184.6	140.2
SG-003A-750-IL	D5	126.8	257.4	190.2	144.4
	F2	121.1	259.1	186.1	141.4
SG-004A-4-IS	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-004A-13-IS	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-004A-25-IS	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-004A -250-IL	D5	177.2	380.1	275.8	211.1
	F2	170.8	385.4	271.9	209.4
SG-004A-750-IL	D5	191.6	419	302.7	231.7
	F2	185.2	422.4	297.1	229.4
SG-005A-4-IS	D5	5.584	6.318	5.24	n/a
	F2	5.588	6.515	5.42	n/a
SG-005A-13-IS	D5	16.16	22.99	19.3	16.31
	F2	15.78	23.34	19.23	15.97
SG-005A-25-IS	D5	29.24	46.51	37.71	31.75
	F2	28.04	46.86	37.14	30.29
SG-005A-250-IL	D5	163	344.8	252	192.1
	F2	156.7	349.4	248.4	190.7
SG-005A-750-IL	D5	174.8	374.3	272.4	208.3
	F2	168.5	379.7	269	207.2
SG-006A-4-IS	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
SG-006A-13-IS	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
SG-006A-25-IS	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
SG-006A-250-IL	D5	159.3	335.8	245.8	187.3
	F2	153.1	340.2	242.3	185.8
SG-006A-750-IL	D5	170.4	363.3	264.9	202.3
	F2	164.1	368.5	261.5	201.2
SG-007A-4-IS	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
SG-007A-13-IS	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
SG-007A-25-IS	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
SG-007A-100-IS	D5	94.19	181.2	137.4	109.2
	F2	89.52	182.2	134.4	102
SG-007B-4-IS	D5	5.584	5.915	n/a	n/a
	F2	5.588	6.213	n/a	n/a
SG-007B-13-IS	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
SG-007B-25-IS	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
SG-007B-100-IS	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-008A-4-IS	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
SG-008A-13-IS	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
SG-008A-25-IS	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
SG-008A-100-IS	D5	94.19	181.2	137.4	109.2
	F2	89.52	182.2	134.4	102
SG-008B-4-IS	D5	5.584	5.915	n/a	n/a
	F2	5.588	6.213	n/a	n/a
SG-008B-13-IS	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
SG-008B-25-IS	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
SG-008B-100-IS	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6
SG-009A-3-IS	D5	2.452	n/a	n/a	n/a
	F2	2.452	n/a	n/a	n/a
SG-009A-13-IS	D5	8.85	11.11	8.934	n/a
	F2	8.851	11.46	9.061	n/a
SG-009A-25-IS	D5	16.32	23.29	19.31	16.03
	F2	15.87	23.56	19.15	15.6
SG-009A-100-IS	D5	55.98	97.91	76.57	62.23
	F2	53.04	98.41	74.82	57.32
SG-009B-3-IS	D5	2.452	2.549	2.421	n/a
	F2	2.452	2.601	2.446	n/a
SG-009B-13-IS	D5	8.85	11.11	9.812	8.79
	F2	8.851	11.47	9.969	8.804
SG-009B-25-IS	D5	16.32	13.31	9.557	9.557
	F2	15.87	23.41	19.43	16.44
SG-009B-100-IS	D5	55.98	97.66	76.64	63.11
	F2	53.04	98.25	74.96	59.19
SG-009B-3-IS	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-010A-10-IS	D5	6.321	7.117	n/a	n/a
	F2	6.325	7.384	5.397	n/a
SG-010A-13-IS	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a
SG-010A-25-IS	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-010A-50-IS	D5	26.96	42.65	34.6	28.78
	F2	26.07	43.07	34.27	27.75
SG-010A-100-IS	D5	49.86	87	68.37	56.17
	F2	47.64	87.6	67.26	53.54

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-010B-3-IS	D5	2.186	2.252	2.169	n/a
	F2	2.186	2.292	2.187	n/a
SG-010B-13-IS	D5	7.942	9.676	8.675	7.886
	F2	7.949	9.97	8.818	7.919
SG-010B-25-IS	D5	14.3	19.76	16.92	14.95
	F2	14.13	20.21	17.04	14.8
SG-010B-100-IS	D5	49.86	86.73	68.4	56.86
	F2	47.64	87.4	67.36	54.38
SG-010C-3-IS	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-010C-13-IS	D5	7.942	9.712	8.335	n/a
	F2	7.949	10	8.526	n/a
SG-010C-25-IS	D5	14.3	19.88	16.84	14.35
	F2	14.13	20.32	16.94	14.23
SG-010C-100-IS	D5	49.86	86.87	68.39	56.54
	F2	47.64	87.5	67.32	54
SG-010D-3-IS	D5	2.186	2.252	2.169	n/a
	F2	2.186	2.292	2.187	n/a
SG-010D-13-IS	D5	7.942	9.676	8.675	7.886
	F2	7.949	9.97	8.818	7.919
SG-010D-25-IS	D5	14.3	19.76	16.92	14.95
	F2	14.13	20.21	17.04	14.8
SG-010D-100-IS	D5	49.86	86.73	68.4	56.86
	F2	47.64	87.4	67.36	54.38
SG-011A-3-IS	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-011A-13-IS	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a
SG-011A-25-IS	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-011A-50-IS	D5	26.96	42.65	34.6	28.78
	F2	26.07	43.07	34.27	27.75
SG-011B-3-IS	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-011B-13-IS	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a
SG-011B-25-IS	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-011B-50-IS	D5	26.96	42.65	34.6	28.78
	F2	26.07	43.07	34.27	27.75
SG-011C-3-IS	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-011C-13-IS	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-011C-25-IS	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-011C-100-IS	D5	49.86	87	68.37	56.17
	F2	47.64	87.6	67.26	53.54
CG-001-4-IS	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
CG-001-13-IS	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
CG-001-25-IS	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
CG-001-67-IS	D5	68.89	124.4	96.44	78.53
	F2	65.38	125.2	94.51	73.82
CG-001A-200-IL	D5	156.6	329.1	241.1	183.6
	F2	150.4	333.2	237.5	182.1
CG-002A-3-IS	D5	4.342	4.801	4.445	3.106
	F2	4.344	4.926	4.513	3.479
CG-002A-13-IS	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
CG-002A-25-IS	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
CG-002A-100-IS	D5	94.19	181.2	137.4	109.2
	F2	89.52	182.2	134.4	102
CG-002B-3-IS	D5	4.342	3.777	n/a	n/a
	F2	4.344	4.147	n/a	n/a
CG-002B-13-IS	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
CG-002B-25-IS	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
CG-002B-100-IS	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6
CG-002C-3-IS	D5	4.342	3.777	n/a	n/a
	F2	4.344	4.147	n/a	n/a
CG-002C-13-IS	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
CG-002C-25-IS	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
CG-002C-100-IS	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6
SG-001A-126L-IS	D5	111.8	222.5	164.7	124.7
	F2	106.5	223	160.3	120.9
SG-001A-400R-IS	D5	114.6	229.1	169.4	128.2
	F2	109.2	229.7	164.9	124.5
SG-001A-400R2-IS	D5	114.6	229.2	169.4	128.3
	F2	109.3	229.8	164.9	124.5

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-002A-4-US	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a
SG-002A-13-US	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-002A-25-US	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-002A-134-UL	D5	114.6	228.7	170.1	129.4
	F2	109.2	229.8	166.1	125.9
SG-002A-400-UL	D5	116.6	233.5	173.5	131.9
	F2	111.2	234.7	169.5	128.5
SG-002B-4-US	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a
SG-002B-13-US	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-002B-25-US	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-002B-134-UL	D5	114.7	229	170.3	129.5
	F2	109.3	230.1	166.3	126
SG-002B-400-UL	D5	116.6	233.5	173.5	131.9
	F2	111.2	234.7	169.5	128.5
SG-003A-4-US	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a
SG-003A-13-US	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-003A-25-US	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-003A-134UL	D5	116.8	233.8	173.7	132.1
	F2	111.3	235	169.7	128.6
SG-003A-250-UL	D5	185	401	290.2	222.1
	F2	178.5	405.4	285.5	220.2
SG-003A-400-UL	D5	125.8	255.2	188.7	143.2
	F2	120.2	256.9	184.6	140.2
SG-003A-750-UL	D5	126.8	257.4	190.2	144.4
	F2	121.1	259.1	186.1	141.4
SG-004A-4-US	D5	5.584	n/a	n/a	n/a
	F2	5.588	n/a	n/a	n/a
SG-004A-13-US	D5	16.16	22.91	16.56	n/a
	F2	15.78	23.16	16.48	n/a
SG-004A-25-US	D5	29.24	47.11	36.81	28.32
	F2	28.04	47.25	36.07	27.19
SG-004A -250-UL	D5	177.2	380.1	275.8	211.1
	F2	170.8	385.4	271.9	209.4
SG-004A-750-UL	D5	191.6	419	302.7	231.7
	F2	185.2	422.4	297.1	229.4

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-005A-4-US	D5	5.584	6.318	5.24	n/a
	F2	5.588	6.515	5.42	n/a
SG-005A-13-US	D5	16.16	22.99	19.3	16.31
	F2	15.78	23.34	19.23	15.97
SG-005A-25-US	D5	29.24	46.51	37.71	31.75
	F2	28.04	46.86	37.14	30.29
SG-005A-250-UL	D5	163	344.8	252	192.1
	F2	156.7	349.4	248.4	190.7
SG-005A-750-UL	D5	174.8	374.3	272.4	208.3
	F2	168.5	379.7	269	207.2
SG-006A-4-US	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
SG-006A-13-US	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
SG-006A-25-US	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
ISG-006A-250-UL	D5	159.3	335.8	245.8	187.3
	F2	153.1	340.2	242.3	185.8
SG-006A-750-UL	D5	170.4	363.3	264.9	202.3
	F2	164.1	368.5	261.5	201.2
SG-007A-4-US	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
SG-007A-13-US	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
SG-007A-25-US	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
SG-007A-100-US	D5	94.19	181.2	137.4	109.2
	F2	89.52	182.2	134.4	102
SG-007B-4-US	D5	5.584	5.915	n/a	n/a
	F2	5.588	6.213	n/a	n/a
SG-007B-13-US	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
SG-007B-25-US	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
SG-007B-100-US	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6
SG-008A-4-US	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
SG-008A-13-US	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
SG-008A-25-US	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
SG-008A-100-US	D5	94.19	181.2	137.4	109.2
	F2	89.52	182.2	134.4	102

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-008B-4-US	D5	5.584	5.915	n/a	n/a
	F2	5.588	6.213	n/a	n/a
SG-008B-13-US	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
SG-008B-25-US	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
SG-008B-100-US	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6
SG-009A-3-US	D5	2.452	n/a	n/a	n/a
	F2	2.452	n/a	n/a	n/a
SG-009A-13-US	D5	8.85	11.11	8.934	n/a
	F2	8.851	11.46	9.061	n/a
SG-009A-25-US	D5	16.32	23.29	19.31	16.03
	F2	15.87	23.56	19.15	15.6
SG-009A-100-US	D5	55.98	97.91	76.57	62.23
	F2	53.04	98.41	74.82	57.32
SG-009B-3-US	D5	2.452	2.549	2.421	n/a
	F2	2.452	2.601	2.446	n/a
SG-009B-13-US	D5	8.85	11.11	9.812	8.79
	F2	8.851	11.47	9.969	8.804
SG-009B-25-US	D5	16.32	13.31	9.557	9.557
	F2	15.87	23.41	19.43	16.44
SG-009B-100-US	D5	55.98	97.66	76.64	63.11
	F2	53.04	98.25	74.96	59.19
SG-009B-3-US	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-010A-10-US	D5	6.321	7.117	n/a	n/a
	F2	6.325	7.384	5.397	n/a
SG-010A-13-US	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a
SG-010A-25-US	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-010A-50-US	D5	26.96	42.65	34.6	28.78
	F2	26.07	43.07	34.27	27.75
SG-010A-100-US	D5	49.86	87	68.37	56.17
	F2	47.64	87.6	67.26	53.54
SG-010B-3-US	D5	2.186	2.252	2.169	n/a
	F2	2.186	2.292	2.187	n/a
SG-010B-13-US	D5	7.942	9.676	8.675	7.886
	F2	7.949	9.97	8.818	7.919
SG-010B-25-US	D5	14.3	19.76	16.92	14.95
	F2	14.13	20.21	17.04	14.8
SG-010B-100-US	D5	49.86	86.73	68.4	56.86
	F2	47.64	87.4	67.36	54.38

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
SG-010C-3-US	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-010C-13-US	D5	7.942	9.712	8.335	n/a
	F2	7.949	10	8.526	n/a
SG-010C-25-US	D5	14.3	19.88	16.84	14.35
	F2	14.13	20.32	16.94	14.23
SG-010C-100-US	D5	49.86	86.87	68.39	56.54
	F2	47.64	87.5	67.32	54
SG-010D-3-US	D5	2.186	2.252	2.169	n/a
	F2	2.186	2.292	2.187	n/a
SG-010D-13-US	D5	7.942	9.676	8.675	7.886
	F2	7.949	9.97	8.818	7.919
SG-010D-25-US	D5	14.3	19.76	16.92	14.95
	F2	14.13	20.21	17.04	14.8
SG-010D-100-US	D5	49.86	86.73	68.4	56.86
	F2	47.64	87.4	67.36	54.38
SG-011A-3-US	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-011A-13-US	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a
SG-011A-25-US	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-011A-50-US	D5	26.96	42.65	34.6	28.78
	F2	26.07	43.07	34.27	27.75
SG-011B-3-US	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-011B-13-US	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a
SG-011B-25-US	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-011B-50-US	D5	26.96	42.65	34.6	28.78
	F2	26.07	43.07	34.27	27.75
SG-011C-3-US	D5	2.186	n/a	n/a	n/a
	F2	2.186	n/a	n/a	n/a
SG-011C-13-US	D5	7.942	9.638	7.782	n/a
	F2	7.949	9.937	7.93	n/a
SG-011C-25-US	D5	14.3	19.97	16.67	13.88
	F2	14.13	20.39	16.77	13.79
SG-011C-100-US	D5	49.86	87	68.37	56.17
	F2	47.64	87.6	67.26	53.54
CG-001-4-US	D5	5.584	6.408	5.858	5.245
	F2	5.588	6.585	5.945	5.417
CG-001-13-US	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
CG-001-25-US	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
CG-001-67-US	D5	68.89	124.4	96.44	78.53
	F2	65.38	125.2	94.51	73.82
CG-001A-200-UL	D5	156.6	329.1	241.1	183.6
	F2	150.4	333.2	237.5	182.1
CG-002A-3-US	D5	4.342	4.801	4.445	3.106
	F2	4.344	4.926	4.513	3.479
CG-002A-13-US	D5	16.16	22.87	19.39	16.97
	F2	15.78	23.24	19.33	16.53
CG-002A-25-US	D5	29.24	46.37	37.74	32.17
	F2	28.04	46.75	37.2	30.84
CG-002A-100-US	D5	94.19	181.2	137.4	109.2
	F2	89.52	182.2	134.4	102
CG-002B-3-US	D5	4.342	3.777	n/a	n/a
	F2	4.344	4.147	n/a	n/a
CG-002B-13-US	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
CG-002B-25-US	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
CG-002B-100-US	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6
CG-002C-3-US	D5	4.342	3.777	n/a	n/a
	F2	4.344	4.147	n/a	n/a
CG-002C-13-US	D5	16.16	23.08	19.16	15.93
	F2	15.78	23.4	19.07	15.59
CG-002C-25-US	D5	29.24	46.64	37.66	31.06
	F2	28.04	46.96	37.06	29.48
CG-002C-100-US	D5	94.19	181.4	137.3	108.5
	F2	89.52	182.3	134.2	101.6

Onshore – Flash Fires

Scenario	Weather	Distance downwind to LFL [m]
SG-001A-126L-IS	D5	
	F2	
SG-001A-400R-IS	D5	307.7
	F2	213.6
SG-001A-400R2-IS	D5	307.7
	F2	213.6
SG-002A-4-IS	D5	
	F2	
SG-002A-13-IS	D5	
	F2	
SG-002A-25-IS	D5	
	F2	
SG-002A-134-IL	D5	93.91
	F2	93.63
SG-002A-400-IL	D5	368.8
	F2	257.5
SG-002B-4-IS	D5	
	F2	
SG-002B-13-IS	D5	
	F2	
SG-002B-25-IS	D5	
	F2	
SG-002B-134-IL	D5	93.91
	F2	93.64
SG-002B-400-IL	D5	368.8
	F2	257.5
SG-003A-4-IS	D5	
	F2	
SG-003A-13-IS	D5	
	F2	
SG-003A-25-IS	D5	
	F2	
SG-003A-134-IL	D5	94.13
	F2	94.53
SG-003A-250-IL	D5	241.7
	F2	224.1
SG-003A-400-IL	D5	368.7
	F2	257.7
SG-003A-750-IL	D5	634.1
	F2	395.6
SG-004A-4-IS	D5	
	F2	
SG-004A-13-IS	D5	

Scenario	Weather	Distance downwind to LFL [m]
	F2	
SG-004A-25-IS	D5	
	F2	
SG-004A -250-IL	D5	223.8
	F2	179.6
SG-004A-750-IL	D5	631.1
	F2	395
SG-005A-4-IS	D5	
	F2	
SG-005A-13-IS	D5	
	F2	
SG-005A-25-IS	D5	22.82
	F2	22.97
SG-005A-250-IL	D5	302.5
	F2	246.6
SG-005A-750-IL	D5	712.1
	F2	443.6
SG-006A-4-IS	D5	5.868
	F2	7.557
SG-006A-13-IS	D5	19.08
	F2	24.53
SG-006A-25-IS	D5	36.75
	F2	46.52
SG-006A-250-IL	D5	329.5
	F2	269.8
SG-006A-750-IL	D5	736.3
	F2	445.3
SG-007A-4-IS	D5	5.868
	F2	7.557
SG-007A-13-IS	D5	19.08
	F2	24.53
SG-007A-25-IS	D5	36.75
	F2	46.52
SG-007A-100-IS	D5	146.4
	F2	165.1
SG-007B-4-IS	D5	
	F2	
SG-007B-13-IS	D5	
	F2	
SG-007B-25-IS	D5	
	F2	
SG-007B-100-IS	D5	108.8
	F2	103.2
SG-008A-4-IS	D5	5.868
	F2	7.557

Scenario	Weather	Distance downwind to LFL [m]
SG-008A-13-IS	D5	19.08
	F2	24.53
SG-008A-25-IS	D5	36.75
	F2	46.52
SG-008A-100-IS	D5	146.4
	F2	165.1
SG-008B-4-IS	D5	
	F2	
SG-008B-13-IS	D5	
	F2	
SG-008B-25-IS	D5	
	F2	
SG-008B-100-IS	D5	108.8
	F2	103.2
SG-009A-3-IS	D5	
	F2	
SG-009A-13-IS	D5	
	F2	
SG-009A-25-IS	D5	
	F2	
SG-009A-100-IS	D5	49.04
	F2	47.69
SG-009B-3-IS	D5	2.335
	F2	3.001
SG-009B-13-IS	D5	10.12
	F2	13.02
SG-009B-25-IS	D5	19.45
	F2	24.98
SG-009B-100-IS	D5	77.98
	F2	94.19
SG-009B-3-IS	D5	
	F2	
SG-010A-10-IS	D5	
	F2	
SG-010A-13-IS	D5	
	F2	
SG-010A-25-IS	D5	
	F2	
SG-010A-50-IS	D5	
	F2	
SG-010A-100-IS	D5	38.84
	F2	38.28
SG-010B-3-IS	D5	1.959
	F2	2.53
SG-010B-13-IS	D5	8.487

Scenario	Weather	Distance downwind to LFL [m]
	F2	10.96
SG-010B-25-IS	D5	16.33
	F2	21.07
SG-010B-100-IS	D5	65.42
	F2	73.77
SG-010C-3-IS	D5	
	F2	
SG-010C-13-IS	D5	
	F2	
SG-010C-25-IS	D5	
	F2	
SG-010C-100-IS	D5	47.71
	F2	47.48
SG-010D-3-IS	D5	1.959
	F2	2.53
SG-010D-13-IS	D5	8.487
	F2	10.96
SG-010D-25-IS	D5	16.33
	F2	21.07
SG-010D-100-IS	D5	65.42
	F2	73.77
SG-011A-3-IS	D5	
	F2	
SG-011A-13-IS	D5	
	F2	
SG-011A-25-IS	D5	
	F2	
SG-011A-50-IS	D5	
	F2	
SG-011B-3-IS	D5	
	F2	
SG-011B-13-IS	D5	
	F2	
SG-011B-25-IS	D5	
	F2	
SG-011B-50-IS	D5	
	F2	
SG-011C-3-IS	D5	
	F2	
SG-011C-13-IS	D5	
	F2	
SG-011C-25-IS	D5	
	F2	
SG-011C-100-IS	D5	38.84
	F2	38.28

Scenario	Weather	Distance downwind to LFL [m]
CG-001-4-IS	D5	5.868
	F2	7.557
CG-001-13-IS	D5	19.08
	F2	24.53
CG-001-25-IS	D5	36.75
	F2	46.52
CG-001-67-IS	D5	98.32
	F2	116.9
CG-001A-200-IL	D5	289.7
	F2	298.1
CG-002A-3-IS	D5	4.402
	F2	5.667
CG-002A-13-IS	D5	19.08
	F2	24.53
CG-002A-25-IS	D5	36.75
	F2	46.52
CG-002A-100-IS	D5	146.4
	F2	165.1
CG-002B-3-IS	D5	
	F2	
CG-002B-13-IS	D5	
	F2	
CG-002B-25-IS	D5	
	F2	
CG-002B-100-IS	D5	108.8
	F2	103.2
CG-002C-3-IS	D5	
	F2	
CG-002C-13-IS	D5	
	F2	
CG-002C-25-IS	D5	
	F2	
CG-002C-100-IS	D5	108.8
	F2	103.2
SG-001A-126L-IS	D5	
	F2	
SG-001A-400R-IS	D5	307.7
	F2	213.6
SG-001A-400R2-IS	D5	307.7
	F2	213.6
SG-002A-4-US	D5	
	F2	
SG-002A-13-US	D5	
	F2	
SG-002A-25-US	D5	

Scenario	Weather	Distance downwind to LFL [m]
	F2	
SG-002A-134-UL	D5	94.1
	F2	94.49
SG-002A-400-UL	D5	416.9
	F2	348.9
SG-002B-4-US	D5	
	F2	
SG-002B-13-US	D5	
	F2	
SG-002B-25-US	D5	
	F2	
SG-002B-134-UL	D5	94.13
	F2	94.5
SG-002B-400-UL	D5	416.9
	F2	348.9
SG-003A-4-US	D5	
	F2	
SG-003A-13-US	D5	
	F2	
SG-003A-25-US	D5	
	F2	
SG-003A-134UL	D5	94.15
	F2	94.58
SG-003A-250-UL	D5	241.7
	F2	224.1
SG-003A-400-UL	D5	416.9
	F2	349
SG-003A-750-UL	D5	634.1
	F2	395.6
SG-004A-4-US	D5	
	F2	
SG-004A-13-US	D5	
	F2	
SG-004A-25-US	D5	
	F2	
SG-004A -250-UL	D5	239.6
	F2	215.4
SG-004A-750-UL	D5	631.1
	F2	395
SG-005A-4-US	D5	
	F2	
SG-005A-13-US	D5	
	F2	
SG-005A-25-US	D5	22.82
	F2	22.97

Scenario	Weather	Distance downwind to LFL [m]
SG-005A-250-UL	D5	325.8
	F2	306.9
SG-005A-750-UL	D5	712.1
	F2	443.6
SG-006A-4-US	D5	5.868
	F2	7.557
SG-006A-13-US	D5	19.08
	F2	24.53
SG-006A-25-US	D5	36.75
	F2	46.52
ISG-006A-250-UL	D5	356.6
	F2	340.9
SG-006A-750-UL	D5	736.3
	F2	445.3
SG-007A-4-US	D5	5.868
	F2	7.557
SG-007A-13-US	D5	19.08
	F2	24.53
SG-007A-25-US	D5	36.75
	F2	46.52
SG-007A-100-US	D5	146.4
	F2	165.1
SG-007B-4-US	D5	
	F2	
SG-007B-13-US	D5	
	F2	
SG-007B-25-US	D5	
	F2	
SG-007B-100-US	D5	108.8
	F2	103.2
SG-008A-4-US	D5	5.868
	F2	7.557
SG-008A-13-US	D5	19.08
	F2	24.53
SG-008A-25-US	D5	36.75
	F2	46.52
SG-008A-100-US	D5	146.4
	F2	165.1
SG-008B-4-US	D5	
	F2	
SG-008B-13-US	D5	
	F2	
SG-008B-25-US	D5	
	F2	
SG-008B-100-US	D5	108.8

Scenario	Weather	Distance downwind to LFL [m]
	F2	103.2
SG-009A-3-US	D5	
	F2	
SG-009A-13-US	D5	
	F2	
SG-009A-25-US	D5	
	F2	
SG-009A-100-US	D5	49.04
	F2	47.69
SG-009B-3-US	D5	2.335
	F2	3.001
SG-009B-13-US	D5	10.12
	F2	13.02
SG-009B-25-US	D5	19.45
	F2	24.98
SG-009B-100-US	D5	77.98
	F2	94.19
SG-009B-3-US	D5	
	F2	
SG-010A-10-US	D5	
	F2	
SG-010A-13-US	D5	
	F2	
SG-010A-25-US	D5	
	F2	
SG-010A-50-US	D5	
	F2	
SG-010A-100-US	D5	38.84
	F2	38.28
SG-010B-3-US	D5	1.959
	F2	2.53
SG-010B-13-US	D5	8.487
	F2	10.96
SG-010B-25-US	D5	16.33
	F2	21.07
SG-010B-100-US	D5	65.42
	F2	73.77
SG-010C-3-US	D5	
	F2	
SG-010C-13-US	D5	
	F2	
SG-010C-25-US	D5	
	F2	
SG-010C-100-US	D5	47.71
	F2	47.48

Scenario	Weather	Distance downwind to LFL [m]
SG-010D-3-US	D5	1.959
	F2	2.53
SG-010D-13-US	D5	8.487
	F2	10.96
SG-010D-25-US	D5	16.33
	F2	21.07
SG-010D-100-US	D5	65.42
	F2	73.77
SG-011A-3-US	D5	
	F2	
SG-011A-13-US	D5	
	F2	
SG-011A-25-US	D5	
	F2	
SG-011A-50-US	D5	
	F2	
SG-011B-3-US	D5	
	F2	
SG-011B-13-US	D5	
	F2	
SG-011B-25-US	D5	
	F2	
SG-011B-50-US	D5	
	F2	
SG-011C-3-US	D5	
	F2	
SG-011C-13-US	D5	
	F2	
SG-011C-25-US	D5	
	F2	
SG-011C-100-US	D5	38.84
	F2	38.28
CG-001-4-US	D5	5.868
	F2	7.557
CG-001-13-US	D5	19.08
	F2	24.53
CG-001-25-US	D5	36.75
	F2	46.52
CG-001-67-US	D5	98.32
	F2	116.9
CG-001A-200-UL	D5	289.7
	F2	298.1
CG-002A-3-US	D5	4.402
	F2	5.667
CG-002A-13-US	D5	19.08

Scenario	Weather	Distance downwind to LFL [m]
	F2	24.53
CG-002A-25-US	D5	36.75
	F2	46.52
CG-002A-100-US	D5	146.4
	F2	165.1
CG-002B-3-US	D5	
	F2	
CG-002B-13-US	D5	
	F2	
CG-002B-25-US	D5	
	F2	
CG-002B-100-US	D5	108.8
	F2	103.2
CG-002C-3-US	D5	
	F2	
CG-002C-13-US	D5	
	F2	
CG-002C-25-US	D5	
	F2	
CG-002C-100-US	D5	108.8
	F2	103.2

AGI

AGI - Release Flowrates

Scenario	Weather	Peak Flowrate [kg/s]
PG-014A-075-US	D5	0.197705
	F2	0.197705
PG-001A-025-IS	D5	7.72285
	F2	7.72285
PG-002A-004-IS	D5	0.197705
	F2	0.197705
PG-002A-025-IS	D5	7.72285
	F2	7.72285
PG-003A-004-IS	D5	0.197705
	F2	0.197705
PG-003A-025-IS	D5	7.72285
	F2	7.72285
PG-004A-004-IS	D5	0.197705
	F2	0.197705
PG-004A-025-IS	D5	7.72285
	F2	7.72285
PG-005A-004-IS	D5	0.197705
	F2	0.197705
PG-005A-025-IS	D5	7.72285
	F2	7.72285
PG-005A-067-IS	D5	55.4686
	F2	55.4686
PG-005A-167-IS	D5	344.612
	F2	344.612
PG-006A-004-IS	D5	0.197705
	F2	0.197705
PG-006A-025-IS	D5	7.72285
	F2	7.72285
PG-006A-150-IS	D5	278.023
	F2	278.023
PG-007A-004-IS	D5	0.199646
	F2	0.199646
PG-007A-010-IS	D5	1.24779
	F2	1.24779
PG-007A-013-IS	D5	2.10876
	F2	2.10876
PG-007A-025-IS	D5	7.79867
	F2	7.79867
PG-007A-100-IS	D5	124.779
	F2	124.779
PG-008A-004-IS	D5	0.199646

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.199646
PG-008A-025-IS	D5	7.79867
	F2	7.79867
PG-008A-100-IS	D5	124.779
	F2	124.779
PG-009A-004-IS	D5	0.199646
	F2	0.199646
PG-009A-025-IS	D5	7.79867
	F2	7.79867
PG-009A-050-IS	D5	31.1947
	F2	31.1947
PG-010A-004-IS	D5	0.190307
	F2	0.190307
PG-010A-025-IS	D5	7.43388
	F2	7.43388
PG-010A-050-IS	D5	29.7355
	F2	29.7355
PG-011A-004-IS	D5	0.190307
	F2	0.190307
PG-011A-025-IS	D5	7.43388
	F2	7.43388
PG-012A-004-IS	D5	0.190307
	F2	0.190307
PG-012A-025-IS	D5	7.43388
	F2	7.43388
PG-013A-004-IS	D5	0.190307
	F2	0.190307
PG-013A-025-IS	D5	7.43388
	F2	7.43388
PG-014A-003-IS	D5	0.111209
	F2	0.111209
PG-014A-004-IS	D5	0.197705
	F2	0.197705
PG-014A-025-IS	D5	7.72285
	F2	7.72285
PG-014A-050-IS	D5	30.8914
	F2	30.8914
PG-014A-075-IS	D5	69.5056
	F2	69.5056
PG-014A-150-I	D5	278.023
	F2	278.023
PG-001A-004-US	D5	0.197705
	F2	0.197705
PG-001A-025-US	D5	7.72285
	F2	7.72285
PG-002A-004-US	D5	0.197705

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.197705
PG-002A-025-US	D5	7.72285
	F2	7.72285
PG-003A-004-US	D5	0.197705
	F2	0.197705
PG-003A-025-US	D5	7.72285
	F2	7.72285
PG-004A-004-US	D5	0.197705
	F2	0.197705
PG-004A-025-US	D5	7.72285
	F2	7.72285
PG-005A-004-US	D5	0.197705
	F2	0.197705
PG-005A-025-US	D5	7.72285
	F2	7.72285
PG-005A-067-US	D5	55.4686
	F2	55.4686
PG-005A-167-US	D5	344.612
	F2	344.612
PG-006A-004-US	D5	0.197705
	F2	0.197705
PG-006A-025-US	D5	7.72285
	F2	7.72285
PG-006A-150-US	D5	278.023
	F2	278.023
PG-007A-004-US	D5	0.199646
	F2	0.199646
PG-007A-010-US	D5	1.24779
	F2	1.24779
PG-007A-013-US	D5	2.10876
	F2	2.10876
PG-007A-025-US	D5	7.79867
	F2	7.79867
PG-007A-100-US	D5	124.779
	F2	124.779
PG-008A-004-US	D5	0.199646
	F2	0.199646
PG-008A-025-US	D5	7.79867
	F2	7.79867
PG-008A-100-US	D5	124.779
	F2	124.779
PG-009A-004-US	D5	0.199646
	F2	0.199646
PG-009A-025-US	D5	7.79867
	F2	7.79867
PG-009A-050-US	D5	31.1947

Scenario	Weather	Peak Flowrate [kg/s]
	F2	31.1947
PG-010A-004-US	D5	0.190307
	F2	0.190307
PG-010A-025-US	D5	7.43388
	F2	7.43388
PG-010A-050-US	D5	29.7355
	F2	29.7355
PG-010A-134-US	D5	213.572
	F2	213.572
PG-011A-004-US	D5	0.190307
	F2	0.190307
PG-011A-025-US	D5	7.43388
	F2	7.43388
PG-012A-004-US	D5	0.190307
	F2	0.190307
PG-012A-025-US	D5	7.43388
	F2	7.43388
PG-013A-004-I	D5	0.190307
	F2	0.190307
PG-013A-004-US	D5	0.190307
	F2	0.190307
PG-013A-025-US	D5	7.43388
	F2	7.43388
PG-014A-003-US	D5	0.111209
	F2	0.111209
PG-014A-004-US	D5	0.197705
	F2	0.197705
PG-014A-025-US	D5	7.72285
	F2	7.72285
PG-014A-050-US	D5	30.8914
	F2	30.8914
PG-014A-075-US	D5	69.5056
	F2	69.5056
PG-014A-150-I	D5	278.023
	F2	278.023

AGI – Jet Fires

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
PG-014A-075-US	D5	5.59773	5.927	n/a	n/a
	F2	5.60157	6.225	n/a	n/a
PG-001A-025-IS	D5	29.22	46.51	37.47	30.97
	F2	28.0179	46.81	36.85	29.41
PG-001A-250-IL	D5	179.108	384.2	278.1	213.7
	F2	172.701	389.9	274.5	212.6
PG-001R-750-IL	D5	211.476	472	338.5	260.4
	F2	204.96	473.2	331	257.8
PG-002A-004-IS	D5	5.59723	2.544	2.249	1.938
	F2	5.60107	2.637	2.292	2.03
PG-002A-025-IS	D5	29.22	30.32	16.68	11.74
	F2	28.0179	30.58	16.93	11.08
PG-002A-250-IL	D5	172.396	244.1	139.9	78.14
	F2	166.036	248.7	141.3	78.03
PG-002A-750-UL	D5	169.436	287.4	126.4	n/a
	F2	217.973	284	90.39	n/a
PG-003A-004-IS	D5	5.59723	n/a	n/a	n/a
	F2	5.60107	4.812	n/a	n/a
PG-003A-025-IS	D5	29.22	46.72	37.28	29.95
	F2	28.0179	46.96	36.61	28.86
PG-003A-150-IL	D5	127.152	257.7	190.2	145.7
	F2	121.455	259.6	186.2	142.2
PG-003A-450-IL	D5	208.255	463.2	332.2	255.5
	F2	201.743	464.7	324.9	252.9
PG-004A-004-IS	D5	5.59723	2.544	2.249	1.938
	F2	5.60107	2.637	2.292	2.03
PG-004A-025-IS	D5	29.22	30.32	16.68	11.74
	F2	28.0179	30.58	16.93	11.08
PG-004A-150-IL	D5	127.152	176.1	100.6	55.69
	F2	121.455	175.7	99.9	54.45
PG-004A-450-IL	D5	166.585	282.9	124.5	n/a
	F2	214.304	278.6	88.26	n/a
PG-005A-004-IS	D5	5.59723	5.926	n/a	n/a
	F2	5.60107	6.224	n/a	n/a
PG-005A-025-IS	D5	29.2173	46.5	37.47	30.97
	F2	28.0152	46.8	36.85	29.41
PG-005A-067-IS	D5	67.5024	121.3	93.69	75.83
	F2	64.0251	122	91.61	70.7
PG-005A-167-IS	D5	123.881	251.9	185.8	142.7
	F2	118.232	254.6	182.1	138.5
PG-005A-200-IL	D5	156.892	329.4	240.2	183.7
	F2	150.685	333.5	236.4	181.9

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
PG-005A-500-IL	D5	209.304	466.1	334.4	257.2
	F2	202.79	467.5	327.1	254.7
PG-006A-004-IS	D5	5.59723	6.422	5.864	5.243
	F2	5.60107	6.604	5.95	5.426
PG-006A-025-IS	D5	29.2172	46.23	37.56	32.1
	F2	28.0151	46.59	36.99	30.75
PG-006A-150-IS	D5	114.634	229.9	170.7	133
	F2	109.199	232.1	167.2	126.9
PG-006A-450-IL	D5	162.74	276.7	122	n/a
	F2	209.359	271.5	85.4	n/a
PG-007A-004-IS	D5	5.63071	5.986	n/a	n/a
	F2	5.63475	6.281	n/a	n/a
PG-007A-010-IS	D5	12.8004	17.39	14.46	11.69
	F2	12.6076	17.73	14.49	11.64
PG-007A-013-IS	D5	16.3183	23.29	19.28	16.07
	F2	15.9117	23.6	19.16	15.7
PG-007A-025-IS	D5	29.4312	46.86	37.74	31.2
	F2	28.1928	47.15	37.09	29.57
PG-007A-100-IS	D5	91.7105	175.3	132.4	105
	F2	87.0636	176.8	129.6	98.36
PG-007A-150-IL	D5	127.476	258.8	191.1	147
	F2	121.765	261	187.2	142.9
PG-007A-300-IL	D5	200.699	443	318.4	244.5
	F2	194.234	446.1	312.3	242.6
PG-008A-004-IS	D5	5.63071	2.568	2.269	1.953
	F2	5.63475	2.662	2.314	2.043
PG-008A-025-IS	D5	29.4312	30.57	16.82	11.86
	F2	28.1928	30.84	17.07	11.16
PG-008A-100-IS	D5	91.7105	122.5	69.42	39.67
	F2	87.0636	122	69.1	37.36
PG-008A-300-IL	D5	160.123	273	120.7	n/a
	F2	205.992	266.8	83.68	n/a
PG-009A-004-IS	D5	5.63029	5.985	n/a	n/a
	F2	5.63433	6.28	n/a	n/a
PG-009A-025-IS	D5	29.3581	46.72	37.64	31.1
	F2	28.1215	47.01	36.98	29.48
PG-009A-050-IS	D5	53.2958	92.58	72.4	59.2
	F2	50.5795	93.05	70.78	55.39
PG-009A-134-IL	D5	117.445	235.1	174.6	135.5
	F2	111.98	236.8	170.8	130
PG-009A-150-IL	D5	127.476	258.8	191.1	147
	F2	121.765	261	187.2	142.9
PG-009A-400-IL	D5	206.729	459.5	329.7	253.3
	F2	200.256	461.7	322.9	251.1

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
PG-010A-004-IS	D5	5.51252	2.501	2.218	1.872
	F2	5.51634	2.593	2.26	1.994
PG-010A-025-IS	D5	28.7325	29.62	16.27	11.54
	F2	27.5395	29.89	16.53	10.87
PG-010A-050-IS	D5	52.2207	62.13	34.72	21.96
	F2	49.574	62.11	34.79	20.29
PG-010A-134-IL	D5	115.433	159	90.63	50.05
	F2	110.025	158	89.76	48.84
PG-010A-150-IL	D5	125.297	173.8	99.22	54.92
	F2	119.637	173.4	98.56	53.69
PG-010A-134-IL	D5	150.596	211.9	121.3	67.39
	F2	144.478	213.8	121.5	66.4
PG-010A-400-IL	D5	157.306	222	127.1	70.74
	F2	151.105	224.8	127.7	69.81
PG-010A-450-IL	D5	166.568	283.2	124.9	n/a
	F2	214.283	278.7	88.43	n/a
PG-011A-004-IS	D5	5.51252	5.771	n/a	n/a
	F2	5.51634	6.087	n/a	n/a
PG-011A-025-IS	D5	28.7325	45.56	36.74	30.41
	F2	27.5395	45.85	36.12	28.82
PG-011A-250-IL	D5	150.562	314.3	229.6	175.3
	F2	144.445	318.1	225.9	173.4
PG-011A-750-IL	D5	212.134	474.2	339.9	261.2
	F2	205.651	475.5	332.3	258.7
PG-012A-004-IS	D5	5.51252	5.771	n/a	n/a
	F2	5.51634	6.087	n/a	n/a
PG-012A-025-IS	D5	28.7325	45.56	36.74	30.41
	F2	27.5395	45.85	36.12	28.82
PG-012A-240-IL	D5	150.562	314.3	229.6	175.3
	F2	144.445	318.1	225.9	173.4
PG-012A-750-IL	D5	211.888	473.5	339.4	260.9
	F2	205.405	474.9	331.9	258.3
PG-013A-004-IS	D5	5.51252	2.501	2.218	1.872
	F2	5.51634	2.593	2.26	1.994
PG-013A-025-IS	D5	28.7325	29.62	16.27	11.54
	F2	27.5395	29.89	16.53	10.87
PG-013A-250-IL	D5	150.562	211.8	121.2	67.37
	F2	144.445	213.8	121.5	66.38
PG-013A-750-IL	D5	123.846	214.5	96.01	n/a
	F2	159.322	200.3	57.58	n/a
PG-014A-003-IS	D5	4.34225	3.754	n/a	n/a
	F2	4.34428	4.137	n/a	n/a
PG-014A-004-IS	D5	5.58349	5.903	n/a	n/a
	F2	5.58732	6.201	n/a	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
PG-014A-025-IS	D5	29.2437	46.55	37.51	31
	F2	28.0411	46.85	36.89	29.44
PG-014A-050-IS	D5	53.7928	93.74	73.26	59.95
	F2	51.1062	94.24	71.7	56.29
PG-014A-075-IS	D5	75.2079	137.7	105.7	85.09
	F2	71.3683	138.6	103.4	79.32
PG-014A-150-I	D5	127.152	257.6	190.4	146.6
	F2	121.455	259.6	186.5	142.4
PG-001A-004-US	D5	5.59741	5.926	n/a	n/a
	F2	5.60125	6.224	n/a	n/a
PG-001A-025-US	D5	29.2647	46.59	37.54	31.02
	F2	28.0615	46.9	36.92	29.46
PG-001A-250-UL	D5	185.422	400.9	289.7	222.6
	F2	178.979	406.1	285.5	221.3
PG-001R-750-UL	D5	211.476	472	338.5	260.4
	F2	204.96	473.2	331	257.8
PG-002A-004-US	D5	5.59741	1.801	1.407	1.403
	F2	5.60125	2.637	2.292	2.03
PG-002A-025-US	D5	29.2647	30.38	16.72	11.76
	F2	28.0615	30.65	16.97	11.09
PG-002A-250-UL	D5	185.422	264.7	151.9	85.01
	F2	178.979	270.4	153.4	85.52
PG-002A-750-UL	D5	169.436	287.4	126.4	n/a
	F2	217.973	284	90.39	n/a
PG-003A-004-US	D5	5.59741	n/a	n/a	n/a
	F2	5.60125	4.812	n/a	n/a
PG-003A-025-US	D5	29.2647	46.81	37.35	30
	F2	28.0615	47.05	36.68	28.91
PG-003A-150-UL	D5	127.152	257.7	190.2	145.7
	F2	121.455	259.6	186.2	142.2
PG-003A-450-UL	D5	208.255	463.2	332.2	255.5
	F2	201.743	464.7	324.9	252.9
PG-004A-004-US	D5	5.59741	2.057	n/a	n/a
	F2	5.60125	2.196	n/a	n/a
PG-004A-025-US	D5	29.2647	30.38	16.72	11.76
	F2	28.0615	30.65	16.97	11.09
PG-004A-150-UL	D5	127.152	176.1	100.6	55.69
	F2	121.455	175.7	99.9	54.45
PG-004A-450-UL	D5	166.585	282.9	124.5	n/a
	F2	214.304	278.6	88.26	n/a
PG-005A-004-US	D5	5.59741	5.926	n/a	n/a
	F2	5.60125	6.224	n/a	n/a
PG-005A-025-US	D5	29.2558	46.58	37.53	31.01
	F2	28.0528	46.88	36.91	29.45

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
PG-005A-067-US	D5	68.2132	122.8	94.8	76.72
	F2	64.7165	123.6	92.73	71.59
PG-005A-167-US	D5	133.015	272.3	200.4	153.3
	F2	127.188	275	196.6	150.1
PG-005A-200-UL	D5	156.892	329.4	240.2	183.7
	F2	150.685	333.5	236.4	181.9
PG-005A-500-UL	D5	209.304	466.1	334.4	257.2
	F2	202.79	467.5	327.1	254.7
PG-006A-004-US	D5	5.59741	4.18	4.18	4.172
	F2	5.60125	6.604	5.95	5.426
PG-006A-025-US	D5	29.2552	46.3	37.61	32.14
	F2	28.0523	46.67	37.05	30.8
PG-006A-150-US	D5	119.964	241.6	179.1	139.2
	F2	114.415	243.8	175.5	133.5
PG-006A-450-UL	D5	162.74	276.7	122	n/a
	F2	209.359	271.5	85.4	n/a
PG-007A-004-US	D5	5.63089	5.986	n/a	n/a
	F2	5.63493	6.281	n/a	n/a
PG-007A-010-US	D5	12.8031	17.4	14.46	11.7
	F2	12.6103	17.73	14.49	11.64
PG-007A-013-US	D5	16.3243	23.3	19.29	16.07
	F2	15.9176	23.61	19.17	15.7
PG-007A-025-US	D5	29.4768	46.95	37.81	31.24
	F2	28.2373	47.24	37.16	29.62
PG-007A-100-US	D5	94.0596	180.7	136.3	108
	F2	89.3543	182.2	133.5	101.3
PG-007A-150-UL	D5	127.476	258.8	191.1	147
	F2	121.765	261	187.2	142.9
PG-007A-300-UL	D5	200.699	443	318.4	244.5
	F2	194.234	446.1	312.3	242.6
PG-008A-004-US	D5	5.63089	2.568	2.269	1.953
	F2	5.63493	2.662	2.314	2.045
PG-008A-025-US	D5	29.4768	30.64	16.85	11.88
	F2	28.2373	30.9	17.1	11.18
PG-008A-100-US	D5	94.0596	126.1	71.55	40.7
	F2	89.3543	125.6	71.21	38.59
PG-008A-300-UL	D5	160.123	273	120.7	n/a
	F2	205.992	266.8	83.68	n/a
PG-009A-004-US	D5	5.63089	5.986	n/a	n/a
	F2	5.63493	6.281	n/a	n/a
PG-009A-025-US	D5	29.4768	46.95	37.81	31.24
	F2	28.2373	47.24	37.16	29.62
PG-009A-050-US	D5	54.0774	94.19	73.6	60.17
	F2	51.3397	94.67	71.98	56.37

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
PG-009A-134-UL	D5	117.445	235.1	174.6	135.5
	F2	111.98	236.8	170.8	130
PG-009A-150-UL	D5	127.476	258.8	191.1	147
	F2	121.765	261	187.2	142.9
PG-009A-400-UL	D5	206.729	459.5	329.7	253.3
	F2	200.256	461.7	322.9	251.1
PG-010A-004-US	D5	5.51308	2.502	2.218	1.872
	F2	5.51689	2.593	2.26	1.995
PG-010A-025-US	D5	28.8425	29.77	16.36	11.59
	F2	27.6469	30.04	16.62	10.92
PG-010A-050-US	D5	52.9508	63.19	35.34	22.26
	F2	50.2837	63.16	35.4	20.59
PG-010A-134-US	D5	115.433	159	90.63	50.05
	F2	110.025	158	89.76	48.84
PG-010A-150-IL	D5	125.297	173.8	99.22	54.92
	F2	119.637	173.4	98.56	53.69
PG-010A-250-UL	D5	182.703	260.9	149.6	83.67
	F2	176.297	266.8	129.1	66.88
PG-010A-400-UL	D5	206.439	301.8	173.5	97.52
	F2	199.96	306.9	173.9	97.99
PG-010A-450-UL	D5	166.568	283.2	124.9	n/a
	F2	214.283	278.7	88.43	n/a
PG-011A-004-US	D5	5.51308	5.772	n/a	n/a
	F2	5.51689	6.088	n/a	n/a
PG-011A-025-US	D5	28.8425	45.78	36.91	30.55
	F2	27.6469	46.06	36.28	28.95
PG-011A-250-UL	D5	182.703	394	284.8	218.7
	F2	176.297	399.8	281	217.6
PG-011A-750-UL	D5	212.134	474.2	339.9	261.2
	F2	205.651	475.5	332.3	258.7
PG-012A-004-US	D5	5.51308	5.772	n/a	n/a
	F2	5.51689	6.088	n/a	n/a
PG-012A-025-US	D5	28.8425	45.78	36.91	30.55
	F2	27.6469	46.06	36.28	28.95
PG-012A-240-UL	D5	182.703	394	284.8	218.7
	F2	176.297	399.8	281	217.6
PG-012A-750-UL	D5	211.888	473.5	339.4	260.9
	F2	205.405	474.9	331.9	258.3
PG-013A-004-I	D5	5.51339	2.502	2.218	1.872
	F2	5.5172	2.594	2.26	1.995
PG-013A-004-US	D5	5.51308	2.502	2.218	1.872
	F2	5.51689	2.593	2.26	1.995
PG-013A-025-US	D5	28.8425	29.77	16.36	11.59
	F2	27.6469	30.04	16.62	10.92

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
PG-013A-250-UL	D5	182.703	260.9	149.6	83.67
	F2	176.297	266.8	129.1	66.88
PG-013A-750-UL	D5	169.992	288.6	127.1	n/a
	F2	218.687	285.1	91	n/a
PG-014A-003-US	D5	4.35293	3.783	n/a	n/a
	F2	4.35497	4.155	n/a	n/a
PG-014A-004-US	D5	5.59684	5.925	n/a	n/a
	F2	5.60068	6.223	n/a	n/a
PG-014A-025-US	D5	29.2111	46.49	37.46	30.96
	F2	28.0092	46.79	36.84	29.4
PG-014A-050-US	D5	53.6113	93.37	72.98	59.72
	F2	50.9296	93.86	71.42	56.07
PG-014A-075-US	D5	75.0619	137.4	105.4	84.91
	F2	71.2263	138.3	103.2	79.15
PG-014A-150-I	D5	127.152	257.6	190.4	146.6
	F2	121.455	259.6	186.5	142.4

AGI – Flash Fires

Scenario	Weather	Distance downwind to LFL [m]
PG-014A-075-US	D5	
	F2	
PG-001A-025-IS	D5	
	F2	
PG-001A-250-IL	D5	294.749
	F2	230.743
PG-001R-750-IL	D5	699.395
	F2	435.693
PG-002A-004-IS	D5	15.5152
	F2	17.7597
PG-002A-025-IS	D5	97.4
	F2	104.848
PG-002A-250-IL	D5	688.492
	F2	341.661
PG-002A-750-UL	D5	
	F2	
PG-003A-004-IS	D5	
	F2	
PG-003A-025-IS	D5	
	F2	
PG-003A-150-IL	D5	150.758
	F2	134.876
PG-003A-450-IL	D5	446.833
	F2	304.557
PG-004A-004-IS	D5	15.5152
	F2	17.7597
PG-004A-025-IS	D5	97.4
	F2	104.848
PG-004A-150-IL	D5	526.833
	F2	289.348
PG-004A-450-IL	D5	
	F2	
PG-005A-004-IS	D5	
	F2	
PG-005A-025-IS	D5	
	F2	
PG-005A-067-IS	D5	65.252
	F2	62.5627
PG-005A-167-IS	D5	175.669
	F2	165.294
PG-005A-200-IL	D5	240.257
	F2	215.62
PG-005A-500-IL	D5	516.756

Scenario	Weather	Distance downwind to LFL [m]
	F2	348.114
PG-006A-004-IS	D5	5.88428
	F2	7.56879
PG-006A-025-IS	D5	36.7398
	F2	46.4255
PG-006A-150-IS	D5	197.668
	F2	217.716
PG-006A-450-IL	D5	
	F2	
PG-007A-004-IS	D5	
	F2	
PG-007A-010-IS	D5	
	F2	
PG-007A-013-IS	D5	
	F2	
PG-007A-025-IS	D5	
	F2	
PG-007A-100-IS	D5	106.731
	F2	101.14
PG-007A-150-IL	D5	173.121
	F2	156.882
PG-007A-300-IL	D5	337.764
	F2	255.86
PG-008A-004-IS	D5	15.7251
	F2	17.9194
PG-008A-025-IS	D5	98.7212
	F2	105.633
PG-008A-100-IS	D5	377.511
	F2	285.038
PG-008A-300-IL	D5	
	F2	
PG-009A-004-IS	D5	
	F2	
PG-009A-025-IS	D5	
	F2	
PG-009A-050-IS	D5	45.1546
	F2	44.0467
PG-009A-134-IL	D5	155.207
	F2	145.392
PG-009A-150-IL	D5	174.831
	F2	159.16
PG-009A-400-IL	D5	434.896
	F2	306.644
PG-010A-004-IS	D5	15.3314
	F2	17.4949

Scenario	Weather	Distance downwind to LFL [m]
PG-010A-025-IS	D5	96.1058
	F2	103.162
PG-010A-050-IS	D5	189.304
	F2	187.94
PG-010A-134-IL	D5	502.363
	F2	289.853
PG-010A-150-IL	D5	530.977
	F2	296.838
PG-010A-134-IL	D5	554.66
	F2	347.901
PG-010A-400-IL	D5	720.703
	F2	421.437
PG-010A-450-IL	D5	
	F2	
PG-011A-004-IS	D5	
	F2	
PG-011A-025-IS	D5	
	F2	
PG-011A-250-IL	D5	282.978
	F2	223.317
PG-011A-750-IL	D5	693.103
	F2	431.669
PG-012A-004-IS	D5	
	F2	
PG-012A-025-IS	D5	
	F2	
PG-012A-240-IL	D5	282.978
	F2	223.317
PG-012A-750-IL	D5	693.123
	F2	431.725
PG-013A-004-IS	D5	15.3314
	F2	17.4949
PG-013A-025-IS	D5	96.1058
	F2	103.162
PG-013A-250-IL	D5	554.665
	F2	347.901
PG-013A-750-IL	D5	
	F2	
PG-014A-003-IS	D5	
	F2	
PG-014A-004-IS	D5	
	F2	
PG-014A-025-IS	D5	
	F2	
PG-014A-050-IS	D5	45.5289

Scenario	Weather	Distance downwind to LFL [m]
	F2	44.395
PG-014A-075-IS	D5	76.8172
	F2	73.3452
PG-014A-150-I	D5	175.052
	F2	165.176
PG-001A-004-US	D5	
	F2	
PG-001A-025-US	D5	
	F2	
PG-001A-250-UL	D5	306.627
	F2	275.993
PG-001R-750-UL	D5	926.432
	F2	698.173
PG-002A-004-US	D5	15.5156
	F2	17.7617
PG-002A-025-US	D5	97.5278
	F2	105.007
PG-002A-250-UL	D5	669.677
	F2	340.345
PG-002A-750-UL	D5	
	F2	
PG-003A-004-US	D5	
	F2	
PG-003A-025-US	D5	
	F2	
PG-003A-150-UL	D5	154.114
	F2	142.849
PG-003A-450-UL	D5	446.833
	F2	304.557
PG-004A-004-US	D5	
	F2	
PG-004A-025-US	D5	97.5278
	F2	105.007
PG-004A-150-UL	D5	569.758
	F2	314.393
PG-004A-450-UL	D5	
	F2	
PG-005A-004-US	D5	
	F2	
PG-005A-025-US	D5	
	F2	
PG-005A-067-US	D5	66.1315
	F2	63.3999
PG-005A-167-US	D5	190.601
	F2	179.55

Scenario	Weather	Distance downwind to LFL [m]
PG-005A-200-UL	D5	221.693
	F2	185.724
PG-005A-500-UL	D5	516.756
	F2	348.114
PG-006A-004-US	D5	5.88446
	F2	7.56902
PG-006A-025-US	D5	36.7865
	F2	46.4833
PG-006A-150-US	D5	206.781
	F2	228.683
PG-006A-450-UL	D5	
	F2	
PG-007A-004-US	D5	
	F2	
PG-007A-010-US	D5	
	F2	
PG-007A-013-US	D5	
	F2	
PG-007A-025-US	D5	
	F2	
PG-007A-100-US	D5	110.018
	F2	104.258
PG-007A-150-UL	D5	177.334
	F2	167.237
PG-007A-300-UL	D5	337.764
	F2	255.86
PG-008A-004-US	D5	15.7255
	F2	17.9199
PG-008A-025-US	D5	98.8757
	F2	105.791
PG-008A-100-US	D5	386.426
	F2	274.683
PG-008A-300-UL	D5	
	F2	
PG-009A-004-US	D5	
	F2	
PG-009A-025-US	D5	
	F2	
PG-009A-050-US	D5	46.0868
	F2	44.9184
PG-009A-134-UL	D5	155.919
	F2	147.187
PG-009A-150-UL	D5	177.334
	F2	167.237
PG-009A-400-UL	D5	434.896

Scenario	Weather	Distance downwind to LFL [m]
	F2	306.644
PG-010A-004-US	D5	15.3327
	F2	17.4966
PG-010A-025-US	D5	96.4191
	F2	103.546
PG-010A-050-US	D5	191.602
	F2	190.557
PG-010A-134-US	D5	504.472
	F2	340.326
PG-010A-150-IL	D5	562.726
	F2	318.659
PG-010A-250-UL	D5	524.474
	F2	340.058
PG-010A-400-UL	D5	710.758
	F2	419.26
PG-010A-450-UL	D5	
	F2	
PG-011A-004-US	D5	
	F2	
PG-011A-025-US	D5	
	F2	
PG-011A-250-UL	D5	277.67
	F2	222.369
PG-011A-750-UL	D5	693.103
	F2	431.669
PG-012A-004-US	D5	
	F2	
PG-012A-025-US	D5	
	F2	
PG-012A-240-UL	D5	277.67
	F2	222.369
PG-012A-750-UL	D5	693.123
	F2	431.725
PG-013A-004-I	D5	15.3334
	F2	17.4976
PG-013A-004-US	D5	15.3327
	F2	17.4966
PG-013A-025-US	D5	96.4191
	F2	103.546
PG-013A-250-UL	D5	604.362
	F2	413.977
PG-013A-750-UL	D5	
	F2	
PG-014A-003-US	D5	
	F2	

Scenario	Weather	Distance downwind to LFL [m]
PG-014A-004-US	D5	
	F2	
PG-014A-025-US	D5	
	F2	
PG-014A-050-US	D5	45.2998
	F2	44.2033
PG-014A-075-US	D5	76.663
	F2	73.1713
PG-014A-150-I	D5	175.052
	F2	165.176

FSRU

FSRU - Release Flowrates

Scenario	Weather	Peak Flowrate [kg/s]
FG013A-1-0004L-IS	D5	0.198
	F2	0.198
FG013A-1-0010L-IS	D5	1.236
	F2	1.236
FG013A-1-0013L-IS	D5	2.088
	F2	2.088
FG013A-1-0025L-IS	D5	7.723
	F2	7.723
FG013A-1-0050L-IS	D5	30.89
	F2	30.89
FG013A-1-0067L-IS	D5	55.47
	F2	55.47
FG013A-2-0004L-IS	D5	0.198
	F2	0.198
FG013A-2-0010L-IS	D5	1.236
	F2	1.236
FG013A-2-0013L-IS	D5	2.088
	F2	2.088
FG013A-2-0025L-IS	D5	7.723
	F2	7.723
FG013A-2-0050L-IS	D5	30.89
	F2	30.89
FG013A-2-0067L-IS	D5	55.47
	F2	55.47
FG013B-1-0004L-IS	D5	0.184
	F2	0.184
FG013B-1-0010L-IS	D5	1.152
	F2	1.152
FG013B-1-0013L-IS	D5	1.947
	F2	1.947
FG013B-1-0025L-IS	D5	7.201
	F2	7.201
FG013B-1-0050L-IS	D5	28.8
	F2	28.8
FG013B-1-0067L-IS	D5	51.72
	F2	51.72
FG013B-2-0004L-IS	D5	0.198
	F2	0.198
FG013B-2-0010L-IS	D5	1.236
	F2	1.236
FG013B-2-0013L-IS	D5	2.088

Scenario	Weather	Peak Flowrate [kg/s]
	F2	2.088
FG013B-2-0025L-IS	D5	7.723
	F2	7.723
FG013B-2-0050L-IS	D5	30.89
	F2	30.89
FG013B-2-0067L-IS	D5	55.47
	F2	55.47
FG014-1-0250L-IS	D5	0.198
	F2	0.198
FG014-1-0013L-IS	D5	2.088
	F2	2.088
FG014-1-0025L-IS	D5	7.723
	F2	7.723
FG014-1-0067L-IS	D5	55.47
	F2	55.47
FG014-1-0084L-IS	D5	87.19
	F2	87.19
FG014-2-0250L-IS	D5	0.184
	F2	0.184
FG014-2-0013L-IS	D5	1.947
	F2	1.947
FG014-2-0025L-IS	D5	7.201
	F2	7.201
FG014-2-0067L-IS	D5	51.72
	F2	51.72
FG014-2-0084L-IS	D5	81.3
	F2	81.3
FG028-0400L-IS	D5	0.111
	F2	0.111
FG028-0004L-IS	D5	0.198
	F2	0.198
FG028-0013L-IS	D5	2.088
	F2	2.088
FG028-0025L-IS	D5	7.723
	F2	7.723
FG028-0084L-IS	D5	87.19
	F2	87.19
FL001A-0003L-UN	D5	0.136
	F2	0.136
FL001A-0004L-UN	D5	0.241
	F2	0.241
FL001A-0013L-UN	D5	2.546
	F2	2.546
FL001A-0025L-UN	D5	9.416
	F2	9.416
FL001B-0003L-UN	D5	0.136

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.136
FL001B-0004L-UN	D5	0.241
	F2	0.241
FL001B-0013L-UN	D5	2.546
	F2	2.546
FL001B-0025L-UN	D5	9.416
	F2	9.416
FL001C-0003L-UN	D5	0.136
	F2	0.136
FL001C-0004L-UN	D5	0.241
	F2	0.241
FL001C-0013L-UN	D5	2.546
	F2	2.546
FL001C-0025L-UN	D5	9.416
	F2	9.416
FL001D-0003L-UN	D5	0.136
	F2	0.136
FL001D-0004L-UN	D5	0.241
	F2	0.241
FL001D-0013L-UN	D5	2.546
	F2	2.546
FL001D-0025L-UN	D5	9.416
	F2	9.416
FL002-0003L-UN	D5	0.136
	F2	0.136
FL002-0004L-UN	D5	0.241
	F2	0.241
FL002-0013L-UN	D5	2.546
	F2	2.546
FL002-0025L-UN	D5	9.416
	F2	9.416
FL002-0075L-UN	D5	84.75
	F2	84.75
FL002-0100L-UN	D5	150.7
	F2	150.7
FL002-0134L-UN	D5	270.5
	F2	270.5
FL002-0167L-UN	D5	420.2
	F2	420.2
FL002-0200L-UN	D5	602.7
	F2	602.7
FL003A-0004L-UN	D5	0.241
	F2	0.241
FL003A-0013L-UN	D5	2.546
	F2	2.546
FL003A-0025L-UN	D5	9.416

Scenario	Weather	Peak Flowrate [kg/s]
	F2	9.416
FL003A-0134L-UN	D5	270.5
	F2	270.5
FL003B-0004L-UN	D5	0.241
	F2	0.241
FL003B-0013L-UN	D5	2.546
	F2	2.546
FL003B-0025L-UN	D5	9.416
	F2	9.416
FL003B-0134L-UN	D5	270.5
	F2	270.5
FL003C-0004L-UN	D5	0.241
	F2	0.241
FL003C-0013L-UN	D5	2.546
	F2	2.546
FL003C-0025L-UN	D5	9.416
	F2	9.416
FL003C-0134L-UN	D5	270.5
	F2	270.5
FL003D-0004L-UN	D5	0.241
	F2	0.241
FL003D-0013L-UN	D5	2.546
	F2	2.546
FL003D-0025L-UN	D5	9.416
	F2	9.416
FL003D-0134L-UN	D5	270.5
	F2	270.5
FL005-0003L-UN	D5	0.096
	F2	0.096
FL005-0004L-UN	D5	0.17
	F2	0.17
FL005-0013L-UN	D5	1.795
	F2	1.795
FL005-0025L-UN	D5	6.638
	F2	6.638
FL005-0038L-UN	D5	14.94
	F2	14.94
FL007A-0003L-UN	D5	0.123
	F2	0.123
FL007A-0013L-UN	D5	2.313
	F2	2.313
FL007A-0025L-UN	D5	8.555
	F2	8.555
FL007B-0003L-UN	D5	0.123
	F2	0.123
FL007B-0013L-UN	D5	2.313

Scenario	Weather	Peak Flowrate [kg/s]
	F2	2.313
FL008A-0003L-UN	D5	0.123
	F2	0.123
FL008A-0013L-UN	D5	2.313
	F2	2.313
FL008B-0003L-UN	D5	0.123
	F2	0.123
FL008B-0013L-UN	D5	2.313
	F2	2.313
FL008C-0003L-UN	D5	0.123
	F2	0.123
FL008C-0013L-UN	D5	2.313
	F2	2.313
FL009A-0003L-UN	D5	0.123
	F2	0.123
FL009A-0013L-UN	D5	2.313
	F2	2.313
FL009A-0025L-UN	D5	8.555
	F2	8.555
FL009B-0003L-UN	D5	0.123
	F2	0.123
FL009B-0013L-UN	D5	2.313
	F2	2.313
FL009B-0025L-UN	D5	8.555
	F2	8.555
FL009C-0003L-UN	D5	0.123
	F2	0.123
FL009C-0013L-UN	D5	2.313
	F2	2.313
FL009C-0025L-UN	D5	8.555
	F2	8.555
FL010-0003L-UN	D5	0.123
	F2	0.123
FL010-0013L-UN	D5	2.313
	F2	2.313
FL010-0025L-UN	D5	8.555
	F2	8.555
FL011-0003L-UN	D5	0.123
	F2	0.123
FL011-0013L-UN	D5	2.315
	F2	2.315
FL011-0025L-UN	D5	8.563
	F2	8.563
FL012A-1-0003L-UN	D5	0.123
	F2	0.123
FL012A-1-0013L-UN	D5	2.315

Scenario	Weather	Peak Flowrate [kg/s]
	F2	2.315
FL012A-1-0025L-UN	D5	8.563
	F2	8.563
FL012A-2-0003L-UN	D5	0.123
	F2	0.123
FL012A-2-0013L-UN	D5	2.315
	F2	2.315
FL012A-2-0025L-UN	D5	8.563
	F2	8.563
FL013A-1-0003L-UN	D5	0.123
	F2	0.123
FL013A-1-0013L-UN	D5	2.315
	F2	2.315
FL013A-1-0025L-UN	D5	8.563
	F2	8.563
FL013B-1-0003L-UN	D5	0.123
	F2	0.123
FL013B-1-0013L-UN	D5	2.315
	F2	2.315
FL013B-1-0025L-UN	D5	8.563
	F2	8.563
FL013A-2-0003L-UN	D5	0.123
	F2	0.123
FL013A-2-0013L-UN	D5	2.315
	F2	2.315
FL013A-2-0025L-UN	D5	8.563
	F2	8.563
FL013B-2-0003L-UN	D5	0.123
	F2	0.123
FL013B-2-0013L-UN	D5	2.315
	F2	2.315
FL013B-2-0025L-UN	D5	8.563
	F2	8.563
FG013A-1-0004L-U	D5	0.198
	F2	0.198
FG013A-1-0010L-U	D5	1.236
	F2	1.236
FG013A-1-0013L-U	D5	2.088
	F2	2.088
FG013A-1-0025L-U	D5	7.723
	F2	7.723
FG013A-1-0050L-U	D5	30.89
	F2	30.89
FG013A-1-0067L-U	D5	55.47
	F2	55.47
FG013A-2-0004L-IS	D5	0.198

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.198
FG013A-2-0010L-IS	D5	1.236
	F2	1.236
FG013A-2-0013L-IS	D5	2.088
	F2	2.088
FG013A-2-0025L-IS	D5	7.723
	F2	7.723
FG013A-2-0050L-IS	D5	30.89
	F2	30.89
FG013A-2-0067L-IS	D5	55.47
	F2	55.47
FG013B-1-0004L-U	D5	0.184
	F2	0.184
FG013B-1-0010L-U	D5	1.152
	F2	1.152
FG013B-1-0013L-U	D5	1.947
	F2	1.947
FG013B-1-0025L-U	D5	7.201
	F2	7.201
FG013B-1-0050L-U	D5	28.8
	F2	28.8
FG013B-1-0067L-U	D5	51.72
	F2	51.72
FG013B-2-0004L-U	D5	0.198
	F2	0.198
FG013B-2-0010L-U	D5	1.236
	F2	1.236
FG013B-2-0013L-U	D5	2.088
	F2	2.088
FG013B-2-0025L-U	D5	7.723
	F2	7.723
FG013B-2-0050L-U	D5	30.89
	F2	30.89
FG013B-2-0067L-U	D5	55.47
	F2	55.47
FG014-1-0250L-IS	D5	0.198
	F2	0.198
FG014-1-0013L-IS	D5	2.088
	F2	2.088
FG014-1-0025L-IS	D5	7.723
	F2	7.723
FG014-1-0067L-IS	D5	55.47
	F2	55.47
FG014-1-0084L-IS	D5	87.19
	F2	87.19
FG014-2-0084L-U	D5	0.184

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.184
FG014-2-0013L-U	D5	1.947
	F2	1.947
FG014-2-0025L-U	D5	7.201
	F2	7.201
FG014-2-0067L-U	D5	51.72
	F2	51.72
FG014-2-0084L-U	D5	81.3
	F2	81.3
FG028-0400L-U	D5	0.111
	F2	0.111
FG028-0004L-U	D5	0.198
	F2	0.198
FG028-0013L-U	D5	2.088
	F2	2.088
FG028-0025L-U	D5	7.723
	F2	7.723
FG028-0084L-U	D5	87.19
	F2	87.19

FSRU – Jet Fires

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
FL001A-0134L-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL001A-0400R-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL001B-0134L-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL001B-0400R-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL001C-0134L-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL001C-0400R-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL001D-0134-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL001D-0400R-IS	D5	0.094	n/a	n/a	n/a
	F2	160.4	162.9	108.3	85.7
FL002-0134L-IS	F2	204.2	213.5	140.1	111
FL002-0400L-IS	D5	0.175	n/a	n/a	n/a
	F2	285.9	311.4	200.6	159
FL003A-0134L-IS	F2	204.2	213.5	140.1	111
FL003A-0400R-IS	D5	0.175	n/a	n/a	n/a
	F2	285.9	311.4	200.6	159
	F2	204.2	213.5	140.1	111
FL003A-0400R-IS	D5	0.175	n/a	n/a	n/a
	F2	285.9	311.4	200.6	159
FL003C-0134L-IS	F2	204.2	213.5	140.1	111
FL003C-0400R-IS	D5	0.175	n/a	n/a	n/a
	F2	285.9	311.4	200.6	159
FL003D-0134L-IS	F2	204.2	213.5	140.1	111
FL005-0003L-IS	D5	0.664	n/a	n/a	n/a
	F2	0.854	n/a	n/a	n/a
FL005-0004L-IS	D5	0.853	n/a	n/a	n/a
	F2	1.098	n/a	n/a	n/a
FL005-0013L-IS	D5	2.367	1.478	n/a	n/a
	F2	3.045	1.531	n/a	n/a
FL005-0025L-IS	D5	4.149	3.255	1.817	n/a
	F2	5.337	3.519	1.884	n/a
FL005-0038L-IS	D5	5.865	4.872	3.072	0.998
	F2	7.545	5.205	3.168	n/a
FL005-0150R-IS	D5	7.042	4.382	1.891	0.809
	F2	9.059	4.115	1.432	n/a
User defined source for F2	D5	1.312	n/a	n/a	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	1.688	n/a	n/a	n/a
FL007A-0013L-IS	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL007A-0025L-IS	D5	8.171	5.427	2.412	0.928
	F2	10.51	7.587	5.175	1.378
FL007A-0075R-IS	D5	0.041	n/a	n/a	n/a
	F2	0.053	n/a	n/a	n/a
FL007B-0003L-IS	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL007B-0013L-IS	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL007B-0025L-IS	D5	7.789	5.128	2.272	0.887
	F2	10.02	4.855	1.851	1.113
FL007B-0075R-IS	D5	7.789	5.128	2.272	0.887
	F2	10.02	4.855	1.851	1.113
FL008A-0003L-IS	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL008A-0013L-IS	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL008B-0003L-IS	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL008B-0013L-IS	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL008C-0003L-IS	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL008C-0013L-IS	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FG013A-1-0004L-IS	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG013A-1-0010L-IS	D5	12.71	17.24	14.38	11.58
	F2	12.53	17.59	14.43	11.56
FG013A-1-0013L-IS	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG013A-1-0025L-IS	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG013A-1-0050L-IS	D5	53.95	94.07	73.73	60.15
	F2	51.26	94.57	72.19	56.49
FG013A-1-0067L-IS	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG013A-1-200R-IS	D5	114.7	228.4	170.6	132.4
	F2	109.3	229.7	166.9	126.5
FG013A-2-0004L-IS	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG013A-2-0010L-IS	D5	12.71	17.24	14.38	11.58

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	12.53	17.59	14.43	11.56
FG013A-2-0013L-IS	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG013A-2-0025L-IS	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG013A-2-0050L-IS	D5	53.95	94.07	73.73	60.15
	F2	51.26	94.57	72.19	56.49
FG013A-2-0067L-IS	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG013A-2-200R-IS	D5	114.7	228.4	170.6	132.4
	F2	109.3	229.7	166.9	126.5
FG013B-1-0004L-IS	D5	5.361	5.465	n/a	n/a
	F2	5.364	5.825	n/a	n/a
FG013B-1-0010L-IS	D5	12	16.11	13.47	10.73
	F2	11.95	16.54	13.65	10.97
FG013B-1-0013L-IS	D5	15.33	21.68	18.07	15.07
	F2	15.1	22.09	18.12	14.91
FG013B-1-0025L-IS	D5	27.83	44.17	35.8	29.76
	F2	26.87	44.58	35.41	28.65
FG013B-1-0050L-IS	D5	51.41	89.82	70.53	57.86
	F2	49.09	90.41	69.34	55.07
FG013B-1-0067L-IS	D5	66.28	119.6	92.77	75.3
	F2	63.16	120.3	91.11	70.79
FG013B-1-0200L-IS	D5	115.4	227.1	170.5	133.2
	F2	110.1	227.7	166.7	127
FG013B-2-0004L-IS	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG013B-2-0010L-IS	D5	12.71	17.24	14.38	11.58
	F2	12.53	17.59	14.43	11.56
FG013B-2-0013L-IS	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG013B-2-0025L-IS	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG013B-2-0050L-IS	D5	53.95	94.07	73.73	60.15
	F2	51.26	94.57	72.19	56.49
FG013B-2-0067L-IS	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG013B-2-0200L-IS	D5	115.4	227.1	170.5	133.2
	F2	110.1	227.7	166.7	127
FG014-1-0250L-IS	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG014-1-0013L-IS	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG014-1-0025L-IS	D5	29.32	46.69	37.72	31.08

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	28.11	47	37.11	29.52
FG014-1-0067L-IS	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG014-1-0084L-IS	D5	82.64	154.1	117.9	94.05
	F2	78.46	155.2	115.5	87.89
FG014-1-0200L-IS	D5	114.7	228.2	170.5	132.3
	F2	109.3	229.6	166.8	126.5
FG014-1-0250L-IS	D5	114.7	228.2	170.5	132.3
	F2	109.3	229.6	166.8	126.5
FG014-2-0250L-IS	D5	5.361	5.465	n/a	n/a
	F2	5.364	5.825	n/a	n/a
FG014-2-0013L-IS	D5	15.33	21.68	18.07	15.07
	F2	15.1	22.09	18.12	14.91
FG014-2-0025L-IS	D5	27.83	44.17	35.8	29.76
	F2	26.87	44.58	35.41	28.65
FG014-2-0067L-IS	D5	66.28	119.6	92.77	75.3
	F2	63.16	120.3	91.11	70.79
FG014-2-0084L-IS	D5	80.02	148.4	114	91.61
	F2	76.21	149.1	111.7	86.19
FG014-2-0200L-IS	D5	114.7	228.2	170.5	132.3
	F2	109.3	229.6	166.8	126.5
FG014-2-0250L-IS	D5	114.7	228.2	170.5	132.3
	F2	109.3	229.6	166.8	126.5
FG028-0400L-IS	D5	4.353	3.784	n/a	n/a
	F2	4.355	4.156	n/a	n/a
FG028-0004L-IS	D5	5.604	5.937	n/a	n/a
	F2	5.608	6.236	n/a	n/a
FG028-0013L-IS	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG028-0025L-IS	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG028-0084L-IS	D5	82.64	154.1	117.9	94.05
	F2	78.46	155.2	115.5	87.89
FG028-0134L-IS	D5	114.7	228.2	170.5	132.3
	F2	109.3	229.6	166.8	126.5
FG028-0250L-IS	D5	114.8	228.6	170.8	132.5
	F2	109.5	230	167.1	126.7
FG028-0400L-IS	D5	114.9	228.7	170.9	132.5
	F2	109.5	230.1	167.2	126.7
FL001A-0134L-UN	D5	0.094	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
FL001A-0400R-UN	D5	0.094	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
FL001B0134L-UN	D5	0.094	n/a	n/a	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	0.12	n/a	n/a	n/a
FL001B-0400R-UN	D5	0.094	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
FL001C-0134L-UN	D5	0.094	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
FL001C-0400R-UN	D5	0.094	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
FL001D-0134L-UN	D5	0.094	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
FL001D-0400R-UN	D5	0.094	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
FL002-0075L-UN	D5	0.049	n/a	n/a	n/a
	F2	0.064	n/a	n/a	n/a
FL002-0100L-UN	D5	0.064	n/a	n/a	n/a
	F2	0.083	n/a	n/a	n/a
FL002-0167L-UN	D5	0.156	n/a	n/a	n/a
	F2	0.201	n/a	n/a	n/a
FL002-0200L-UN	D5	0.121	n/a	n/a	n/a
	F2	0.155	n/a	n/a	n/a
FL002-0400L-UN	D5	0.175	n/a	n/a	n/a
	F2	0.225	n/a	n/a	n/a
FL002-0500L-UN	D5	0.175	n/a	n/a	n/a
	F2	0.225	n/a	n/a	n/a
FL002-0600L-UN	D5	0.175	n/a	n/a	n/a
	F2	0.225	n/a	n/a	n/a
FL003A-0134L-UN	F2	204.2	213.5	140.1	111
FL003A-0400R-UN	D5	0.175	n/a	n/a	n/a
	F2	0.225	n/a	n/a	n/a
FL003B-0134L-UN	F2	204.2	213.5	140.1	111
FL003B-0400R-UN	D5	0.175	n/a	n/a	n/a
	F2	0.225	n/a	n/a	n/a
FL003C-0134L-UN	F2	204.2	213.5	140.1	111
FL003C-0400R-UN	D5	0.175	n/a	n/a	n/a
	F2	0.225	n/a	n/a	n/a
FL003D-0134L-UN	F2	204.2	213.5	140.1	111
FL003D-0400R-UN	D5	0.175	n/a	n/a	n/a
	F2	0.225	n/a	n/a	n/a
FL005-0003L-UN	D5	0.664	n/a	n/a	n/a
	F2	0.854	n/a	n/a	n/a
FL005-0004L-UN	D5	0.853	n/a	n/a	n/a
	F2	1.098	n/a	n/a	n/a
FL005-0013L-UN	D5	2.367	1.478	n/a	n/a
	F2	3.045	1.531	n/a	n/a
FL005-0025L-UN	D5	4.149	3.255	1.817	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	5.337	3.519	1.884	n/a
FL005-0038L-UN	D5	5.865	4.872	3.072	0.998
	F2	7.545	5.205	3.168	n/a
FL007A-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL007A-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL007A-0025L-UN	D5	8.171	5.427	2.412	0.928
	F2	10.51	7.587	5.175	1.378
FL007A-0075R-UN	D5	0.041	n/a	n/a	n/a
	F2	0.053	n/a	n/a	n/a
FL007B-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL007B-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL008A-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL008A-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL008B-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL008B-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL008C-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL008C-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL009A-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL009A-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL009A-0025L-UN	D5	8.171	5.427	2.412	0.928
	F2	10.51	7.587	5.175	1.378
FL009B-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL009B-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL009B-0025L-UN	D5	8.171	5.427	2.412	0.928
	F2	10.51	7.587	5.175	1.378
FL009C-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL009C-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL009C-0025L-UN	D5	8.171	5.427	2.412	0.928

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	10.51	7.587	5.175	1.378
FL010-0003L-UN	D5	1.312	n/a	n/a	n/a
	F2	1.688	n/a	n/a	n/a
FL010-0013L-UN	D5	4.667	3.805	2.345	0.701
	F2	6.003	4.098	2.35	n/a
FL010-0025L-UN	D5	8.171	5.427	2.412	0.928
	F2	10.51	7.587	5.175	1.378
FL011-0003L-UN	D5	1.004	n/a	n/a	n/a
	F2	1.292	n/a	n/a	n/a
FL011-0013L-UN	D5	3.586	2.758	1.401	n/a
	F2	4.613	2.966	1.385	n/a
FL011-0025L-UN	D5	6.287	5.295	3.458	1.424
	F2	8.089	5.7	3.627	n/a
FL012A-1-0003L-UN	D5	1.004	n/a	n/a	n/a
	F2	1.292	n/a	n/a	n/a
FL012A-1-0013L-UN	D5	3.586	2.758	1.401	n/a
	F2	4.613	2.966	1.385	n/a
FL012A-1-0025L-UN	D5	6.287	5.295	3.458	1.424
	F2	8.089	5.7	3.627	n/a
FL012A-2-0003L-UN	D5	1.004	n/a	n/a	n/a
	F2	1.292	n/a	n/a	n/a
FL012A-2-0013L-UN	D5	3.586	2.758	1.401	n/a
	F2	4.613	2.966	1.385	n/a
FL012A-2-0025L-UN	D5	6.287	5.295	3.458	1.424
	F2	8.089	5.7	3.627	n/a
FL013A-1-0003L-UN	D5	1.004	n/a	n/a	n/a
	F2	1.292	n/a	n/a	n/a
FL013A-1-0013L-UN	D5	3.586	2.758	1.401	n/a
	F2	4.613	2.966	1.385	n/a
FL013A-1-0025L-UN	D5	6.287	5.295	3.458	1.424
	F2	8.089	5.7	3.627	n/a
FL013B-1-0003L-UN	D5	1.004	n/a	n/a	n/a
	F2	1.292	n/a	n/a	n/a
FL013B-1-0013L-UN	D5	3.586	2.758	1.401	n/a
	F2	4.613	2.966	1.385	n/a
FL013B-1-0025L-UN	D5	6.287	5.295	3.458	1.424
	F2	8.089	5.7	3.627	n/a
FL013A-2-0003L-UN	D5	1.004	n/a	n/a	n/a
	F2	1.292	n/a	n/a	n/a
FL013A-2-0013L-UN	D5	3.586	2.758	1.401	n/a
	F2	4.613	2.966	1.385	n/a
FL013A-2-0025L-UN	D5	6.287	5.295	3.458	1.424
	F2	8.089	5.7	3.627	n/a
FL013B-2-0003L-UN	D5	1.004	n/a	n/a	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	1.292	n/a	n/a	n/a
FL013B-2-0013L-UN	D5	3.586	2.758	1.401	n/a
	F2	4.613	2.966	1.385	n/a
FL013B-2-0025L-UN	D5	6.287	5.295	3.458	1.424
	F2	8.089	5.7	3.627	n/a
FG013A-1-0004L-U	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG013A-1-0010L-U	D5	12.71	17.24	14.38	11.58
	F2	12.53	17.59	14.43	11.56
FG013A-1-0013L-U	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG013A-1-0025L-U	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG013A-1-0050L-U	D5	53.95	94.07	73.73	60.15
	F2	51.26	94.57	72.19	56.49
FG013A-1-0067L-U	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG013A-1-200R-U	D5	114.7	228.4	170.6	132.4
	F2	109.4	229.8	166.9	126.6
FG013A-2-0004L-IS	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG013A-2-0010L-IS	D5	12.71	17.24	14.38	11.58
	F2	12.53	17.59	14.43	11.56
FG013A-2-0013L-IS	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG013A-2-0025L-IS	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG013A-2-0050L-IS	D5	53.95	94.07	73.73	60.15
	F2	51.26	94.57	72.19	56.49
FG013A-2-0067L-IS	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG013A-2-200R-U	D5	114.7	228.4	170.6	132.4
	F2	109.3	229.7	166.9	126.5
FG013B-1-0004L-U	D5	5.361	5.465	n/a	n/a
	F2	5.364	5.825	n/a	n/a
FG013B-1-0010L-U	D5	12	16.11	13.47	10.73
	F2	11.95	16.54	13.65	10.97
FG013B-1-0013L-U	D5	15.33	21.68	18.07	15.07
	F2	15.1	22.09	18.12	14.91
FG013B-1-0025L-U	D5	27.83	44.17	35.8	29.76
	F2	26.87	44.58	35.41	28.65
FG013B-1-0050L-U	D5	51.41	89.82	70.53	57.86
	F2	49.09	90.41	69.34	55.07
FG013B-1-0067L-U	D5	66.28	119.6	92.77	75.3

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	63.16	120.3	91.11	70.79
FG013B-1-0200L-IS	D5	115.4	227.1	170.5	133.2
	F2	110.1	227.8	166.8	127.1
FG013B-2-0004L-U	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG013B-2-0010L-U	D5	12.71	17.24	14.38	11.58
	F2	12.53	17.59	14.43	11.56
FG013B-2-0013L-U	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG013B-2-0025L-U	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG013B-2-0050L-U	D5	53.95	94.07	73.73	60.15
	F2	51.26	94.57	72.19	56.49
FG013B-2-0067L-U	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG013B-2-0200L-U	D5	115.4	227.1	170.5	133.2
	F2	110.1	227.8	166.8	127.1
FG014-1-0250L-IS	D5	5.598	5.927	n/a	n/a
	F2	5.602	6.225	n/a	n/a
FG014-1-0013L-IS	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG014-1-0025L-IS	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG014-1-0067L-IS	D5	69.06	124.6	96.44	77.77
	F2	65.54	125.4	94.39	72.65
FG014-1-0084L-IS	D5	82.64	154.1	117.9	94.05
	F2	78.46	155.2	115.5	87.89
FG014-1-0250L-U	D5	114.8	228.5	170.7	132.4
	F2	109.4	229.8	167	126.6
FG014-1-0250R-U	D5	114.8	228.6	170.7	132.5
	F2	109.4	229.9	167	126.6
FG014-2-0084L-U	D5	5.361	5.465	n/a	n/a
	F2	5.364	5.825	n/a	n/a
FG014-2-0013L-U	D5	15.33	21.68	18.07	15.07
	F2	15.1	22.09	18.12	14.91
FG014-2-0025L-U	D5	27.83	44.17	35.8	29.76
	F2	26.87	44.58	35.41	28.65
FG014-2-0067L-U	D5	66.28	119.6	92.77	75.3
	F2	63.16	120.3	91.11	70.79
FG014-2-0084L-U	D5	80.02	148.4	114	91.61
	F2	76.21	149.1	111.7	86.19
FG014-2-0250L-U	D5	114.8	228.5	170.7	132.4
	F2	109.4	229.8	167	126.6
FG014-2-0250R-U	D5	114.8	228.6	170.7	132.5

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	109.4	229.9	167	126.6
FG028-0400L-U	D5	4.353	3.784	n/a	n/a
	F2	4.355	4.156	n/a	n/a
FG028-0004L-U	D5	5.604	5.937	n/a	n/a
	F2	5.608	6.236	n/a	n/a
FG028-0013L-U	D5	16.21	23.12	19.19	15.96
	F2	15.82	23.44	19.1	15.62
FG028-0025L-U	D5	29.32	46.69	37.72	31.08
	F2	28.11	47	37.11	29.52
FG028-0084L-U	D5	82.64	154.1	117.9	94.05
	F2	78.46	155.2	115.5	87.89
FG028-0400L-U	D5	114.7	228.3	170.5	132.3
	F2	109.3	229.6	166.8	126.5
FG028-0250L-U	D5	115.1	229.2	171.2	132.8
	F2	109.7	230.6	167.5	127
FG028-0400L-U	D5	114.9	228.7	170.9	132.5
	F2	109.5	230.1	167.2	126.7

FSRU – Flash Fires

Scenario	Weather	Distance downwind to LFL [m]
FL001A-0003L-IS	D5	8.953
	F2	2.478
FL001A-0134L-IS	D5	206.6
	F2	187
FL001A-0400R-IS	D5	206.6
	F2	187
FL001B-0003L-IS	D5	8.876
	F2	14.45
FL001B-0004L-IS	D5	13.59
	F2	21.64
FL001B-0013L-IS	D5	35.06
	F2	48.56
FL001B-0025L-IS	D5	61.15
	F2	71.7
FL001B-0134L-IS	D5	206.6
	F2	187
FL001B-0400R-IS	D5	206.6
	F2	187
FL001C-0003L-IS	D5	8.876
	F2	14.45
FL001C-0004L-IS	D5	13.59

Scenario	Weather	Distance downwind to LFL [m]
	F2	21.64
FL001C-0013L-IS	D5	35.06
	F2	48.56
FL001C-0025L-IS	D5	61.15
	F2	71.7
FL001C-0134L-IS	D5	206.6
	F2	187
FL001C-0400R-IS	D5	206.6
	F2	187
FL001D-0003L-IS	D5	8.876
	F2	14.45
FL001D-0013L-IS	D5	35.06
	F2	48.56
FL001D-0025L-IS	D5	61.15
	F2	71.7
FL001D-0134L-IS	D5	206.6
	F2	187
FL001D-0400R-IS	D5	206.6
	F2	187
\FL002-0004L-IS	D5	13.59
	F2	21.64
\FL002-0013L-IS	D5	35.06
	F2	48.56
\FL002-0025L-IS	D5	61.15
	F2	71.7
\FL002-0134L-IS	D5	262.7
	F2	201.3
\FL002-0400L-IS	D5	350.3
	F2	231.5
FL003A-0004L-IS	D5	13.59
	F2	21.64
FL003A-0013L-IS	D5	35.06
	F2	48.56
FL003A-0025L-IS	D5	61.15
	F2	71.7
FL003A-0134L-IS	D5	262.7
	F2	201.3
FL003A-0400R-IS	D5	350.3
	F2	231.5
FL003B-0004L-IS	D5	13.59
	F2	21.64
FL003B-0013L-IS	D5	35.06
	F2	48.56
FL003B-0025L-IS	D5	61.15
	F2	71.7

Scenario	Weather	Distance downwind to LFL [m]
FL003B-0134L-IS	D5	262.7
	F2	201.3
FL003B-0400R-IS	D5	350.3
	F2	231.5
FL003C-0004L-IS	D5	13.59
	F2	21.64
FL003C-0013L-IS	D5	35.06
	F2	48.56
FL003C-0025L-IS	D5	61.15
	F2	71.7
FL003C-0134L-IS	D5	262.7
	F2	201.3
FL003C-0400R-IS	D5	373.4
	F2	329
FL003D-0004L-IS	D5	13.59
	F2	21.64
FL003D-0013L-IS	D5	35.06
	F2	48.56
FL003D-0025L-IS	D5	61.15
	F2	71.7
FL003D-0134L-IS	D5	262.7
	F2	201.3
FL003D-0400R-IS	D5	443.3
	F2	330.1
\FL005-0003L-IS	D5	1.164
	F2	2.051
\FL005-0004L-IS	D5	11.91
	F2	18.65
\FL005-0013L-IS	D5	30.54
	F2	44.21
\FL005-0025L-IS	D5	52.75
	F2	67.82
\FL005-0038L-IS	D5	74.22
	F2	87.66
\FL005-0050L-IS	D5	88.59
	F2	93.15
\FL005-0150R-IS	D5	88.9
	F2	99.3
FL007A-0003L-IS	D5	2.783
	F2	3.778
FL007A-0013L-IS	D5	34.6
	F2	50.38
FL007A-0025L-IS	D5	59.36
	F2	83.54
FL007A-0075R-IS	D5	74.83

Scenario	Weather	Distance downwind to LFL [m]
	F2	82.77
FL007B-0003L-IS	D5	2.783
	F2	3.778
FL007B-0013L-IS	D5	34.6
	F2	50.38
FL007B-0025L-IS	D5	56.6
	F2	80.21
FL007B-0075R-IS	D5	56.6
	F2	80.21
FL008A-0003L-IS	D5	2.783
	F2	3.778
FL008A-0013L-IS	D5	34.6
	F2	50.38
FL008A-0025L-IS	D5	56.08
	F2	67.78
FL008A-0075R-IS	D5	56.08
	F2	67.78
FL008B-0003L-IS	D5	2.783
	F2	3.778
FL008B-0013L-IS	D5	34.6
	F2	50.38
FL008B-0025L-IS	D5	55.98
	F2	91.21
FL008B-0075R-IS	D5	55.98
	F2	91.21
FL008C-0003L-IS	D5	2.783
	F2	3.778
FL008C-0013L-IS	D5	34.6
	F2	50.38
FL008C-0025L-IS	D5	56.08
	F2	67.78
FL008C-0075R-IS	D5	56.08
	F2	67.78
FL009A-0003L-IS	D5	16.2
	F2	26.02
FL009A-0013L-IS	D5	53.51
	F2	66
FL009A-0025L-IS	D5	92.49
	F2	97.52
FL009A-0075R-IS	D5	88.61
	F2	93.33
FL009B-0003L-IS	D5	16.2
	F2	26.02
FL009B-0013L-IS	D5	53.51
	F2	66

Scenario	Weather	Distance downwind to LFL [m]
FL009B-0025L-IS	D5	92.49
	F2	97.52
FL009B-0075R-IS	D5	88.61
	F2	93.33
FL009C-0003L-IS	D5	16.2
	F2	26.02
FL009C-0013L-IS	D5	53.51
	F2	66
FL009C-0025L-IS	D5	92.49
	F2	97.52
FL009C-0075R-IS	D5	88.61
	F2	93.33
FL010-0003L-IS	D5	16.2
	F2	26.02
FL010-0013L-IS	D5	53.51
	F2	66
FL010-0025L-IS	D5	92.49
	F2	97.52
FL010-0075L-IS	D5	88.61
	F2	93.33
FL010-0100R-IS	D5	88.61
	F2	93.33
FL011-0003L-IS	D5	16.17
	F2	26.01
FL011-0013L-IS	D5	54
	F2	65.95
FL011-0025L-IS	D5	92.44
	F2	97.31
FL011-0075R-IS	D5	88.61
	F2	93.33
FL012A-1-0003L-IS	D5	16.17
	F2	26.01
FL012A-1-0013L-IS	D5	54
	F2	65.95
FL012A-1-0025L-IS	D5	93.66
	F2	120.5
FL012A-1-0050L-IS	D5	88.61
	F2	93.33
FL012A-1-0075R-IS	D5	88.61
	F2	93.33
FL012A-2-0003L-IS	D5	16.17
	F2	26.01
FL012A-2-0013L-IS	D5	54
	F2	65.95
FL012A-2-0025L-IS	D5	93.66

Scenario	Weather	Distance downwind to LFL [m]
	F2	120.5
FL012A-2-0050L-IS	D5	88.58
	F2	82.78
FL012A-2-0075R-IS	D5	89.15
	F2	158.9
FL013A-1-0003L-IS	D5	16.17
	F2	26.01
FL013A-1-0013L-IS	D5	54
	F2	65.95
FL013A-1-0025L-IS	D5	92.44
	F2	97.31
FL013A-1-0050R-IS	D5	88.61
	F2	93.33
FL013B-1-0003L-IS	D5	16.17
	F2	26.01
FL013B-1-0013L-IS	D5	54
	F2	65.95
FL013B-1-0025L-IS	D5	92.44
	F2	97.31
FL013B-1-0050R-IS	D5	88.61
	F2	93.33
FL013A-2-0003L-IS	D5	16.17
	F2	26.01
FL013A-2-0013L-IS	D5	54
	F2	65.95
FL013A-2-0025L-IS	D5	92.44
	F2	97.31
FL013A-2-0050R-IS	D5	88.61
	F2	93.33
FL013B-2-0003L-IS	D5	16.17
	F2	26.01
FL013B-2-0013L-IS	D5	54
	F2	65.95
FL013B-2-0025L-IS	D5	92.44
	F2	97.31
FL013B-2-0050R-IS	D5	88.61
	F2	93.33
FG013A-1-0004L-IS	D5	
	F2	
FG013A-1-0010L-IS	D5	
	F2	
FG013A-1-0013L-IS	D5	
	F2	
FG013A-1-0025L-IS	D5	
	F2	

Scenario	Weather	Distance downwind to LFL [m]
FG013A-1-0050L-IS	D5	45.49
	F2	43.48
FG013A-1-0067L-IS	D5	66.36
	F2	62.46
FG013A-1-0200R-IS	D5	232.1
	F2	207.6
FG013A-2-0004L-IS	D5	
	F2	
FG013A-2-0010L-IS	D5	
	F2	
FG013A-2-0013L-IS	D5	
	F2	
FG013A-2-0025L-IS	D5	
	F2	
FG013A-2-0050L-IS	D5	45.49
	F2	43.48
FG013A-2-0067L-IS	D5	66.36
	F2	62.46
FG013A-2-0200R-IS	D5	232.1
	F2	207.6
FG013A-2-0067L-IS	D5	
	F2	
FG013B-1-0010L-IS	D5	
	F2	
FG013B-1-0013L-IS	D5	
	F2	
FG013B-1-0025L-IS	D5	
	F2	
FG013B-1-0050L-IS	D5	41.01
	F2	39.46
FG013B-1-0067L-IS	D5	60.26
	F2	56.96
FG013B-1-0200R-IS	D5	211.5
	F2	191.6
FG013B-2-0004L-IS	D5	
	F2	
FG013B-2-0010L-IS	D5	
	F2	
FG013B-2-0013L-IS	D5	
	F2	
FG013B-2-0025L-IS	D5	
	F2	
FG013B-2-0050L-IS	D5	45.49
	F2	43.48
FG013B-2-0067L-IS	D5	66.36

Scenario	Weather	Distance downwind to LFL [m]
	F2	62.46
FG013B-2-0200R-IS	D5	219.5
	F2	198
FG014-1-0004L-IS	D5	
	F2	
FG014-1-0013L-IS	D5	
	F2	
FG014-1-0025L-IS	D5	
	F2	
FG014-1-0067L-IS	D5	66.36
	F2	62.46
FG014-1-0084L-IS	D5	87.29
	F2	81.67
FG014-1-0200L-IS	D5	232.1
	F2	207.6
FG014-1-0250R-IS	D5	286.4
	F2	226.9
FG014-2-0004L-IS	D5	
	F2	
FG014-2-0013L-IS	D5	
	F2	
FG014-2-0025L-IS	D5	
	F2	
FG014-2-0067L-IS	D5	60.26
	F2	56.96
FG014-2-0084L-IS	D5	79.45
	F2	74.62
FG014-2-0200L-IS	D5	232.1
	F2	207.6
FG014-2-0250R-IS	D5	294
	F2	253.5
8\FG028-0003L-IS	D5	
	F2	
8\FG028-0004L-IS	D5	
	F2	
8\FG028-0013L-IS	D5	
	F2	
8\FG028-0025L-IS	D5	
	F2	
8\FG028-0084L-IS	D5	87.29
	F2	81.67
8\FG028-0134L-IS	D5	149.7
	F2	139.1
8\FG028-0250L-IS	D5	294
	F2	253.5

Scenario	Weather	Distance downwind to LFL [m]
8\FG028-0400R-IS	D5	476
	F2	378.2
\FL001A-0003L-UN	D5	8.761
	F2	29.41
\FL001A-0004L-UN	D5	12.34
	F2	37.52
\FL001A-0013L-UN	D5	31.46
	F2	85.72
\FL001A-0025L-UN	D5	58
	F2	104.2
\FL001A-0134L-UN	D5	204.3
	F2	311.5
\FL001A-0400R-UN	D5	204.3
	F2	311.5
\FL001B-0003L-UN	D5	8.761
	F2	29.41
\FL001B-0004L-UN	D5	12.34
	F2	37.52
\FL001B-0013L-UN	D5	31.46
	F2	85.72
\FL001B-0025L-UN	D5	58
	F2	104.2
\FL001B-0134L-UN	D5	200.6
	F2	292.6
\FL001B-0400R-UN	D5	204.3
	F2	311.5
\FL001C-0003L-UN	D5	8.761
	F2	29.41
\FL001C-0004L-UN	D5	12.34
	F2	37.52
\FL001C-0013L-UN	D5	31.46
	F2	85.72
\FL001C-0025L-UN	D5	58
	F2	104.2
\FL001C-0134L-UN	D5	200.6
	F2	292.6
\FL001C-0400R-UN	D5	204.3
	F2	311.5
\FL001D-0003L-UN	D5	8.761
	F2	29.41
\FL001D-0004L-UN	D5	12.34
	F2	37.52
\FL001D-0013L-UN	D5	31.46
	F2	85.72
\FL001D-0025L-UN	D5	58

Scenario	Weather	Distance downwind to LFL [m]
	F2	104.2
\FL001D-0134L-UN	D5	200.6
	F2	292.6
\FL001D-0400R-UN	D5	204.3
	F2	311.5
N\FL002-0003L-UN	D5	8.761
	F2	29.41
N\FL002-0004L-UN	D5	12.35
	F2	37.55
N\FL002-0013L-UN	D5	31.46
	F2	85.72
N\FL002-0025L-UN	D5	58
	F2	104.2
N\FL002-0075L-UN	D5	156.7
	F2	262.9
N\FL002-0100L-UN	D5	204.3
	F2	312.5
N\FL002-0134L-UN	D5	262.6
	F2	361.5
N\FL002-0167L-UN	D5	313.7
	F2	391.9
N\FL002-0200L-UN	D5	362.4
	F2	400.9
N\FL002-0400L-UN	D5	363.5
	F2	404.3
N\FL002-0500L-UN	D5	363.5
	F2	404.3
N\FL002-0600R-UN	D5	363.5
	F2	404.3
\FL003A-0004L-UN	D5	12.35
	F2	37.52
\FL003A-0013L-UN	D5	32.79
	F2	56.36
\FL003A-0025L-UN	D5	60.28
	F2	101.3
\FL003A-0134L-UN	D5	264.2
	F2	227.1
\FL003A-0400R-UN	D5	363.5
	F2	404.3
\FL003B-0004L-UN	D5	12.35
	F2	37.52
\FL003B-0013L-UN	D5	32.79
	F2	56.36
\FL003B-0025L-UN	D5	60.28
	F2	101.3

Scenario	Weather	Distance downwind to LFL [m]
\FL003B-0134L-UN	D5	264.2
	F2	227.1
\FL003B-0400R-UN	D5	363.5
	F2	404.3
\FL003C-0004L-UN	D5	12.35
	F2	37.52
\FL003C-0013L-UN	D5	32.79
	F2	56.36
\FL003C-0025L-UN	D5	60.28
	F2	101.3
\FL003C-0134L-UN	D5	264.2
	F2	227.1
\FL003C-0400R-UN	D5	363.5
	F2	404.3
\FL003D-0004L-UN	D5	12.35
	F2	37.52
\FL003D-0013L-UN	D5	32.79
	F2	56.36
\FL003D-0025L-UN	D5	60.28
	F2	101.3
\FL003D-0134L-UN	D5	264.2
	F2	227.1
\FL003D-0400R-UN	D5	363.5
	F2	404.3
5\FL005-0003L-UN	D5	1.165
	F2	2.05
5\FL005-0004L-UN	D5	11.96
	F2	33.2
5\FL005-0013L-UN	D5	26.85
	F2	83.2
5\FL005-0025L-UN	D5	49.56
	F2	82.37
5\FL005-0038L-UN	D5	71.88
	F2	133
5\FL005-0050L-UN	D5	88.9
	F2	172.7
5\FL005-0150R-UN	D5	88.9
	F2	172.7
\FL007A-0003L-UN	D5	8.318
	F2	31.49
\FL007A-0013L-UN	D5	30.46
	F2	99.48
\FL007A-0025L-UN	D5	56.22
	F2	132.6
\FL007A-0075R-UN	D5	74.8

Scenario	Weather	Distance downwind to LFL [m]
	F2	138.2
\FL007B-0003L-UN	D5	8.318
	F2	31.49
\FL007B-0013L-UN	D5	30.46
	F2	99.48
\FL007B-0025L-UN	D5	55.13
	F2	91.65
\FL007B-0075R-UN	D5	55.13
	F2	91.65
\FL008A-0003L-UN	D5	8.318
	F2	31.49
\FL008A-0013L-UN	D5	30.46
	F2	99.48
\FL008A-0025L-UN	D5	55.13
	F2	91.65
\FL008A-0075R-UN	D5	55.13
	F2	91.65
\FL008B-0003L-UN	D5	8.318
	F2	31.49
\FL008B-0013L-UN	D5	30.46
	F2	99.48
\FL008B-0025L-UN	D5	55.13
	F2	91.65
\FL008B-0075R-UN	D5	55.13
	F2	91.65
\FL008C-0003L-UN	D5	8.318
	F2	31.49
\FL008C-0013L-UN	D5	30.46
	F2	99.48
\FL008C-0025L-UN	D5	55.13
	F2	91.65
\FL008C-0075R-UN	D5	55.13
	F2	91.65
\FL009A-0003L-UN	D5	8.318
	F2	31.49
\FL009A-0013L-UN	D5	30.46
	F2	99.48
\FL009A-0025L-UN	D5	56.22
	F2	132.6
\FL009A-0075R-UN	D5	88.94
	F2	173.1
\FL009B-0003L-UN	D5	8.318
	F2	31.49
\FL009B-0013L-UN	D5	30.46
	F2	99.48

Scenario	Weather	Distance downwind to LFL [m]
\FL009B-0025L-UN	D5	56.22
	F2	132.6
\FL009B-0075R-UN	D5	88.94
	F2	173.1
\FL009C-0003L-UN	D5	8.318
	F2	31.49
\FL009C-0013L-UN	D5	30.46
	F2	99.48
\FL009C-0025L-UN	D5	56.22
	F2	132.6
\FL009C-0075R-UN	D5	88.94
	F2	173.1
0\FL010-0003L-UN	D5	8.318
	F2	31.52
0\FL010-0013L-UN	D5	31.81
	F2	101.4
0\FL010-0025L-UN	D5	58.31
	F2	131.5
0\FL010-0075L-UN	D5	88.94
	F2	173.1
0\FL010-0100R-UN	D5	88.94
	F2	173.1
1\FL011-0003L-UN	D5	8.314
	F2	30.11
1\FL011-0013L-UN	D5	31.75
	F2	77.47
1\FL011-0025L-UN	D5	58.13
	F2	90.98
1\FL011-0075R-UN	D5	88.94
	F2	173.1
L012A-1-0003L-UN	D5	8.315
	F2	30.09
L012A-1-0013L-UN	D5	31.32
	F2	96.27
L012A-1-0025L-UN	D5	58.01
	F2	90.71
L012A-1-0050L-UN	D5	88.94
	F2	173.1
L012A-1-0075R-UN	D5	88.94
	F2	173.1
L012A-2-0003L-UN	D5	8.315
	F2	30.09
L012A-2-0013L-UN	D5	31.32
	F2	96.27
L012A-2-0025L-UN	D5	58.01

Scenario	Weather	Distance downwind to LFL [m]
	F2	90.71
L012A-2-0050L-UN	D5	88.94
	F2	173.1
L012A-2-0075R-UN	D5	88.94
	F2	173.1
L013A-1-0003L-UN	D5	8.315
	F2	30.09
L013A-1-0013L-UN	D5	31.32
	F2	96.27
L013A-1-0025L-UN	D5	58.01
	F2	90.71
L013A-1-0050R-UN	D5	88.94
	F2	173.1
L013B-1-0003L-UN	D5	8.315
	F2	30.09
L013B-1-0013L-UN	D5	31.32
	F2	96.27
L013B-1-0025L-UN	D5	58.01
	F2	90.71
L013B-1-0050R-UN	D5	88.94
	F2	173.1
L013A-2-0003L-UN	D5	8.315
	F2	30.09
L013A-2-0013L-UN	D5	31.32
	F2	96.27
L013A-2-0025L-UN	D5	58.01
	F2	90.71
L013A-2-0050R-UN	D5	88.94
	F2	173.1
L013B-2-0003L-UN	D5	8.315
	F2	30.09
L013B-2-0013L-UN	D5	31.32
	F2	96.27
L013B-2-0025L-UN	D5	58.01
	F2	90.71
L013B-2-0050R-UN	D5	88.94
	F2	173.1
FG013A-1-0004L-U	D5	
	F2	
FG013A-1-0010L-U	D5	
	F2	
FG013A-1-0013L-U	D5	
	F2	
FG013A-1-0025L-U	D5	
	F2	

Scenario	Weather	Distance downwind to LFL [m]
FG013A-1-0050L-U	D5	45.49
	F2	43.48
FG013A-1-0067L-U	D5	66.36
	F2	62.46
FG013A-1-0200R-U	D5	233.3
	F2	214.9
\FG013A-1-200R-U	D5	
	F2	
FG013A-2-0010L-U	D5	
	F2	
FG013A-2-0013L-U	D5	
	F2	
FG013A-2-0025L-U	D5	
	F2	
FG013A-2-0050L-U	D5	45.49
	F2	43.48
FG013A-2-0067L-U	D5	66.36
	F2	62.46
FG013A-2-0200R-U	D5	232.1
	F2	207.6
FG013A-2-0067L-U	D5	
	F2	
FG013B-1-0010L-U	D5	
	F2	
FG013B-1-0013L-U	D5	
	F2	
FG013B-1-0025L-U	D5	
	F2	
FG013B-1-0050L-U	D5	41.01
	F2	39.46
FG013B-1-0067L-U	D5	60.26
	F2	56.96
FG013B-1-0200R-U	D5	220.6
	F2	204.2
FG013B-2-0004L-U	D5	
	F2	
FG013B-2-0010L-U	D5	
	F2	
FG013B-2-0013L-U	D5	
	F2	
FG013B-2-0025L-U	D5	
	F2	
FG013B-2-0050L-U	D5	45.49
	F2	43.48
FG013B-2-0067L-U	D5	66.36

Scenario	Weather	Distance downwind to LFL [m]
	F2	62.46
FG013B-1-0200R-U	D5	220.6
	F2	204.2
FG014-1-0004L-U	D5	
	F2	
FG014-1-0013L-U	D5	
	F2	
FG014-1-0025L-U	D5	
	F2	
FG014-1-0067L-U	D5	66.36
	F2	62.46
FG014-1-0084L-U	D5	87.29
	F2	81.67
FG014-1-0200L-U	D5	233.3
	F2	214.9
FG014-1-0250R-U	D5	297
	F2	270.8
FG014-2-0004L-U	D5	
	F2	
FG014-2-0013L-U	D5	
	F2	
FG014-2-0025L-U	D5	
	F2	
FG014-2-0067L-U	D5	60.26
	F2	56.96
FG014-2-0084L-U	D5	79.45
	F2	74.62
FG014-2-0200L-U	D5	233.3
	F2	214.9
FG014-2-0250R-U	D5	297
	F2	270.8
FG028-0400L-U	D5	
	F2	
FG028-0004L-U	D5	
	F2	
FG028-0013L-U	D5	
	F2	
FG028-0025L-U	D5	
	F2	
FG028-0084L-U	D5	87.29
	F2	81.67
FG028-0400L-U	D5	149.7
	F2	139.3
FG028-0250L-U	D5	297
	F2	270.8

Scenario	Weather	Distance downwind to LFL [m]
FG028-0400L-U	D5	476
	F2	378.2

FSRU – Pool Fires

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
FL001A-0003L-IS	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001A-0134L-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001A-0400R-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001B-0003L-IS	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001B-0004L-IS	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL001B-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL001B-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL001B-0134L-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001B-0400R-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001C-0003L-IS	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001C-0004L-IS	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL001C-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL001C-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL001C-0134L-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001C-0400R-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001D-0003L-IS	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001D-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL001D-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL001D-0134L-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001D-0400R-IS	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL002-0004L-IS	D5	1.475	4.642	3.155	0.931

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	1.475	4.405	2.649	0.931
FL002-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL002-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL002-0134L-IS	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL002-0400L-IS	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003A-0004L-IS	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL003A-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL003A-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003A-0134L-IS	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003A-0400R-IS	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003B-0004L-IS	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL003B-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL003B-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003B-0134L-IS	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003B-0400R-IS	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003C-0004L-IS	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL003C-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL003C-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003C-0134L-IS	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003C-0400R-IS	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003D-0004L-IS	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL003D-0013L-IS	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
FL003D-0025L-IS	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003D-0134L-IS	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003D-0400R-IS	D5	107.3	450.3	285.3	181.4
	F2	107.3	438.6	267.9	150.1
\FL005-0003L-IS	D5	0.928	2.403	1.204	n/a
	F2	0.928	2.265	1.042	n/a
\FL005-0004L-IS	D5	1.237	3.618	2.329	n/a
	F2	1.237	3.42	1.893	n/a
\FL005-0013L-IS	D5	4.021	18.42	12.25	5.572
	F2	4.021	17.88	11.18	4.64
\FL005-0025L-IS	D5	7.734	41.94	27.52	16.41
	F2	7.734	40.95	25.39	12.76
\FL005-0038L-IS	D5	11.6	66.36	43.24	27.63
	F2	11.6	64.87	40.03	21.46
\FL005-0050L-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
\FL005-0150R-IS	D5	14.38	83.01	53.87	34.63
	F2	14.38	81.15	49.96	27.16
FL007A-0003L-IS	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL007A-0013L-IS	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL007A-0025L-IS	D5	8.749	48.45	31.73	19.59
	F2	8.749	47.33	29.31	15.07
FL007A-0075R-IS	D5	11.75	67.29	43.83	28.03
	F2	11.75	65.79	40.58	21.79
FL007B-0003L-IS	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL007B-0013L-IS	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL007B-0025L-IS	D5	8.273	45.4	29.76	18.08
	F2	8.273	44.34	27.47	14
FL007B-0075R-IS	D5	8.273	45.4	29.76	18.08
	F2	8.273	44.34	27.47	14
FL008A-0003L-IS	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL008A-0013L-IS	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL008A-0025L-IS	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008A-0075R-IS	D5	8.31	45.64	29.92	18.2

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	8.31	44.58	27.62	14.09
FL008B-0003L-IS	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL008B-0013L-IS	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL008B-0025L-IS	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008B-0075R-IS	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008C-0003L-IS	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL008C-0013L-IS	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL008C-0025L-IS	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008C-0075R-IS	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL009A-0003L-IS	D5	1.822	6.246	4.26	1.161
	F2	1.822	5.966	3.686	1.161
FL009A-0013L-IS	D5	7.894	42.97	28.19	16.93
	F2	7.894	41.96	26.01	13.12
FL009A-0025L-IS	D5	15.18	87.66	56.83	36.55
	F2	15.18	85.69	52.72	28.74
FL009A-0075R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL009B-0003L-IS	D5	1.822	6.246	4.26	1.161
	F2	1.822	5.966	3.686	1.161
FL009B-0013L-IS	D5	7.894	42.97	28.19	16.93
	F2	7.894	41.96	26.01	13.12
FL009B-0025L-IS	D5	15.18	87.66	56.83	36.55
	F2	15.18	85.69	52.72	28.74
FL009B-0075R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL009C-0003L-IS	D5	1.822	6.246	4.26	1.161
	F2	1.822	5.966	3.686	1.161
FL009C-0013L-IS	D5	7.894	42.97	28.19	16.93
	F2	7.894	41.96	26.01	13.12
FL009C-0025L-IS	D5	15.18	87.66	56.83	36.55
	F2	15.18	85.69	52.72	28.74
FL009C-0075R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL010-0003L-IS	D5	1.822	6.246	4.26	1.161
	F2	1.822	5.966	3.686	1.161

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
FL010-0013L-IS	D5	7.894	42.97	28.19	16.93
	F2	7.894	41.96	26.01	13.12
FL010-0025L-IS	D5	15.18	87.66	56.83	36.55
	F2	15.18	85.69	52.72	28.74
FL010-0075L-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL010-0100R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL011-0003L-IS	D5	1.823	6.25	4.263	1.161
	F2	1.823	5.97	3.688	1.161
FL011-0013L-IS	D5	7.898	42.99	28.2	16.94
	F2	7.898	41.98	26.03	13.13
FL011-0025L-IS	D5	15.19	87.7	56.85	36.57
	F2	15.19	85.73	52.75	28.75
FL011-0075R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-1-0003L-IS	D5	1.823	6.25	4.263	1.161
	F2	1.823	5.97	3.688	1.161
FL012A-1-0013L-IS	D5	7.898	42.99	28.2	16.94
	F2	7.898	41.98	26.03	13.13
FL012A-1-0025L-IS	D5	15.19	87.7	56.85	36.57
	F2	15.19	85.73	52.75	28.75
FL012A-1-0050L-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-1-0075R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-2-0003L-IS	D5	1.823	6.25	4.263	1.161
	F2	1.823	5.97	3.688	1.161
FL012A-2-0013L-IS	D5	7.898	42.99	28.2	16.94
	F2	7.898	41.98	26.03	13.13
FL012A-2-0025L-IS	D5	15.19	87.7	56.85	36.57
	F2	15.19	85.73	52.75	28.75
FL012A-2-0050L-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-2-0075R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL013A-1-0003L-IS	D5	1.823	6.25	4.263	1.161
	F2	1.823	5.97	3.688	1.161
FL013A-1-0013L-IS	D5	7.898	42.99	28.2	16.94
	F2	7.898	41.98	26.03	13.13
FL013A-1-0025L-IS	D5	15.19	87.7	56.85	36.57
	F2	15.19	85.73	52.75	28.75
FL013A-1-0050R-IS	D5	14.39	83.1	53.93	34.66

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	14.39	81.24	50.01	27.19
FL013B-1-0003L-IS	D5	1.823	6.25	4.263	1.161
	F2	1.823	5.97	3.688	1.161
FL013B-1-0013L-IS	D5	7.898	42.99	28.2	16.94
	F2	7.898	41.98	26.03	13.13
FL013B-1-0025L-IS	D5	15.19	87.7	56.85	36.57
	F2	15.19	85.73	52.75	28.75
FL013B-1-0050R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL013A-2-0003L-IS	D5	1.823	6.25	4.263	1.161
	F2	1.823	5.97	3.688	1.161
FL013A-2-0013L-IS	D5	7.898	42.99	28.2	16.94
	F2	7.898	41.98	26.03	13.13
FL013A-2-0025L-IS	D5	15.19	87.7	56.85	36.57
	F2	15.19	85.73	52.75	28.75
FL013A-2-0050R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL013B-2-0003L-IS	D5	1.823	6.25	4.263	1.161
	F2	1.823	5.97	3.688	1.161
FL013B-2-0013L-IS	D5	7.898	42.99	28.2	16.94
	F2	7.898	41.98	26.03	13.13
FL013B-2-0025L-IS	D5	15.19	87.7	56.85	36.57
	F2	15.19	85.73	52.75	28.75
FL013B-2-0050R-IS	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL001A-0003L-UN	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001A-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL001A-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL001A-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL001A-0134L-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001A-0400R-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001B-0003L-UN	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001B-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL001B-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
FL001B-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL001B-0134L-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001B-0400R-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001C-0003L-UN	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001C-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL001C-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL001C-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL001C-0134L-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001C-0400R-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001D-0003L-UN	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL001D-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL001D-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL001D-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL001D-0134L-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL001D-0400R-UN	D5	37.01	193.3	123.5	79.22
	F2	37.01	188.4	115.3	63.87
FL002-0003L-UN	D5	1.107	3.085	1.822	n/a
	F2	1.107	2.913	1.52	n/a
FL002-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL002-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL002-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL002-0075L-UN	D5	27.66	151.9	97.43	62.65
	F2	27.66	148.2	90.8	50.16
FL002-0100L-UN	D5	36.88	192.8	123.1	79.01
	F2	36.88	187.9	115	63.69
FL002-0134L-UN	D5	49.43	243.8	155.2	99.35

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	49.43	237.4	145.2	80.62
FL002-0167L-UN	D5	61.6	290.4	184.3	117.9
	F2	61.6	282.6	172.8	96.15
FL002-0200L-UN	D5	73.77	335	212.2	135.6
	F2	73.77	325.9	199.2	111.1
FL002-0400L-UN	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL002-0500L-UN	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL002-0600L-UN	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003A-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL003A-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL003A-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003A-0134L-UN	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003A-0400R-UN	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003B-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL003B-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL003B-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003B-0134L-UN	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003B-0400R-UN	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003C-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931
FL003C-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL003C-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003C-0134L-UN	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003C-0400R-UN	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL003D-0004L-UN	D5	1.475	4.642	3.155	0.931
	F2	1.475	4.405	2.649	0.931

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
FL003D-0013L-UN	D5	4.795	23.17	15.3	7.699
	F2	4.795	22.54	14.07	6.136
FL003D-0025L-UN	D5	9.221	51.46	33.67	21.05
	F2	9.221	50.28	31.11	16.17
FL003D-0134L-UN	D5	49.43	243.8	155.2	99.35
	F2	49.43	237.4	145.2	80.62
FL003D-0400R-UN	D5	74.02	335.9	212.8	135.9
	F2	74.02	326.8	199.8	111.4
FL005-0003L-UN	D5	0.928	2.403	1.204	n/a
	F2	0.928	2.265	1.042	n/a
FL005-0004L-UN	D5	1.237	3.618	2.329	n/a
	F2	1.237	3.42	1.893	n/a
FL005-0013L-UN	D5	4.021	18.42	12.25	5.572
	F2	4.021	17.88	11.18	4.64
FL005-0025L-UN	D5	7.734	41.94	27.52	16.41
	F2	7.734	40.95	25.39	12.76
FL005-0038L-UN	D5	11.6	66.36	43.24	27.63
	F2	11.6	64.87	40.03	21.46
FL005-0050L-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL005-0150R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL007A-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL007A-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL007A-0025L-UN	D5	8.749	48.45	31.73	19.59
	F2	8.749	47.33	29.31	15.07
FL007A-0075R-UN	D5	11.75	67.29	43.83	28.03
	F2	11.75	65.79	40.58	21.79
FL007B-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL007B-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL007B-0025L-UN	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL007B-0075R-UN	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008A-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL008A-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL008A-0025L-UN	D5	8.31	45.64	29.92	18.2

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	8.31	44.58	27.62	14.09
FL008A-0075R-UN	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008B-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL008B-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL008B-0025L-UN	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008B-0075R-UN	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008C-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL008C-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL008C-0025L-UN	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL008C-0075R-UN	D5	8.31	45.64	29.92	18.2
	F2	8.31	44.58	27.62	14.09
FL009A-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL009A-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL009A-0025L-UN	D5	8.749	48.45	31.73	19.59
	F2	8.749	47.33	29.31	15.07
FL009A-0075R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL009B-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL009B-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL009B-0025L-UN	D5	8.749	48.45	31.73	19.59
	F2	8.749	47.33	29.31	15.07
FL009B-0075R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL009C-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL009C-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL009C-0025L-UN	D5	8.749	48.45	31.73	19.59
	F2	8.749	47.33	29.31	15.07
FL009C-0075R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
FL010-0003L-UN	D5	1.05	2.864	1.632	n/a
	F2	1.05	2.702	1.349	n/a
FL010-0013L-UN	D5	4.55	21.65	14.32	6.967
	F2	4.55	21.05	13.14	5.677
FL010-0025L-UN	D5	8.749	48.45	31.73	19.59
	F2	8.749	47.33	29.31	15.07
FL010-0075L-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL010-0100R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL011-0003L-UN	D5	1.053	2.875	1.638	n/a
	F2	1.053	2.712	1.367	n/a
FL011-0013L-UN	D5	4.561	21.72	14.37	6.983
	F2	4.561	21.12	13.19	5.699
FL011-0025L-UN	D5	8.772	48.59	31.83	19.67
	F2	8.772	47.47	29.39	15.12
FL011-0075R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-1-0003L-UN	D5	1.053	2.875	1.638	n/a
	F2	1.053	2.712	1.367	n/a
FL012A-1-0013L-UN	D5	4.561	21.72	14.37	6.983
	F2	4.561	21.12	13.19	5.699
FL012A-1-0025L-UN	D5	8.772	48.59	31.83	19.67
	F2	8.772	47.47	29.39	15.12
FL012A-1-0050L-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-1-0075R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-2-0003L-UN	D5	1.053	2.875	1.638	n/a
	F2	1.053	2.712	1.367	n/a
FL012A-2-0013L-UN	D5	4.561	21.72	14.37	6.983
	F2	4.561	21.12	13.19	5.699
FL012A-2-0025L-UN	D5	8.772	48.59	31.83	19.67
	F2	8.772	47.47	29.39	15.12
FL012A-2-0050L-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL012A-2-0075R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL013A-1-0003L-UN	D5	1.053	2.875	1.638	n/a
	F2	1.053	2.712	1.367	n/a
FL013A-1-0013L-UN	D5	4.561	21.72	14.37	6.983
	F2	4.561	21.12	13.19	5.699
FL013A-1-0025L-UN	D5	8.772	48.59	31.83	19.67

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	8.772	47.47	29.39	15.12
FL013A-1-0050R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL013B-1-0003L-UN	D5	1.053	2.875	1.638	n/a
	F2	1.053	2.712	1.367	n/a
FL013B-1-0013L-UN	D5	4.561	21.72	14.37	6.983
	F2	4.561	21.12	13.19	5.699
FL013B-1-0025L-UN	D5	8.772	48.59	31.83	19.67
	F2	8.772	47.47	29.39	15.12
FL013B-1-0050R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL013A-2-0003L-UN	D5	1.053	2.875	1.638	n/a
	F2	1.053	2.712	1.367	n/a
FL013A-2-0013L-UN	D5	4.561	21.72	14.37	6.983
	F2	4.561	21.12	13.19	5.699
FL013A-2-0025L-UN	D5	8.772	48.59	31.83	19.67
	F2	8.772	47.47	29.39	15.12
FL013A-2-0050R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19
FL013B-2-0003L-UN	D5	1.053	2.875	1.638	n/a
	F2	1.053	2.712	1.367	n/a
FL013B-2-0013L-UN	D5	4.561	21.72	14.37	6.983
	F2	4.561	21.12	13.19	5.699
FL013B-2-0025L-UN	D5	8.772	48.59	31.83	19.67
	F2	8.772	47.47	29.39	15.12
FL013B-2-0050R-UN	D5	14.39	83.1	53.93	34.66
	F2	14.39	81.24	50.01	27.19

LNGC

LNGC - Release Flowrates

Scenario	Weather	Peak Flowrate [kg/s]
LL002-2-0003L-IS	D5	0.083
	F2	0.083
LL002-2-0004L-IS	D5	0.148
	F2	0.148
LL002-2-0013L-IS	D5	1.559
	F2	1.559
LL002-2-0025L-IS	D5	5.766
	F2	5.766
LL002-2-0050L-IS	D5	23.07
	F2	23.07
LL002-2-0134L-IS	D5	165.7
	F2	165.7
LL002-3-0003L-IS	D5	0.083
	F2	0.083
LL002-3-0004L-IS	D5	0.148
	F2	0.148
LL002-3-0013L-IS	D5	1.559
	F2	1.559
LL002-3-0025L-IS	D5	5.766
	F2	5.766
LL002-3-0050L-IS	D5	23.07
	F2	23.07
LL002-3-0134L-IS	D5	165.7
	F2	165.7
LL002-4-0003L-IS	D5	0.083
	F2	0.083
LL002-4-0004L-IS	D5	0.148
	F2	0.148
LL002-4-0013L-IS	D5	1.559
	F2	1.559
LL002-4-0025L-IS	D5	5.766
	F2	5.766
LL002-4-0050L-IS	D5	23.07
	F2	23.07
LL002-4-0134L-IS	D5	165.7
	F2	165.7
LL004A-0003L-IS	D5	0.083
	F2	0.083
LL004A-0004L-IS	D5	0.148
	F2	0.148
LL004A-0013L-IS	D5	1.559

Scenario	Weather	Peak Flowrate [kg/s]
	F2	1.559
LL004A-0025L-IS	D5	5.766
	F2	5.766
LL004A-0050L-IS	D5	23.07
	F2	23.07
LL004A-0134L-IS	D5	165.7
	F2	165.7
LL004B-0003L-IS	D5	0.136
	F2	0.136
LL004B-0004L-IS	D5	0.241
	F2	0.241
LL004B-0013L-IS	D5	2.546
	F2	2.546
LL004B-0025L-IS	D5	9.416
	F2	9.416
LL004B-0050L-IS	D5	37.67
	F2	37.67
LL004B-0134L-IS	D5	270.5
	F2	270.5
LL004C-0003L-IS	D5	0.136
	F2	0.136
LL004C-0004L-IS	D5	0.241
	F2	0.241
LL004C-0013L-IS	D5	2.546
	F2	2.546
LL004C-0025L-IS	D5	9.416
	F2	9.416
LL004C-0050L-IS	D5	37.67
	F2	37.67
LL004C-0134L-IS	D5	270.5
	F2	270.5
LG001A-0003L-IS	D5	0.001
	F2	0.001
LG001A-0004L-IS	D5	0.002
	F2	0.002
LG001A-0013L-IS	D5	0.023
	F2	0.023
LG001A-0025L-IS	D5	0.085
	F2	0.085
LG001A-0134L-IS	D5	2.45
	F2	2.45
LG001A-0400R-IS	D5	21.83
	F2	21.83
LG001B-0079L-IS	D5	0.852
	F2	0.852
LG001B-0250R-IS	D5	8.529

Scenario	Weather	Peak Flowrate [kg/s]
	F2	8.529
LG002-0003L-IS	D5	0.001
	F2	0.001
LG002-0004L-IS	D5	0.002
	F2	0.002
LG002-0013L-IS	D5	0.023
	F2	0.023
LG002-0025L-IS	D5	0.085
	F2	0.085
LG002-0050L-IS	D5	0.341
	F2	0.341
LG002-0084L-IS	D5	0.963
	F2	0.963
LG002-0100L-IS	D5	1.365
	F2	1.365
LG002-0134L-IS	D5	2.45
	F2	2.45
LG002-0150L-IS	D5	3.071
	F2	3.071
LG002-0200L-IS	D5	5.459
	F2	5.459
LG002-0250L-IS	D5	8.529
	F2	8.529
LG002-0300L-IS	D5	12.28
	F2	12.28
LG002-0400L-IS	D5	21.83
	F2	21.83
LG002-0600L-IS	D5	49.13
	F2	49.13
LG002-0750R-IS	D5	76.76
	F2	76.76
LL002-1-0003L-UN	D5	0.136
	F2	0.136
LL002-1-0004L-UN	D5	0.241
	F2	0.241
LL002-1-0013L-UN	D5	2.546
	F2	2.546
LL002-1-0025L-UN	D5	9.416
	F2	9.416
LL002-1-0050L-UN	D5	37.67
	F2	37.67
LL002-1-0134L-UN	D5	270.5
	F2	270.5
LL002-2-0003L-UN	D5	0.136
	F2	0.136
LL002-2-0004L-UN	D5	0.241

Scenario	Weather	Peak Flowrate [kg/s]
	F2	0.241
LL002-2-0013L-UN	D5	2.546
	F2	2.546
LL002-2-0025L-UN	D5	9.416
	F2	9.416
LL002-2-0050L-UN	D5	37.67
	F2	37.67
LL002-2-0134L-UN	D5	270.5
	F2	270.5
LL002-3-0003L-UN	D5	0.136
	F2	0.136
LL002-3-0004L-UN	D5	0.241
	F2	0.241
LL002-3-0013L-UN	D5	2.546
	F2	2.546
LL002-3-0025L-UN	D5	9.416
	F2	9.416
LL002-3-0050L-UN	D5	37.67
	F2	37.67
LL002-3-0134L-UN	D5	270.5
	F2	270.5
LL002-4-0003L-UN	D5	0.136
	F2	0.136
LL002-4-0004L-UN	D5	0.241
	F2	0.241
LL002-4-0013L-UN	D5	2.546
	F2	2.546
LL002-4-0025L-UN	D5	9.416
	F2	9.416
LL002-4-0050L-UN	D5	37.67
	F2	37.67
LL002-4-0134L-UN	D5	270.5
	F2	270.5
LL003-0003L-UN	D5	0.136
	F2	0.136
LL003-0004L-UN	D5	0.241
	F2	0.241
LL003-0013L-UN	D5	2.546
	F2	2.546
LL003-0025L-UN	D5	9.416
	F2	9.416
LL003-0038L-UN	D5	21.19
	F2	21.19
LL003-0050L-UN	D5	37.67
	F2	37.67
LL003-0067L-UN	D5	67.63

Scenario	Weather	Peak Flowrate [kg/s]
	F2	67.63
LL003-0075L-UN	D5	84.75
	F2	84.75
LL003-0100L-UN	D5	150.7
	F2	150.7
LL003-0150L-UN	D5	339
	F2	339
LL003-0167L-UN	D5	420.2
	F2	420.2
LL003-0200L-UN	D5	602.7
	F2	602.7
LL004A-0003L-UN	D5	0.136
	F2	0.136
LL004A-0004L-UN	D5	0.241
	F2	0.241
LL004A-0013L-UN	D5	2.546
	F2	2.546
LL004A-0025L-UN	D5	9.416
	F2	9.416
LL004A-0050L-UN	D5	37.67
	F2	37.67
LL004A-0134L-UN	D5	270.5
	F2	270.5
LL004B-0003L-UN	D5	0.136
	F2	0.136
LL004B-0004L-UN	D5	0.241
	F2	0.241
LL004B-0013L-UN	D5	2.546
	F2	2.546
LL004B-0025L-UN	D5	9.416
	F2	9.416
LL004B-0050L-UN	D5	37.67
	F2	37.67
LL004B-0134L-UN	D5	270.5
	F2	270.5
LL004C-0003L-UN	D5	0.136
	F2	0.136
LL004C-0004L-UN	D5	0.241
	F2	0.241
LL004C-0013L-UN	D5	2.546
	F2	2.546
LL004C-0025L-UN	D5	9.416
	F2	9.416
LL004C-0050L-UN	D5	37.67
	F2	37.67
LL004C-0134L-UN	D5	270.5

Scenario	Weather	Peak Flowrate [kg/s]
	F2	270.5
LL004D-0003L-UN	D5	0.136
	F2	0.136
LL004D-0004L-UN	D5	0.241
	F2	0.241
LL004D-0013L-UN	D5	2.546
	F2	2.546
LL004D-0025L-UN	D5	9.416
	F2	9.416
LL004D-0050L-UN	D5	37.67
	F2	37.67
LL004D-0134L-UN	D5	270.5
	F2	270.5
LG001A-0003L-UN	D5	0.001
	F2	0.001
LG001A-0004L-UN	D5	0.002
	F2	0.002
LG001A-0013L-UN	D5	0.023
	F2	0.023
LG001A-0025L-UN	D5	0.085
	F2	0.085
LG001A-0134L-UN	D5	2.45
	F2	2.45
LG001A-0400R-UN	D5	21.83
	F2	21.83
LG001B-0079L-UN	D5	0.852
	F2	0.852
LG001B-0250R-UN	D5	8.529
	F2	8.529
LG002-0003L-UN	D5	0.001
	F2	0.001
LG002-0004L-UN	D5	0.002
	F2	0.002
LG002-0013L-UN	D5	0.023
	F2	0.023
LG002-0025L-UN	D5	0.085
	F2	0.085
LG002-0050L-UN	D5	0.341
	F2	0.341
LG002-0084L-UN	D5	0.963
	F2	0.963
LG002-0100L-UN	D5	1.365
	F2	1.365
LG002-0134L-UN	D5	2.45
	F2	2.45
LG002-0150L-UN	D5	3.071

Scenario	Weather	Peak Flowrate [kg/s]
	F2	3.071
LG002-0200L-UN	D5	5.459
	F2	5.459
LG002-0250L-UN	D5	8.529
	F2	8.529
LG002-0300L-UN	D5	12.28
	F2	12.28
LG002-0400L-UN	D5	21.83
	F2	21.83
LG002-0750R-UN	D5	76.76

LNGC – Jet Fires

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL002-1-0134L-IS	F2	173.2	158	116.8	90.65
LL002-1-0400R-IS	F2	218.6	209.6	150.8	119.4
LL003-0100L-IS	F2	135.8	120	89.9	70
LL003-0150L-IS	F2	190.2	175.6	129.1	100.3
LL003-0167L-IS	F2	207.9	194.2	142.1	110.3
LL003-0200L-IS	F2	241.4	229.9	166.9	129.4
LL004A-0400R-IS	F2	218.6	209.6	150.8	119.4
LL004B-0050L-IS	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL004B-0400R-IS	F2	218.6	209.6	150.8	119.4
LL004C-0050L-IS	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL004C-0400R-IS	F2	218.6	209.6	150.8	119.4
LG001A-0003L-IS	D5	0.794	n/a	n/a	n/a
	F2	0.779	n/a	n/a	n/a
LG001A-0004L-IS	D5	1.098	n/a	n/a	n/a
	F2	1.03	n/a	n/a	n/a
LG001A-0013L-IS	D5	3.506	n/a	n/a	n/a
	F2	3.057	n/a	n/a	n/a
LG001A-0025L-IS	D5	6.23	n/a	n/a	n/a
	F2	5.381	n/a	n/a	n/a
LG001A-0134L-IS	D5	22.39	24	n/a	n/a
	F2	18.91	24.58	n/a	n/a
LG001A-0400R-IS	D5	53.83	76.21	66.13	53.82
	F2	47.03	82.58	59.68	34.92
LG001B-0079L-IS	D5	15.18	n/a	n/a	n/a
	F2	12.65	n/a	n/a	n/a
LG001B-0250R-IS	D5	36.68	48.73	40.54	n/a
	F2	31.56	52.03	35.85	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LG002-0003L-IS	D5	0.794	n/a	n/a	n/a
	F2	0.779	n/a	n/a	n/a
LG002-0004L-IS	D5	1.098	n/a	n/a	n/a
	F2	1.03	n/a	n/a	n/a
LG002-0013L-IS	D5	3.506	n/a	n/a	n/a
	F2	3.057	n/a	n/a	n/a
LG002-0025L-IS	D5	6.23	n/a	n/a	n/a
	F2	5.381	n/a	n/a	n/a
LG002-0050L-IS	D5	10.99	n/a	n/a	n/a
	F2	9.097	n/a	n/a	n/a
LG002-0084L-IS	D5	15.86	n/a	n/a	n/a
	F2	13.23	n/a	n/a	n/a
LG002-0100L-IS	D5	17.99	15.03	n/a	n/a
	F2	15.07	15.04	n/a	n/a
LG002-0134L-IS	D5	22.39	24	n/a	n/a
	F2	18.91	24.58	n/a	n/a
LG002-0150L-IS	D5	24.42	27.21	n/a	n/a
	F2	20.69	28.93	n/a	n/a
LG002-0200L-IS	D5	30.64	38.52	29.54	n/a
	F2	26.18	40.98	27.26	n/a
LG002-0250L-IS	D5	36.68	48.73	40.54	n/a
	F2	31.56	52.03	35.85	n/a
LG002-0300L-IS	D5	42.55	58.27	49.81	37.72
	F2	36.83	62.56	43.68	n/a
LG002-0400L-IS	D5	53.83	76.21	66.13	53.82
	F2	47.03	82.58	59.68	34.92
LG002-0600L-IS	D5	74.95	110.8	95.53	83.35
	F2	66.43	120	88.92	60.36
LG002-0750R-IS	D5	89.87	136.1	116.3	101.9
	F2	80.32	143.5	106.7	73.94
LL002-1-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL002-2-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL002-3-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL002-4-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL003-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL003-0075L-UN	D5	0.049	n/a	n/a	n/a
	F2	0.064	n/a	n/a	n/a
LL003-0100L-UN	D5	0.064	n/a	n/a	n/a
	F2	0.083	n/a	n/a	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL003-0150L-UN	D5	0.093	n/a	n/a	n/a
	F2	0.12	n/a	n/a	n/a
LL003-0167L-UN	D5	0.156	n/a	n/a	n/a
	F2	0.201	n/a	n/a	n/a
LL003-0200L-UN	D5	0.121	n/a	n/a	n/a
	F2	0.155	n/a	n/a	n/a
LL003-0500L-UN	F2	389.3	399.4	278.9	221
LL004A-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL004B-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL004C-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LL004D-0050L-UN	D5	0.034	n/a	n/a	n/a
	F2	0.044	n/a	n/a	n/a
LG001A-0003L-UN	D5	0.794	n/a	n/a	n/a
	F2	0.779	n/a	n/a	n/a
LG001A-0004L-UN	D5	1.098	n/a	n/a	n/a
	F2	1.03	n/a	n/a	n/a
LG001A-0013L-UN	D5	3.506	n/a	n/a	n/a
	F2	3.057	n/a	n/a	n/a
LG001A-0025L-UN	D5	6.23	n/a	n/a	n/a
	F2	5.381	n/a	n/a	n/a
LG001A-0134L-UN	D5	22.39	24	n/a	n/a
	F2	18.91	24.58	n/a	n/a
LG001A-0400R-UN	D5	53.83	76.21	66.13	53.82
	F2	47.03	82.58	59.68	34.92
LG001B-0079L-UN	D5	15.18	n/a	n/a	n/a
	F2	12.65	n/a	n/a	n/a
LG001B-0250R-UN	D5	36.68	48.73	40.54	n/a
	F2	31.56	52.03	35.85	n/a
LG002-0003L-UN	D5	0.794	n/a	n/a	n/a
	F2	0.779	n/a	n/a	n/a
LG002-0004L-UN	D5	1.098	n/a	n/a	n/a
	F2	1.03	n/a	n/a	n/a
LG002-0013L-UN	D5	3.506	n/a	n/a	n/a
	F2	3.057	n/a	n/a	n/a
LG002-0025L-UN	D5	6.23	n/a	n/a	n/a
	F2	5.381	n/a	n/a	n/a
LG002-0050L-UN	D5	10.99	n/a	n/a	n/a
	F2	9.097	n/a	n/a	n/a
LG002-0084L-UN	D5	15.86	n/a	n/a	n/a
	F2	13.23	n/a	n/a	n/a
LG002-0100L-UN	D5	17.99	15.03	n/a	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	15.07	15.04	n/a	n/a
LG002-0134L-UN	D5	22.39	24	n/a	n/a
	F2	18.91	24.58	n/a	n/a
LG002-0150L-UN	D5	24.42	27.21	n/a	n/a
	F2	20.69	28.93	n/a	n/a
LG002-0200L-UN	D5	30.64	38.52	29.54	n/a
	F2	26.18	40.98	27.26	n/a
LG002-0250L-UN	D5	36.68	48.73	40.54	n/a
	F2	31.56	52.03	35.85	n/a
LG002-0300L-UN	D5	42.55	58.27	49.81	37.72
	F2	36.83	62.56	43.68	n/a
LG002-0400L-UN	D5	53.83	76.21	66.13	53.82
	F2	47.03	82.58	59.68	34.92
LG002-0750R-UN	D5	89.87	136.1	116.3	101.9
	F2	80.32	143.5	106.7	73.94

LNGC – Flash Fires

Scenario	Weather	Distance downwind to LFL [m]
LL002-1-0003L-IS	D5	0
	F2	0
LL002-1-0004L-IS	D5	9.149
	F2	14.73
LL002-1-0013L-IS	D5	29.13
	F2	38.23
LL002-1-0025L-IS	D5	48.83
	F2	56.1
LL002-1-0050L-IS	D5	87.55
	F2	85.51
LL002-1-0134L-IS	D5	211.8
	F2	167.3
LL002-1-0400R-IS	D5	273.3
	F2	177.2
LL002-2-0003L-IS	D5	0
	F2	0
LL002-2-0004L-IS	D5	9.01
	F2	30.06
LL002-2-0013L-IS	D5	24.4
	F2	76.16
LL002-2-0025L-IS	D5	45.15
	F2	67.72
LL002-2-0050L-IS	D5	85.88

Scenario	Weather	Distance downwind to LFL [m]
	F2	154.9
LL002-2-0134L-IS	D5	206.2
	F2	283.3
LL002-2-0400R-IS	D5	276.3
	F2	280.3
LL002-3-0003L-IS	D5	0
	F2	0
LL002-3-0004L-IS	D5	9.01
	F2	30.06
LL002-3-0013L-IS	D5	24.4
	F2	76.16
LL002-3-0025L-IS	D5	45.15
	F2	67.72
LL002-3-0050L-IS	D5	85.88
	F2	154.9
LL002-3-0134L-IS	D5	206.2
	F2	283.3
LL002-3-0400R-IS	D5	276.3
	F2	280.3
LL002-4-0003L-IS	D5	0
	F2	0
LL002-4-0004L-IS	D5	9.01
	F2	30.06
LL002-4-0013L-IS	D5	24.4
	F2	76.16
LL002-4-0025L-IS	D5	45.15
	F2	67.72
LL002-4-0050L-IS	D5	85.88
	F2	154.9
LL002-4-0134L-IS	D5	206.2
	F2	283.3
LL002-4-0400R-IS	D5	276.3
	F2	280.3
LL003-0003L-IS	D5	0
	F2	0
LL003-0004L-IS	D5	9.149
	F2	14.73
LL003-0013L-IS	D5	29.13
	F2	38.23
LL003-0025L-IS	D5	48.83
	F2	56.1
LL003-0038L-IS	D5	69.02
	F2	71.63
LL003-0050L-IS	D5	87.55
	F2	85.51

Scenario	Weather	Distance downwind to LFL [m]
LL003-0067L-IS	D5	111.9
	F2	112.4
LL003-0075L-IS	D5	123.5
	F2	130.1
LL003-0100L-IS	D5	161.5
	F2	164.1
LL003-0150L-IS	D5	232.7
	F2	176.7
LL003-0167L-IS	D5	252.9
	F2	179.9
LL003-0200L-IS	D5	288.5
	F2	179.6
LL003-0300L-IS	D5	430.7
	F2	327.6
LL003-0450L-IS	D5	430.7
	F2	327.6
LL003-0500L-IS	D5	430.7
	F2	327.6
LL003-0600R-IS	D5	430.7
	F2	327.6
LL004A-0003L-IS	D5	0
	F2	0
LL004A-0004L-IS	D5	9.01
	F2	30.06
LL004A-0013L-IS	D5	24.4
	F2	76.16
LL004A-0025L-IS	D5	45.15
	F2	67.72
LL004A-0050L-IS	D5	86
	F2	156.4
LL004A-0134L-IS	D5	206.2
	F2	282.9
LL004A-0400R-IS	D5	273.3
	F2	177.2
LL004B-0003L-IS	D5	8.655
	F2	28.99
LL004B-0004L-IS	D5	12.55
	F2	37.03
LL004B-0013L-IS	D5	31.51
	F2	47.36
LL004B-0025L-IS	D5	57.91
	F2	93.48
LL004B-0050L-IS	D5	107.8
	F2	201.1
LL004B-0134L-IS	D5	254.2

Scenario	Weather	Distance downwind to LFL [m]
	F2	299.9
LL004B-0400R-IS	D5	273.3
	F2	177.2
LL004C-0003L-IS	D5	8.655
	F2	28.99
LL004C-0004L-IS	D5	12.55
	F2	37.03
LL004C-0013L-IS	D5	31.51
	F2	47.36
LL004C-0025L-IS	D5	57.91
	F2	93.48
LL004C-0050L-IS	D5	107.8
	F2	201.1
LL004C-0134L-IS	D5	254.2
	F2	299.9
LL004C-0400R-IS	D5	273.3
	F2	177.2
LG001A-0003L-IS	D5	
	F2	
LG001A-0004L-IS	D5	
	F2	
LG001A-0013L-IS	D5	
	F2	
LG001A-0025L-IS	D5	
	F2	
LG001A-0134L-IS	D5	
	F2	
LG001A-0400R-IS	D5	
	F2	
LG001B-0079L-IS	D5	
	F2	
LG001B-0250R-IS	D5	
	F2	
LG002-0003L-IS	D5	
	F2	
LG002-0004L-IS	D5	
	F2	
LG002-0013L-IS	D5	
	F2	
LG002-0025L-IS	D5	
	F2	
LG002-0050L-IS	D5	
	F2	
LG002-0084L-IS	D5	
	F2	

Scenario	Weather	Distance downwind to LFL [m]
LG002-0100L-IS	D5	
	F2	
LG002-0134L-IS	D5	
	F2	
LG002-0150L-IS	D5	
	F2	
LG002-0200L-IS	D5	
	F2	
LG002-0250L-IS	D5	
	F2	
LG002-0300L-IS	D5	
	F2	
LG002-0400L-IS	D5	
	F2	
LG002-0600L-IS	D5	
	F2	
LG002-0750R-IS	D5	
	F2	
LL002-1-0003L-UN	D5	8.613
	F2	29.02
LL002-1-0004L-UN	D5	12.43
	F2	36.95
LL002-1-0013L-UN	D5	30.92
	F2	80.44
LL002-1-0025L-UN	D5	57
	F2	95.99
LL002-1-0050L-UN	D5	107.1
	F2	183.5
LL002-1-0134L-UN	D5	256.7
	F2	301.8
LL002-1-0400R-UN	D5	272.6
	F2	307.5
LL002-2-0003L-UN	D5	8.613
	F2	29.02
LL002-2-0004L-UN	D5	12.43
	F2	36.95
LL002-2-0013L-UN	D5	30.92
	F2	80.44
LL002-2-0025L-UN	D5	57
	F2	95.99
LL002-2-0050L-UN	D5	107.1
	F2	183.5
LL002-2-0134L-UN	D5	256.7
	F2	301.8
LL002-2-0400R-UN	D5	272.6

Scenario	Weather	Distance downwind to LFL [m]
	F2	307.5
LL002-3-0003L-UN	D5	8.613
	F2	29.02
LL002-3-0004L-UN	D5	12.43
	F2	36.95
LL002-3-0013L-UN	D5	30.92
	F2	80.44
LL002-3-0025L-UN	D5	57
	F2	95.99
LL002-3-0050L-UN	D5	107.1
	F2	183.5
LL002-3-0134L-UN	D5	256.7
	F2	301.8
LL002-3-0400R-UN	D5	272.6
	F2	307.5
LL002-4-0003L-UN	D5	8.613
	F2	29.02
LL002-4-0004L-UN	D5	12.43
	F2	36.95
LL002-4-0013L-UN	D5	30.92
	F2	80.44
LL002-4-0025L-UN	D5	57
	F2	95.99
LL002-4-0050L-UN	D5	107.1
	F2	183.5
LL002-4-0134L-UN	D5	256.7
	F2	301.8
LL002-4-0400R-UN	D5	272.6
	F2	307.5
LL003-0003L-UN	D5	8.613
	F2	29.02
LL003-0004L-UN	D5	12.43
	F2	36.95
LL003-0013L-UN	D5	30.92
	F2	80.44
LL003-0025L-UN	D5	57
	F2	95.99
LL003-0038L-UN	D5	82.34
	F2	148.2
LL003-0050L-UN	D5	107.1
	F2	183.5
LL003-0067L-UN	D5	139.3
	F2	216
LL003-0075L-UN	D5	153.5
	F2	230.9

Scenario	Weather	Distance downwind to LFL [m]
LL003-0100L-UN	D5	199.3
	F2	270.7
LL003-0150L-UN	D5	281.6
	F2	308.1
LL003-0167L-UN	D5	306
	F2	305.4
LL003-0200L-UN	D5	353.5
	F2	288.6
LL003-0300L-UN	D5	496.9
	F2	282.6
LL003-0450L-UN	D5	496.9
	F2	282.6
LL003-0500L-UN	D5	502.5
	F2	265.6
LL003-0600R-UN	D5	496.9
	F2	282.6
LL004A-0003L-UN	D5	8.613
	F2	29.02
LL004A-0004L-UN	D5	12.43
	F2	36.95
LL004A-0013L-UN	D5	30.92
	F2	80.44
LL004A-0025L-UN	D5	57
	F2	95.99
LL004A-0050L-UN	D5	107
	F2	184.5
LL004A-0134L-UN	D5	256.7
	F2	302
LL004A-0400R-UN	D5	286.2
	F2	277.8
LL004B-0003L-UN	D5	8.613
	F2	29.02
LL004B-0004L-UN	D5	12.43
	F2	36.95
LL004B-0013L-UN	D5	30.92
	F2	80.44
LL004B-0025L-UN	D5	57
	F2	95.99
LL004B-0050L-UN	D5	107
	F2	184.5
LL004B-0134L-UN	D5	256.7
	F2	302
LL004B-0400R-UN	D5	276.3
	F2	280.3
LL004C-0003L-UN	D5	8.613

Scenario	Weather	Distance downwind to LFL [m]
	F2	29.02
LL004C-0004L-UN	D5	12.43
	F2	36.95
LL004C-0013L-UN	D5	30.92
	F2	80.44
LL004C-0025L-UN	D5	57
	F2	95.99
LL004C-0050L-UN	D5	107
	F2	184.5
LL004C-0134L-UN	D5	256.7
	F2	302
LL004C-0400R-UN	D5	272.6
	F2	307.5
LL004D-0003L-UN	D5	8.613
	F2	29.02
LL004D-0004L-UN	D5	12.43
	F2	36.95
LL004D-0013L-UN	D5	30.92
	F2	80.44
LL004D-0025L-UN	D5	57
	F2	95.99
LL004D-0050L-UN	D5	107
	F2	184.5
LL004D-0134L-UN	D5	256.7
	F2	302
LL004D-0400R-UN	D5	272.6
	F2	307.5

LNGC – Pool Fires

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL002-1-0003L-IS	D5	0.866	2.009	1.017	n/a
	F2	0.866	1.893	0.901	n/a
LL002-1-0004L-IS	D5	1.155	3.042	2.018	n/a
	F2	1.155	2.861	1.654	n/a
LL002-1-0013L-IS	D5	3.752	15.53	11.18	4.885
	F2	3.752	14.81	10.19	4.094
LL002-1-0025L-IS	D5	7.216	35.54	25.33	14.79
	F2	7.216	34.21	23.37	11.53
LL002-1-0050L-IS	D5	14.43	76.49	54.01	34.75
	F2	14.43	73.87	50.1	27.29
LL002-1-0134L-IS	D5	38.68	183.4	127.8	82

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	38.68	177	119.4	66.24
LL002-1-0400R-IS	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL002-2-0003L-IS	D5	0.866	2.009	1.017	n/a
	F2	0.866	1.893	0.901	n/a
LL002-2-0004L-IS	D5	1.155	3.042	2.018	n/a
	F2	1.155	2.861	1.654	n/a
LL002-2-0013L-IS	D5	3.752	15.53	11.18	4.885
	F2	3.752	14.81	10.19	4.094
LL002-2-0025L-IS	D5	7.216	35.54	25.33	14.79
	F2	7.216	34.21	23.37	11.53
LL002-2-0050L-IS	D5	14.43	76.49	54.01	34.75
	F2	14.43	73.87	50.1	27.29
LL002-2-0134L-IS	D5	38.68	183.4	127.8	82
	F2	38.68	177	119.4	66.24
LL002-2-0400R-IS	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL002-3-0003L-IS	D5	0.866	2.009	1.017	n/a
	F2	0.866	1.893	0.901	n/a
LL002-3-0004L-IS	D5	1.155	3.042	2.018	n/a
	F2	1.155	2.861	1.654	n/a
LL002-3-0013L-IS	D5	3.752	15.53	11.18	4.885
	F2	3.752	14.81	10.19	4.094
LL002-3-0025L-IS	D5	7.216	35.54	25.33	14.79
	F2	7.216	34.21	23.37	11.53
LL002-3-0050L-IS	D5	14.43	76.49	54.01	34.75
	F2	14.43	73.87	50.1	27.29
LL002-3-0134L-IS	D5	38.68	183.4	127.8	82
	F2	38.68	177	119.4	66.24
LL002-3-0400R-IS	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL002-4-0003L-IS	D5	0.866	2.009	1.017	n/a
	F2	0.866	1.893	0.901	n/a
LL002-4-0004L-IS	D5	1.155	3.042	2.018	n/a
	F2	1.155	2.861	1.654	n/a
LL002-4-0013L-IS	D5	3.752	15.53	11.18	4.885
	F2	3.752	14.81	10.19	4.094
LL002-4-0025L-IS	D5	7.216	35.54	25.33	14.79
	F2	7.216	34.21	23.37	11.53
LL002-4-0050L-IS	D5	14.43	76.49	54.01	34.75
	F2	14.43	73.87	50.1	27.29
LL002-4-0134L-IS	D5	38.68	183.4	127.8	82
	F2	38.68	177	119.4	66.24

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL002-4-0400R-IS	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL003-0003L-IS	D5	0.866	2.009	1.017	n/a
	F2	0.866	1.893	0.901	n/a
LL003-0004L-IS	D5	1.155	3.042	2.018	n/a
	F2	1.155	2.861	1.654	n/a
LL003-0013L-IS	D5	3.752	15.53	11.18	4.885
	F2	3.752	14.81	10.19	4.094
LL003-0025L-IS	D5	7.216	35.54	25.33	14.79
	F2	7.216	34.21	23.37	11.53
LL003-0038L-IS	D5	10.82	56.57	40.11	25.58
	F2	10.82	54.59	37.12	19.82
LL003-0050L-IS	D5	14.43	76.49	54.01	34.75
	F2	14.43	73.87	50.1	27.29
LL003-0067L-IS	D5	19.34	101.4	71.32	45.95
	F2	19.34	97.96	66.31	36.48
LL003-0075L-IS	D5	21.65	112.4	78.91	50.83
	F2	21.65	108.5	73.42	40.49
LL003-0100L-IS	D5	28.86	144.2	100.8	64.85
	F2	28.86	139.2	94.03	52.04
LL003-0150L-IS	D5	43.3	200.8	139.7	89.59
	F2	43.3	193.9	130.7	72.56
LL003-0167L-IS	D5	48.2	218.7	152	97.42
	F2	48.2	211.3	142.3	79.08
LL003-0200L-IS	D5	57.73	252.4	175.1	112.1
	F2	57.73	244	164.1	91.36
LL003-0300L-IS	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL003-0450L-IS	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL003-0500L-IS	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL003-0600R-IS	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL004A-0003L-IS	D5	0.866	2.009	1.017	n/a
	F2	0.866	1.893	0.901	n/a
LL004A-0004L-IS	D5	1.155	3.042	2.018	n/a
	F2	1.155	2.861	1.654	n/a
LL004A-0013L-IS	D5	3.752	15.53	11.18	4.885
	F2	3.752	14.81	10.19	4.094
LL004A-0025L-IS	D5	7.216	35.54	25.33	14.79
	F2	7.216	34.21	23.37	11.53
LL004A-0050L-IS	D5	14.43	76.49	54.01	34.75

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	14.43	73.87	50.1	27.29
LL004A-0134L-IS	D5	38.68	183.4	127.8	82
	F2	38.68	177	119.4	66.24
LL004A-0400R-IS	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL004B-0003L-IS	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL004B-0004L-IS	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL004B-0013L-IS	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL004B-0025L-IS	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL004B-0050L-IS	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL004B-0134L-IS	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL004B-0400R-IS	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL004C-0003L-IS	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL004C-0004L-IS	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL004C-0013L-IS	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL004C-0025L-IS	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL004C-0050L-IS	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL004C-0134L-IS	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL004C-0400R-IS	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL002-1-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL002-1-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL002-1-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL002-1-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL002-1-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL002-1-0134L-UN	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL002-1-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL002-2-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL002-2-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL002-2-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL002-2-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL002-2-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL002-2-0134L-UN	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL002-2-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL002-3-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL002-3-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL002-3-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL002-3-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL002-3-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL002-3-0134L-UN	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL002-3-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL002-4-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL002-4-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL002-4-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL002-4-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL002-4-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL002-4-0134L-UN	D5	49.43	223.1	155	99.34

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	49.43	215.6	145.1	80.69
LL002-4-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL003-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL003-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL003-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL003-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL003-0038L-UN	D5	13.83	73.27	51.77	33.28
	F2	13.83	70.76	48.01	26.1
LL003-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL003-0067L-UN	D5	24.71	126.3	88.51	56.98
	F2	24.71	121.9	82.44	45.55
LL003-0075L-UN	D5	27.66	139.1	97.35	62.62
	F2	27.66	134.3	90.74	50.2
LL003-0100L-UN	D5	36.88	176.5	123	78.99
	F2	36.88	170.3	114.9	63.74
LL003-0150L-UN	D5	55.33	244	169.4	108.4
	F2	55.33	235.9	158.7	88.31
LL003-0167L-UN	D5	61.6	265.7	184.2	117.9
	F2	61.6	256.9	172.7	96.23
LL003-0200L-UN	D5	73.77	306.3	212.1	135.6
	F2	73.77	296.4	199.2	111.2
LL003-0300L-UN	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL003-0450L-UN	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL003-0500L-UN	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL003-0600R-UN	D5	107.3	411.6	285	181.4
	F2	107.3	398.8	267.7	150.2
LL004A-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL004A-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL004A-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL004A-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL004A-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL004A-0134L-UN	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL004A-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL004B-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL004B-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL004B-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL004B-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL004B-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL004B-0134L-UN	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL004B-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL004C-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL004C-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL004C-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL004C-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL004C-0050L-UN	D5	18.44	97.06	68.29	44
	F2	18.44	93.73	63.47	34.87
LL004C-0134L-UN	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL004C-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15
LL004D-0003L-UN	D5	1.107	2.862	1.823	n/a
	F2	1.107	2.692	1.52	n/a
LL004D-0004L-UN	D5	1.475	4.307	3.15	0.931
	F2	1.475	4.052	2.65	0.931
LL004D-0013L-UN	D5	4.795	21.38	15.27	7.707
	F2	4.795	20.48	14.05	6.138
LL004D-0025L-UN	D5	9.221	47.33	33.63	21.06
	F2	9.221	45.64	31.08	16.21
LL004D-0050L-UN	D5	18.44	97.06	68.29	44

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
	F2	18.44	93.73	63.47	34.87
LL004D-0134L-UN	D5	49.43	223.1	155	99.34
	F2	49.43	215.6	145.1	80.69
LL004D-0400R-UN	D5	53.64	238.1	165.3	105.9
	F2	53.64	230.1	154.8	86.15

Ship to Ship Transfer

STS - Release Flowrates

Scenario	Weather	Peak Flowrate [kg/s]
Refer to main report		

STS – Jet Fires

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL005A-0015R-IS HOSE	F2	241.371	229.887	166.908	129.448
LL005A-0200R2-IS HOSE	F2	271.186	266.776	189.693	150.285

STS – Flash Fires

Scenario	Weather	Distance downwind to LFL [m]
LL005A-0005L-IS HOSE	D5	12.97
	F2	24
LL005A-0015R-IS HOSE	D5	297.5
	F2	189.4
LL005A-0200R2-IS HOSE	D5	335.8
	F2	188.5
LL005A-0005L-UN HOSE	D5	12.89
	F2	22.84
LL005A-0015R-UN HOSE	D5	291.5
	F2	306.2
LL005A-0200R-UN HOSE	D5	342.1
	F2	300.8

STS – Pool Fires

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL005A-0005L-IS HOSE	D5	1.443	4.175	3.05	0.91
	F2	1.443	3.927	2.542	0.91
LL005A-0015R-IS HOSE	D5	57.73	252.4	175.1	112.1
	F2	57.73	244	164.1	91.36

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
LL005A-0200R2-IS HOSE	D5	69.46	292.1	202.3	129.4
	F2	69.46	282.6	189.9	105.9
LL005A-0005L-UN HOSE	D5	1.443	4.175	3.05	0.91
	F2	1.443	3.927	2.542	0.91
LL005A-0015R-UN HOSE	D5	57.73	252.4	175.1	112.1
	F2	57.73	244	164.1	91.36
LL005A-0200R-UN HOSE	D5	69.46	292.1	202.3	129.4
	F2	69.46	282.6	189.9	105.9

Ship Collisions

Ship Collision - Release Flowrates

Scenario	Weather	Peak Flowrate [kg/s]
Large (LNGC or FSRU)	D5	3131
	F2	3131
Small (LNGC or FSRU)	D5	7.548
	F2	7.548

Ship Collision – Jet Fires

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
Small (LNGC or FSRU)	D5	31.08	52.08	40.13	32.69
	F2	37.52	54.89	41.93	39.43

Ship Collision – Flash Fires

Scenario	Weather	Distance downwind to LFL [m]
Large (LNGC or FSRU)	D5	712.747
	F2	343.664
Small (LNGC or FSRU)	D5	76.291
	F2	84.1259

Ship Collision – Pool Fires

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
Large (LNGC or FSRU)	D5	168.155	641.187	406.858	257.691
	F2	168.155	625.328	382.168	215.916
Small (LNGC or FSRU)	D5	7.53443	45.1831	31.2476	20.3856
	F2	7.64169	44.8304	29.5208	17.0787

Odorant

Odorant - Release Flowrates

Scenario	Weather	Peak Flowrate [kg/s]
ML-001A-CAT-U	D5	n/a
	F2	n/a
ML-001A-050-U	D5	22.91
	F2	22.91
ML-001A-025-U	D5	5.727
	F2	5.727
ML-001A-013-U	D5	1.548
	F2	1.548
ML-001A-006-U	D5	0.33
	F2	0.33
ML-001B-CAT-U	D5	n/a
	F2	n/a
ML-001B-050-U	D5	22.91
	F2	22.91
ML-001B-025-U	D5	5.727
	F2	5.727
ML-001B-013-U	D5	1.548
	F2	1.548
ML-001B-006-U	D5	0.33
	F2	0.33
ML-002-15-I	D5	2.062
	F2	2.062
ML-002-005-I	D5	0.229
	F2	0.229
ML-002-15-I	D5	2.062
	F2	2.062
ML-002-005-I	D5	0.229
	F2	0.229

Odorant – Jet Fires

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
ML-001A-050-U	D5	45.56	81.77	61.66	48.05
	F2	57.2	89.94	68.08	59.6
ML-001A-025-U	D5	27.36	47.23	35.71	29
	F2	34.39	52.07	39.6	36.22
ML-001A-013-U	D5	16.6	27.66	20.94	17.97
	F2	20.91	30.59	23.19	n/a

Scenario	Weather	Flame length [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
ML-001A-006-U	D5	9.012	14.42	10.88	10.05
	F2	11.38	15.99	12.61	n/a
ML-001B-050-U	D5	45.56	81.77	61.66	48.05
	F2	57.2	89.94	68.08	59.6
ML-001B-025-U	D5	27.36	47.23	35.71	29
	F2	34.39	52.07	39.6	36.22
ML-001B-013-U	D5	16.6	27.66	20.94	17.97
	F2	20.91	30.59	23.19	n/a
ML-001B-006-U	D5	9.012	14.42	10.88	10.05
	F2	11.38	15.99	12.61	n/a
ML-002-050-I	D5	25.66	44.1	33.35	27.26
	F2	32.26	48.63	36.97	34.04
ML-002-15-I	D5	18.56	31.15	23.58	19.97
	F2	23.34	34.41	26.11	24.89
ML-002-005-I	D5	7.781	12.33	9.313	8.659
	F2	9.826	13.69	10.97	n/a
ML-002-050-I	D5	25.66	44.1	33.35	27.26
	F2	32.26	48.63	36.97	34.04
ML-002-15-I	D5	18.56	31.15	23.58	19.97
	F2	23.34	34.41	26.11	24.89
ML-002-005-I	D5	7.781	12.33	9.313	8.659
	F2	9.826	13.69	10.97	n/a

Odorant – Flash Fires

Scenario	Weather	Distance downwind to LFL [m]
ML-001A-CAT-U	D5	132.1
	F2	160.1
ML-001A-050-U	D5	60.31
	F2	89.54
ML-001A-025-U	D5	28.48
	F2	49.13
ML-001A-013-U	D5	5.034
	F2	21.46
ML-001A-006-U	D5	
	F2	0.004
ML-001B-CAT-U	D5	132.1
	F2	160.1
ML-001B-050-U	D5	60.31
	F2	89.54
ML-001B-025-U	D5	28.48
	F2	49.13

Scenario	Weather	Distance downwind to LFL [m]
ML-001B-013-U	D5	5.034
	F2	21.46
ML-001B-006-U	D5	
	F2	0.004
ML-002-050-I	D5	8.118
	F2	15.3
ML-002-15-I	D5	7.092
	F2	10.9
ML-002-005-I	D5	
	F2	5.781
ML-002-050-I	D5	8.118
	F2	15.3
ML-002-15-I	D5	6.03
	F2	20.23
ML-002-005-I	D5	
	F2	6.636

Odorant – Pool Fires

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
ML-001A-050-U	D5	20.27	72.49	50.47	29.3
	F2	20.43	70.44	46.83	25.83
ML-001A-025-U	D5	9.897	40.83	29.49	15.86
	F2	9.987	39.29	26.79	14.57
ML-001A-013-U	D5	5.047	24.54	18.41	9.683
	F2	5.095	23.17	16.16	8.959
ML-001A-006-U	D5	2.289	14.14	10.97	6.512
	F2	2.311	12.76	8.85	5.684
ML-001B-050-U	D5	20.27	72.49	50.47	29.3
	F2	20.43	70.44	46.83	25.83
ML-001B-025-U	D5	9.897	40.83	29.49	15.86
	F2	9.987	39.29	26.79	14.57
ML-001B-013-U	D5	5.047	24.54	18.41	9.683
	F2	5.095	23.17	16.16	8.959
ML-001B-006-U	D5	2.289	14.14	10.97	6.512
	F2	2.311	12.76	8.85	5.684
ML-002-050-I	D5	7.558	33.51	24.65	13.35
	F2	7.738	32.43	22.42	12.38
ML-002-15-I	D5	5.32	25.68	19.24	10.17
	F2	5.462	24.6	17.17	9.537
ML-002-005-I	D5	1.901	12.53	9.538	6.033
	F2	1.92	11.13	7.631	5.125

Scenario	Weather	Pool diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.5 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
ML-002-050-I	D5	7.558	33.51	24.65	13.35
	F2	7.738	32.43	22.42	12.38
ML-002-15-I	D5	5.845	27.36	20.35	10.72
	F2	5.903	25.96	18.02	9.901
ML-002-005-I	D5	1.901	12.53	9.538	6.033
	F2	1.92	11.13	7.631	5.125

Odorant – Fireball/BLEVE

Scenario	Weather	Fireball Diameter [m]	Distance downwind to 4 kW/m2 [m]	Distance downwind to 12.7 kW/m2 [m]	Distance downwind to 37.5 kW/m2 [m]
ML-001A-CAT-U	D5	65.62	132.9	73.32	35.55
	F2	65.62	132.9	73.32	35.55
ML-001B-CAT-U	D5	65.62	132.9	73.32	35.55
	F2	65.62	132.9	73.32	35.55

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Vysus Group

Report for

Shannon LNG Limited

Shannon Technology and Energy Park (STEP) – Preliminary MATTE Assessment

Summary

Shannon Technology and Energy Park (STEP) – Preliminary MATTE Assessment

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00	CJS	LHW	MKF	05/08/2021	Initial Issue
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Executive summary

A preliminary assessment of Major Accidents to the Environment (MATTE) has been undertaken for the proposed Shannon Technology and Energy Park (STEP). Based on qualitative assessment of possible scenarios for accidental releases from the STEP has indicated that large quantities of the following materials have the potential for causing a MATTE:

- **Odorant NB** – this material is classed as being hazardous to the environment under the COMAH Regulations and any scenarios where large quantities of the material are released to the aqueous environment can be considered a MATTE.
- **Transformer Oil –** transformer oil may be hazardous to the environment depending on its chemical composition and a significant release to the estuary could result in a MATTE.
- **Firefighting Water -** the water may be contaminated with materials that are toxic to the environment and, as such, a release of a large quantity of firefighting water into the Shannon estuary may also lead to a MATTE.

All of the identified MATTE events are considered to be low risk, as the initiating event for a release would be a significant fire or explosion on the LNG Terminal or Power Plant and measures for prevention of discharge to the estuary are present within the plant design and operating philosophy.

It is recommended that a quantitative assessment of MATTE is undertaken when the STEP is at detailed design.

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Glossary

Abbreviation	Description
AGI	Above Ground Installation
BESS	Battery Energy Storage Facility
BLEVE	Boiling Liquid Expanding Vapour Explosion
CCGT	Combined Cycle Gas Turbines
CDOIF	Chemical and Downstream Oil Industries Forum
CHP	Combined Heat and Power
COMAH	Control of Major Accident Hazards
EIAR	Environmental Impact Assessment Report
EU	European Union
FSRU	Floating Storage and Regasification Unit
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
HNS	Hazardous and Noxious Substances
HRD	Hydrocarbon Release Database
HSA	Health and Safety Authority
IMO	International Maritime Organization
IPIECA	International Petroleum Industry Environmental Conservation Association
KCC	Kerry County Council
LFL	Lower Flammability Limit
LNG	Liquified Natural Gas
LNGC	Liquified Natural Gas Carrier
MARPOL	International Convention for the Prevention of Pollution from Ships
MATTE	Major Accidents to the Environment
MSDS	Material Safety Data Sheet
NCP	National Contingency Plan

NECP	National Energy & Climate Plan
NHA	National Heritage Area
OCEMP	Construction Environmental Management Plan (OCEMP).
QRA	Quantitative Risk Assessment
SAC	Special Area of Conservation
SEAPT	Shannon Estuary Anti-Pollution Team
SIGTTO	The Society of International Gas Tanker and Terminal Operators
SPA	Special Protection Area
SPZ	Source Protection Zone
STEP	Shannon Technology and Energy Park
STS	Ship to Ship
UPS	Uninterruptible Power Supply
WFD	Water Framework Directive

1. Introduction

1.1 Project Background

The Shannon Technology and Energy Park (STEP) consists of a Liquefied Natural Gas (LNG) Terminal, Power Plant and Above Ground Installation (AGI). The STEP addresses Ireland's significant security of supply policy goals and provides additional flexible power generation capacity to support intermittent renewable generation and resolve a predicted generation capacity shortfall.

Ireland's Climate Action Plan[1], sets a target of 70% of electricity to be generated from renewable sources by 2030. It also commits to an early and complete phase-out of coal and peat-fired electricity generation. This leaves natural gas as being the only back up for intermittent wind generation at that point.

But despite its reliance on natural gas for renewable energy support, Ireland has very limited supply sources of natural gas. The country's sole gas field, Corrib, is rapidly declining by about 20% per year, resulting in a growing reliance on UK imports to meet its gas demand. Ireland currently imports over 50% of its gas needs from the UK via a single supply point and these imports will grow to over 80% by 2025 and 90% by 2030. The impact of losing this single gas supply from the UK has been assessed[2] by the Commission for Energy Regulation (CRU) as being *"disastrous"* for electricity production in Ireland.

Recently[3], the Minister for the Environment, Climate and Communications has also noted "*the UK has left the European Union which will lead, at the end of the withdrawal period, to difficulties for Ireland in meeting the requirements of EU law in relation to gas security of supply including potential challenges for future compliance with EU law including the "N-1" infrastructure standard and the supply standard*"

Consequently, Government polices clearly support the urgent need for the development. For example, the *National Energy & Climate Plan (NECP) 2021-2030* contains a policy goal to support natural gas infrastructure projects, such as the STEP, that enhance Ireland's security of supply. Eirgrid's *All-Island Generation capacity Statement 2020-2029* confirms the need for additional conventional power plants. The new power generators at STEP will have the ability to transition to future technologies, such as hydrogen as an alternative fuel source, in the medium to long term.

The STEP addresses Ireland's significant gas security of supply concerns and provides additional flexible power generation capacity to support intermittent renewable generation and resolve a predicted generation capacity shortfall.

The Shannon Estuary comprises 500 km^2 of navigable water extending from Loop Head, in County Clare, and Kerry Head, in County Kerry, eastwards to the city of Limerick, a distance of 100 km. The naturally occurring deep and sheltered waters of the estuary are connected to the Atlantic Ocean and are accessible to large ocean-going vessels of varying types and sizes of up to 185,000 deadweight tonnes (dwt).

The Proposed Development will be comprised of two main components:

1. A Power Plant; and,
2. An LNG Terminal.

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1 Climate Action Plan 2019. Department of the Environment, Climate and Communications. 17th June 2019
2 Identification of National Electricity Crisis Scenarios for Ireland. CRU/20/138. Commission for energy regulation. 20/11/2020
3 Request for Tenders dated 2 November 2020 for the provision of Consultancy Services to undertake a Technical Analysis to inform a Review of the Security of Energy Supply of Ireland's Electricity and Natural Gas Systems

LNG is natural gas that has been cooled to approximately minus 160 degrees centigrade, at which point it becomes a liquid at atmospheric pressure. As a liquid, the volume of natural gas is approximately 600 times less than the volume of the equivalent amount in the gaseous stage, making it more manageable for storage and ocean transportation. LNG is stored and transported in insulated tanks operating at pressures slightly above normal atmospheric pressure.

LNG is produced primarily in locations with large gas reserves which are too distant from market areas to be transported economically by pipeline. The natural gas from these fields is gathered and brought by pipeline to liquefaction plants where it is liquefied, pumped into LNG storage tanks and then loaded onto LNG ships and transported to the market areas of the world. Ireland is one of very few countries in Western Europe with a national gas distribution network that does not have an LNG import terminal. Once the LNG is delivered to the regasification terminal, the liquid is unloaded into the storage tanks, converted back into gas and transmitted via the gas pipeline system.

The previously consented 26 km 30” Shannon Pipeline (planning reference: PL08.GA0003), once constructed, will facilitate transport of the natural gas from the Proposed Development site to the national gas network at Foynes.

The Power Plant will generate power for its own needs and for the LNG Terminal, and for sale to the market via the national electricity grid exported via a 220 kV connection, which will be subject to a separate planning application. An application to connect to the national electrical transmission system via this 220 kV connection was submitted to EirGrid in September 2020. An offer has yet to be received. Once the connection offer is made, this 220 kV connection will be subject to a separate planning application.

The Proposed Development has a flexible design that will be able to accommodate alternative low carbon fuels in future. The location of the Proposed Development site will provide access to future offshore renewable projects around the world, combined with facilities for the production and landing of hydrogen. This would contribute to the decarbonisation of Ireland’s energy system by providing long term hydrogen energy storage (produced onsite or into the national gas transmission system), renewable energy storage (through the BESS) and direct electricity generation at the Power Plant. The modular Power Plant offers flexibility to incorporate alternative fuels, and the modern nature of the LNG Terminal will ensure it can easily be adapted in future. Refer to New Fortress Energy Inc.’s ‘A Step Towards a Zero Carbon Future’ policy for further details.

The LNG Terminal could also be operational before the Power Plant and the 220 kV grid connection are completed. Therefore, a medium voltage (10/ 20 kV) connection to supply power to the LNG Terminal in the absence of the 600 MW Power Plant will be required. This medium voltage connection will also be subject to a separate planning application.

The Masterplan for STEP will integrate the Proposed Development and a (future) Data Centre Campus. The Data Centre Campus is not included in this application and will therefore be subject to a separate planning application. The Data Centre Campus, the 220 kV and the medium voltage (10/ 20 kV) cables have been considered as part of the cumulative impact assessment.

Planning consents were previously granted by ABP for the development of an LNG Terminal (2007) and a Combined Heat and Power Plant (CHP) (2012) on the Proposed Development site. The current application is a new Strategic Infrastructure Development (SID) application and does not rely on any of the previous planning applications. A Site Selection Assessment has been undertaken by AECOM in 2021 and a report prepared. The report concluded that Ballylongford / Tarbert landbank is the most suitable location to accommodate and safely operate the Proposed Development.

The location offers the following:

- A large unoccupied landbank on the coast which is zoned for industrial purposes adjacent to the foreshore;
- Access to water depth greater than 13 m;
- A navigational channel of uniform cross-sectional depth suitable for LNG carriers including the largest vessel;
- Turning circle for LNG ships that provide adequate turning space of up to approximately 690 m;
- Space outside the main navigation channel for a marine control zone around the LNGC and FSRU;
- Protection from swell waves from the Atlantic and is only subject to locally generated wind waves;
- Access to high-capacity gas transmission system that can receive up to 800 mmscf/d;
- The ability to get a high voltage export grid connection offer within the generation capacity shortfall time window[4]; and
- Access to high-capacity electricity grid (220 kV or higher) that can export 600 MW without undue system constraint.

4 Shannon LNG Limited made a successful high voltage grid application under Enduring Connection Policy (ECP2.1)

1.2 Location and Surroundings

As stated above, STEP is planned for the south bank of the Shannon estuary between Tarbert and Ballylongford in County Kerry, Ireland; this location is shown in Figure 1-1 (marked in red).

The STEP is to be located on a circa 200 acre site on the Shannon Estuary at Ralappane, between Tarbert and Ballylongford in Co. Kerry and accessed off the existing L-1010 (Coast Road).

The *Kerry County Development Plan 2015-2021* has zoned the site 'Industry' as part of the Tarbert/Ballylongford Land Bank, and more specifically for marine related industry and compatible industries requiring deep water access.

Figure 1-1: Site Location

Figure 1-2 provides an overview of the site.

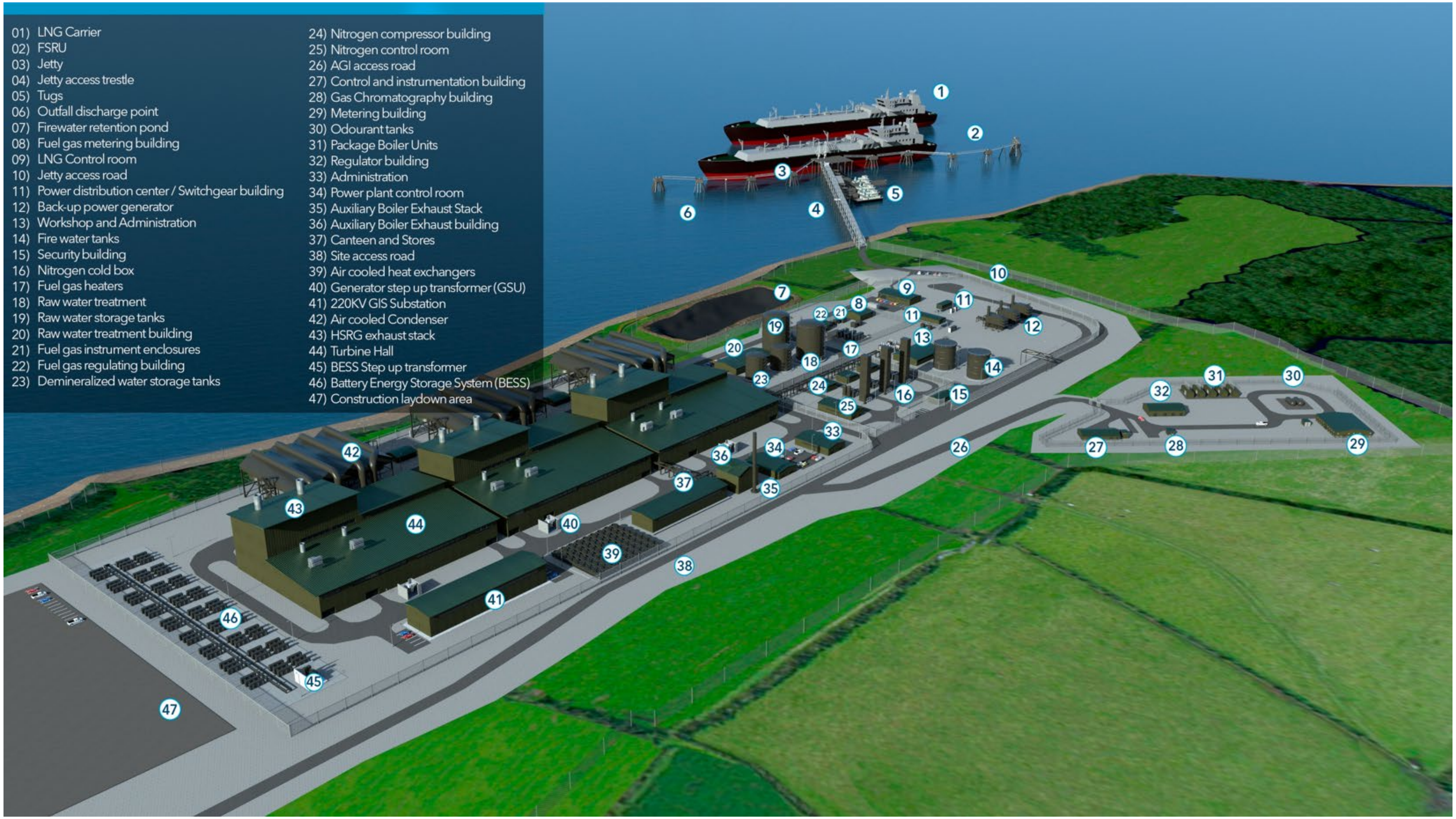


Figure 1-2: Proposed Site Overview

1.3 STEP Summary

The STEP consists of two main components:

1. LNG Terminal
2. Power Plant.

The proposed LNG Terminal will comprise of:

- A floating storage regasification unit (FSRU), which will have an LNG storage capacity of up to 180,000 m^3. The LNG vaporisation process equipment to regasify the LNG to natural gas shall be on-board the FSRU. The heat for LNG regasification shall be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. Loading of LNG onto the FSRU shall be via a ship to ship transfer from another LNG carrier (LNGC) berthed alongside.
- Jetty and access trestle, with the jetty comprising of an unloading platform, mooring dolphins and breasting dolphins.
- Four tugboats moored on the proposed jetty for FSRU and LNG carrier mooring operations.
- Onshore facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator, fire water system.
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, gas metering and pressure control equipment. The AGI facilitates the connection of the LNG terminal to the consented 26 km Shannon Pipeline.

The proposed Power Plant will comprise of:

- A flexible modular power plant design with up to three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of circa 200 MW for a total installed capacity of up to 600 MW. The multishaft arrangement of the power plant provides fast acting response with very low minimum stable generation and is ideally suited to support increased intermittent renewable generation.
- Each block shall comprise of two (2) gas turbine generators, two (2) heat recovery steam generator and one (1) steam turbine generator and an air-cooled condenser.
- A 120 MW for 1 hour (120 MWhr) Battery energy storage facility (BESS). Due to its very fast response, the BESS supports intermittent renewable generation.

The STEP will supply up to 22.6 MMscm/d (800 MMscf/d) of natural gas to the Irish gas transmission system via the previously consented 26 km Shannon Pipeline.

An application to connect to the national electrical transmission system via a 220 kV connection was submitted to EirGrid in September 2020. An offer has yet to be received. It is expected that the connection will run 5 km east under the L-1010 road to the Eirgrid Killpaddogue 220 kV substation. Once the connection offer is made, this 220 kV connection will be subject to a separate planning design and planning application.

1.3.1 Pollution Mitigation and Response

The risk of marine pollution from the operation of the Proposed Development has been considered and reduced as far as possible. Specifically, the assessment of likelihood and consequences of release events from the Proposed Development are set out in the relevant sections of the following documents:

- Marine Navigation Risk Assessment;
- Quantitative Risk Assessment (QRA);
- Environmental Impact Assessment Report (EIAR); and,
- Construction Environmental Management Plan (OCEMP).

Additionally, the operation of the Proposed Development will be controlled and regulated by the following bodies:

- Environmental Protection Agency;
- Commission for Regulation of Utilities;
- Health and Safety Authority; and,
- Local Planning Authority (KCC).

The Shannon Foynes Port Company has statutory jurisdiction over marine activities. In consultation with Shannon Foynes Port Company and the Shannon Estuary Anti-Pollution Team (SEAPT), Shannon LNG Limited has prepared an Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework for the Proposed Development. This document describes the framework in which Shannon LNG Limited will develop plans to provide a graduated, tiered and coordinated response to release incidents in the unlikely event they should occur. The developed plans will follow international best practice guidelines of the International Maritime Organization (IMO), The Society of International Gas Tanker and Terminal Operators (SIGTTO), and International Petroleum Industry Environmental Conservation Association (IPIECA) while taking into account relevant Irish legislative and regulatory approval requirements. In particular the plans will follow the requirements made within the National Maritime Contingency Plan Oil and HNS Spills 2019 (National Contingency Plan, NCP) and the National Framework for the Management of Major Emergencies. The plans will be developed to cover both In-Land (onshore) and Marine based releases and shall cover the Construction and Operational Phases of the project.

1.3.1.1 The Shannon Estuary Anti-Pollution Team (SEAPT)

The Shannon Estuary Anti-Pollution Team (SEAPT) is a Mutual Aid Group and the primary response organisations for oil and HNS spills within the Shannon Estuary. The SEAPT consists of the Shannon Foynes Port company, Kerry, Limerick and Clare Local Authorities and commercial and industrial entities operating within the Shannon Estuary. SEAPT was initiated to form a unified coordinated response to pollution incidents on the Shannon Estuary. SEAPT is a member’s organisation. Members contribute annually to maintain equipment, carry out exercises and training, and purchase new and replacement equipment. SEAPT holds a significant stockpile of equipment. This equipment is available to respond to any pollution incident or threat thereof. The Proposed Development will also be able to avail of spill dispersion modelling capability held by SEAPT. SEAPT are also the custodians of the Shannon Estuary Oil/ HNS Contingency Plan developed in accordance with the NCP and approved by the Irish Coast Guard. Shannon LNG Limited has consulted extensively with SEAPT and the intention is to join the SEAPT organisation on successfully receiving development consents and prior to commencement of the construction phase. The Proposed

Development has (provisional to project go-ahead) been accepted as a member of the Shannon Estuary Anti-Pollution Team (SEAPT). Membership of SEAPT will enable the Proposed Development to interface directly with the approved Shannon Estuary Oil/ HNS Plan and access additional response equipment to augment that held within the LNG Terminal. Through the membership process, the Proposed Development will additionally be contributing to the ongoing development and strengthening of the SEAPT organisation.

1.3.1.2 Incident Response

In accordance with the requirements of the NCP Standard Operation Procedure 05, and the final STEP Oil and HNS Spill Plan, there will be the five operational phases of an incident response:

- Phase 1 – Discovery and Notification, Evaluation, Identification and Activation;
- Phase 2 – Development of an Action Plan;
- Phase 3 – Action Plan Implementation;
- Phase 4 – Response Termination and Demobilisation; and,
- Phase 5 – Post Operations, Documentation of Costs/ Litigation.

The Proposed Development will manage the response to any Tier 1 (Local – within the capability of the operator on site) and Tier 2 (Regional – beyond the in-house capability of the operator) incident for any pollution on the water within their area of jurisdiction with the full cooperation and integration of the response with the Shannon Foynes Port, the Shannon Estuary Anti-Pollution Team (SEAPT) mutual aid group which includes the three local authorities of Kerry, Clare and Limerick and other agencies as appropriate. The developed plans will identify realistic Tier 1 and Tier 2 scenarios and the resources required to effectively response to and mitigate these. The plans will further describe any escalation to Tier 3 (requiring national resources) and as discussed above, interface with the National Marine Oil/ HNS Spill Contingency Plan. A training and exercising program forms part of the plans. The completed plans will be submitted to the Irish Coast Guard and EPA for appropriate approvals.

2. MATTE Assessment Requirement

An assessment of Major Accidents to the Environment (MATTE) is required for materials that will be present on the STEP. The STEP will be an 'upper tier' establishment as defined by the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 [1]. (COMAH Regulations). The COMAH Regulations implement the latest version of the 'Seveso III' Directive (Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012).

The Health and Safety Authority (HSA) provides technical advice to the planning authority on the potential effects of major accidents to the environment (MATTEs) regarding applications for planning permission for new COMAH establishments. The HSA has set out its approach to providing such advice [3]. In providing this advice, the HSA limits its considerations to environmental effects that are major accidents and does not consider routine emissions (which fall within the remit of the local authority or the Environmental Protection Agency).

The HSA guidance notes that at present within the European Union (EU) there is no common approach on suitable scenarios or endpoints for the assessment of MATTEs. As a result, assessment of MATTEs tends to be more qualitative than the assessment of major accidents and their effects on people. There are a number of other factors which also lead to use of a qualitative approach for MATTE assessment:

- the variability in the nature and sensitivity of environmental receptors;
- the lack of suitable sensitivity data for all environmental receptors;
- the multiplicity of such receptors in the environment; and,
- the lack of agreement on basic modelling assumptions and limited understanding of the reactions of ecosystem components, both of which restrict the use of quantitative modelling of environmental impacts.

Hence in its approach the HSA emphasises:

- the prevention of releases of potentially harmful substances to the environment;
- the control of the routes (or 'pathways') by which potentially harmful substances may travel from the point of release to an environmental receptor; and,
- the provision of appropriate measures to respond to environmental accidents.

The HSA summarises its approach as follows [3]:

> *The approach of the Authority, therefore, is to examine potential impacts to the environment from the identified credible major accident hazards and satisfy itself that appropriate 'best practicable means' are/will be in place to prevent such impacts. Best practicable means might constitute adequate bunding for storage tanks containing dangerous substances allied with tertiary containment to prevent migration off-site of any overtopping fraction, or contaminated firefighting water, for example.*
>
> *The potential for initiating a major accident due to natural phenomena is also examined. For example, the effect of flooding, storm damage, subsidence is considered in relation to the potential effect on storage tanks and storage areas, as well as important site utilities. The operator must demonstrate that other potential initiators have been considered (lightning for example) and control/mitigation measures employed where required.*
>
> *While the 'best practicable means' standard is also applied to control of gaseous loss of containment events (e.g. suitably-sized catch pots for reaction vessels), the*

consequences of such releases are examined as part of the general major accident scenarios for human receptors.

The HSA guidance [4] also lists the aspects that should be addressed in a systematic MATTE assessment:

- Are there any environmentally sensitive areas in the vicinity of the establishment?
- Are there any endangered species?
- Are there protected water resources/biospheres?
- How can the environment around the establishment be contaminated and the ecosystem be destroyed? What environmental compartments are in risk? What types of accident can cause this environmental damage (e.g. firefighting water)?
- Which are the possible routes of contamination (e.g. water courses)?
- What measures are in place in order to protect the environment? Are they sufficient?
- If release and contamination occurs, what measures are in place in order to contain it? What emergency actions are foreseen and have they been included in the internal and external emergency plan (e.g. collection of firefighting water)?
- What is the estimated recovery period (even qualitatively) with and without interventions?
- If the environmental risk is assessed in quantitative or semi-quantitative terms (even as an index), is the assessed risk “desirable”?

In view of the guidance provided by HSA [3], and since the proposed facilities are at the planning stage, detailed assessment of accidental releases from the site has not been undertaken and the following MATTE assessment is qualitative in nature.

3. Definition of a MATTE

In defining what constitutes a MATTE, the HSA [3] makes reference to Schedule 6 of the COMAH Regulations, which sets out what constitutes a major accident for the purposes of giving notification to the European Commission. In summary, an accident causing at least one of the following would constitute a MATTE:

- Permanent or long-term damage to terrestrial habitats:
  - 0.5 hectares (Ha) or more of a habitat of environmental or conservation importance protected by legislation;
  - 10 or more hectares of more widespread habitat, including agricultural land;
- Significant or long-term damage to freshwater and marine habitats:
  - 10 km or more of river or canal;
  - one ha or more of a lake or pond;
  - 2 ha or more of delta;
  - 2 ha or more of a coastline or open sea;
  - Significant damage to an aquifer or underground water;
- Significant damage to an aquifer or underground water:
  - 1 ha or more.

Further, more detailed definitions of what constitutes a MATTE have been proposed by other EU regulators [2] and these have been used as a guide in this assessment.

The time it would take to recover from an event is an important consideration when determining if an event can cause a MATTE. The Chemical and Downstream Oil Industries Forum (CDOIF) [3] provide guidance on durations for recovery, as summarised in Table 3-1 below.

Table 3-1: Main MATTE Consequence Duration Guidance

Description	Short-term [Harm with such short recovery is not considered a MATTE]	Medium term	Long term	Very long term
Groundwater or surface water drinking water source (public or private)			Harm affecting drinking water source or SPZ < 6 years	Harm affecting drinking water source or SPZ >6 years
Groundwater (except drinking water sources): WFD Hazardous / Non- Hazardous Substances	WFD hazardous substances < 3 months	WFD hazardous substances > 3 months	WFD hazardous substances > 6yrs	WFD hazardous substances >20 years
Surface water (except drinking water sources)	< 1year	>1 year	>10 years	>20 years
Land	< 3 years or < 2 growing seasons for agricultural land	> 3 years or > 2 growing seasons for agricultural land	>20 years	>50 years
Built Environment	Can be repaired in < 3 years, such that its designation can be reinstated	Can be repaired in > 3 years, such that its designation can be reinstated	Feature destroyed, cannot be rebuilt, all features except world heritage site	Feature destroyed, cannot be rebuilt, world heritage site

Note: WFD: Water Framework Directive. SPZ: Source Protection Zone.

4. Source, Pathway, Receptor model

Environmental risk assessment follows the source-pathway-receptor method, which requires that a linkage (pathway) must exist between the source and receptor in order for an accident to occur. Therefore any assessment of potential MATTE events will require the presence of a material that could harm the environment, a scenario for the release of the material, some pathway through which the material could pass to the environment, and some feature of the environment that could be significantly harmed.

Possible sources, pathways and receptors are detailed in the following sections.

4.1 Sources

Materials that have been identified as present at the STEP are shown in Table 4-1. As the installation and LNGC have not been subject to detailed design and tendering, this is a provisional list that is indicative of the types and quantities of materials that may be present.

Table 4-1: Materials and Inventory

Material	CAS Number	Inventory	Annual Use	Form	Location and Containment	Use
Liquefied Natural Gas (LNG)[e] and Natural Gas	74-82-8	FSRU: 180,000 m^3 LNG (approx.) LNGC: 180,000 m^3 LNG (approx.) Natural Gas: 40 tonnes (approx.)	5,400,000 tonnes (approx. maximum)	Liquid and gas	LNG tanks on the FSRU/LNGC. Piping and equipment containing gas on the FSRU, LNGC and onshore.	Process material (gas supply)
Ammonia hydroxide (19%)	1336-21-6	1,500 litres	13,140 litres	Liquid	Power Station, Tote 1,500 litres	pH control
Tri-Sodium Phosphate	7601-54-9	1,500 litres	13,140 litres	Liquid	Power Station, Tote 1,500 litres	pH buffer and harness/scale treatment
Sodium Bisulphite (30% - 50%)	7631-90-5	1,500 litres	3,500 litres	Liquid	Power Station, Tote 1,500 litres	Dechlorination agent
Odorant NB - Mix of Tertiary Butyl Mercaptan and Dimethyl sulphide	TBM 75-66-1 DMS 75-18-3	36,320 litres max.	Unknown	Liquid	AGI, Bulk storage (2 off) tank in bund	Odorant for natural gas
Sulphuric Acid (77-100%)	7664-93-9	3,000 litres	Unknown	Liquid	Power Station, Storage tank and Batteries	pH Control

e Liquefied Natural Gas and natural Gas are both the same material chemically (methane). The hazardous properties differ with the phase of the material.

Material	CAS Number	Inventory	Annual Use	Form	Location and Containment	Use
Diesel	68476-34-6	9.8 m^3	Unknown	Liquid	NFE site, Black Start Generator	Fuel
Transformer oil (Mineral oil, petroleum distillates)	Varies depending on supplier	110 m^3	Unknown	Liquid	Within transformers on the Power Station and Terminal	Electrical system cooling

Additional materials including antiscalants, biocides, corrosion inhibitors, antifreeze, cleaning chemicals, paints, hydraulic oil, grease and lubricating oils are expected to be present on site in small quantities. These materials, whilst present at the site, are not anticipated to be present in sufficient quantities to materially affect the outcome of this assessment.

The FSRU and LNGC are assumed to be designed, constructed and inspected in accordance to relevant standards and regulations for these types of vessels, and that they operate under the International Convention for the Prevention of Pollution from Ships (MARPOL) Convention. The MARPOL Convention is the main International Marine Organisation (IMO) convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. With the exception of LNG and natural gas, materials present on the FSRU and LNGC have not been included in this preliminary assessment as they do not differ in any notable way from other large ships passing along the estuary.

A review of the Material Safety Data Sheets (MSDS) [6][7][8][9][10], the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) [3] and the COMAH Regulations [1] has provided details of the classification and ecotoxicity of the materials listed in Table 4-1. The findings from this review are summarised in Table 4-2. Where the material classification is not directly available from GHS relevant data then date from the Material Safety Data Sheets (MSDS) has been used.

Any materials that are identified as 'Dangerous Substances' under the COMAH Regulations or have Hazard Classifications indicating the potential for significant environmental damage on release have been identified.

Table 4-2: Material Classification and Ecotoxicity

Chemical [CAS No.]	GHC Classification	Hazard Statement	Environmental Effects			COMAH Classification
			Toxicity	Biodegradability	Bioaccumulation	
Liquefied Natural Gas	Flam. Gas 1	H220	No environmental toxicity identified.	No data available	No data available	**Named: Liquefied Flammable Gasses**
Natural Gas	Flam. Gas 1 Press. Gas	H220	No environmental toxicity identified.	No data available	No data available	
Odorant NB	**Tertiary butyl mercaptan** Flammable liquids (Category 2) Skin sensitization (Sub-category 1B) Long-term (chronic) aquatic hazard (Category 2),	H225 H317 **H411**	Inhalation rat LC50: 83.84 mg/l Oral rat LD50: 4729 mg/kg Skin rabbit LC50L: >2000 mg/kg LC50 – Oncorhynchus mykiss (rainbow trout) – 34 mg/l – 96 h Daphnia magna (Water flea) – 6.7 mg/l – 48 h (OECD Test Guideline 202) ErC50 – Pseudokirchneriella subcapitata (green algae) – 24 mg/l – 72 h (OECD Test Guid Pseudokirchneriella subcapitata (green algae) – 6.41 mg/l – 72 h	Aerobic – Exposure time 63 d Result: 6 % - Not readily biodegradable.	Not persistent or bioaccumulative	**Hazardous to the Aquatic Environment**
	Dimethylsulphide Flammable liquids (Category 2)	H225	LD0 Oral – Rat – female - > 2,000 mg/kg LC50 Inhalation – Rat – male and female – 4 h – 102 mg/l LD0 Dermal – Rat – male and female - > 2,000 mg/kg Oncorhynchus mykiss (rainbow trout) – 213 mg/l – 96 h EC50 – Daphnia magna (Water flea) – 29 mg/l – 48 h ErC50 – Pseudokirchneriella subcapitata (green algae) - > 113.7 mg/l – 72 h	Aerobic – Exposure time 28 d Result: 77 % - Readily biodegradable.	No Data available	

Chemical [CAS No.]	GHC Classification	Hazard Statement	Environmental Effects			COMAH Classification
			Toxicity	Biodegradability	Bioaccumulation	
Sulphuric Acid (Including Battery Acid)	May be corrosive to metals. Causes severe skin burns and eye damage.	H290 H314	LD50 Oral – rat – 2,140 mg/kg LC50 Inhalation – rat – 2 h – 510 mg/m3 Skin – rabbit – Extremely corrosive and destructive to tissue. Eyes – rabbit – Severe eye irritation EC50 – Daphnia magna (Water flea) - > 100 mg/l – 48 h ErC50 – Desmodesmus subspicatus (green algae) - > 100 mg/l – 72 h	No data available	No data available	None
Ammonia Hydroxide	Harmful if swallowed. Causes severe skin burns and eye damage. May cause respiratory irritation. Very toxic to aquatic life.	H302 H314 H335 **H400**	LD50 Oral – Rat – 350 mg/kg (Ammonium hydroxide) LC50 – Fish – 0.44 mg/l – 96 h (Ammonium hydroxide) LC50 – Daphnia magna (Water flea) – 25.4 mg/l – 48 h (Ammonium hydroxide)	No data available	Does not bioaccumulate	**Hazardous to the Aquatic Environment**
Tri-Sodium Phosphate	Causes skin irritation Causes serious eye irritation May cause respiratory irritation	H315 H319 H335	LD50 Oral – Rat – female - > 2,000 mg/kg LC50 Inhalation – Rat – male and female – 4 h - > 0.83 mg/l LD50 Dermal – Rat – male and female - > 2,000 mg/kg LC50 – Oncorhynchus mykiss (rainbow trout) - > 100 mg/l – 96 h EC50 – Daphnia magna (Water flea) - > 100 mg/l – 48 h ErC50 – Desmodesmus subspicatus (green algae) - > 100 mg/l – 72 h Toxicity to bacteria static test EC50 – activated sludge - > 1,000 mg/l – 3 h	Not applicable to inorganic materials	No data available	None

Chemical [CAS No.]	GHC Classification	Hazard Statement	Environmental Effects			COMAH Classification
			Toxicity	Biodegradability	Bioaccumulation	
Sodium Bisulphite	Exempt from Regulation (EC) No 1272/2008.	-	No data available	No data available	Not bioaccumulitive	None
Diesel	Flam. Liquid Skin Corrosion/Irritation Aspiration Hazard STOT SE Carcinogenicity Aquatic Chronic Eye Damage/ Irritation	H226 H315 H304 H336 H350 **H411** H319	Inhalation LC50 Rat >6 mg/l/4h Acute Toxicity LD50 Dermal Rabbit >5000 mg/kg Acute Toxicity LD50 Oral Rabbit >5000 mg/kg Toxic to aquatic organisms based on an acute basis LC50/EC50 >1 but < 10 mg/L in the most sensitive species. Material is a long-term aquatic hazard based on a chronic basis (C50/EC50 >1 but < 10 mg/L in the most sensitive species.	No data available	No data available	**Named: Petroleum products (gas oils)**
Transformer Oil (1)	May be fatal if swallowed and enters airways. Harmful to aquatic life with long lasting effects.	H304 **H412**	LD50 (Rat): > 2,860 mg/kg LC50 (Rat): > 5.2 mg/l, 4 h	No Data available.	No data available.	**Hazardous to the Aquatic Environment**

Notes:

(1) Transformer oil classification based on review of a range of oil MSDS, the H412 categorisation may not be applicable to some transformer oils.

Of the materials listed in Table 4-2 those classified with the following categories are the most hazardous to the environment. Specifically:

- H400 – Very toxic to aquatic life (Ammonia hydroxide);
- H411 – Long-term (chronic) aquatic hazard (Category 2) (Odorant NB and Diesel); and,
- H412 - Harmful to aquatic life with long lasting effects (Transformer Oil).

The main storage locations and areas in which the materials are used are detailed in Table 4-3 and shown in Figure 4-1 through to Figure 4-3.

It is acknowledged that many of the materials will be transported around the site by vehicle or piping systems.

Table 4-3: Main Material Locations

Material	NFE Site	Power Station	AGI	FSRU	LNGC
Liquefied Natural Gas				✓	✓
Natural Gas	✓	✓	✓	✓	✓
Odorant NB			✓		
Sulphuric Acid		✓			
Ammonia Hydroxide		✓ (1)			
Tri-Sodium Phosphate		✓ (1)			
Sodium Bisulphite		✓ (1)			
Diesel	✓ (1)			✓ (2)	✓ (2)
Transformer Oil	✓	✓			

Notes:

(1) Small quantities (<5000 litres)
(2) Marine fuel – excluded from the assessment

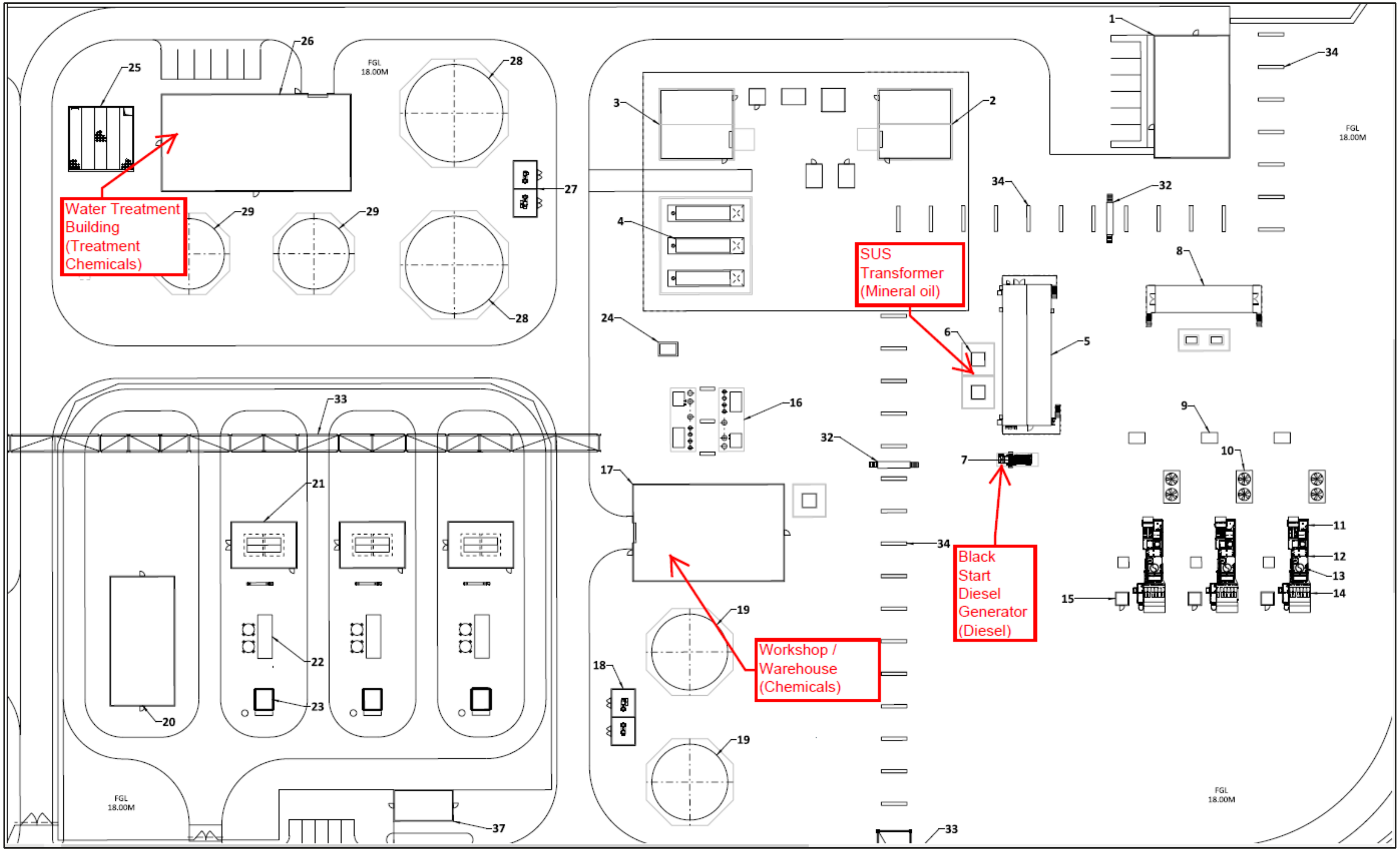


Figure 4-1: Terminal Storage Areas

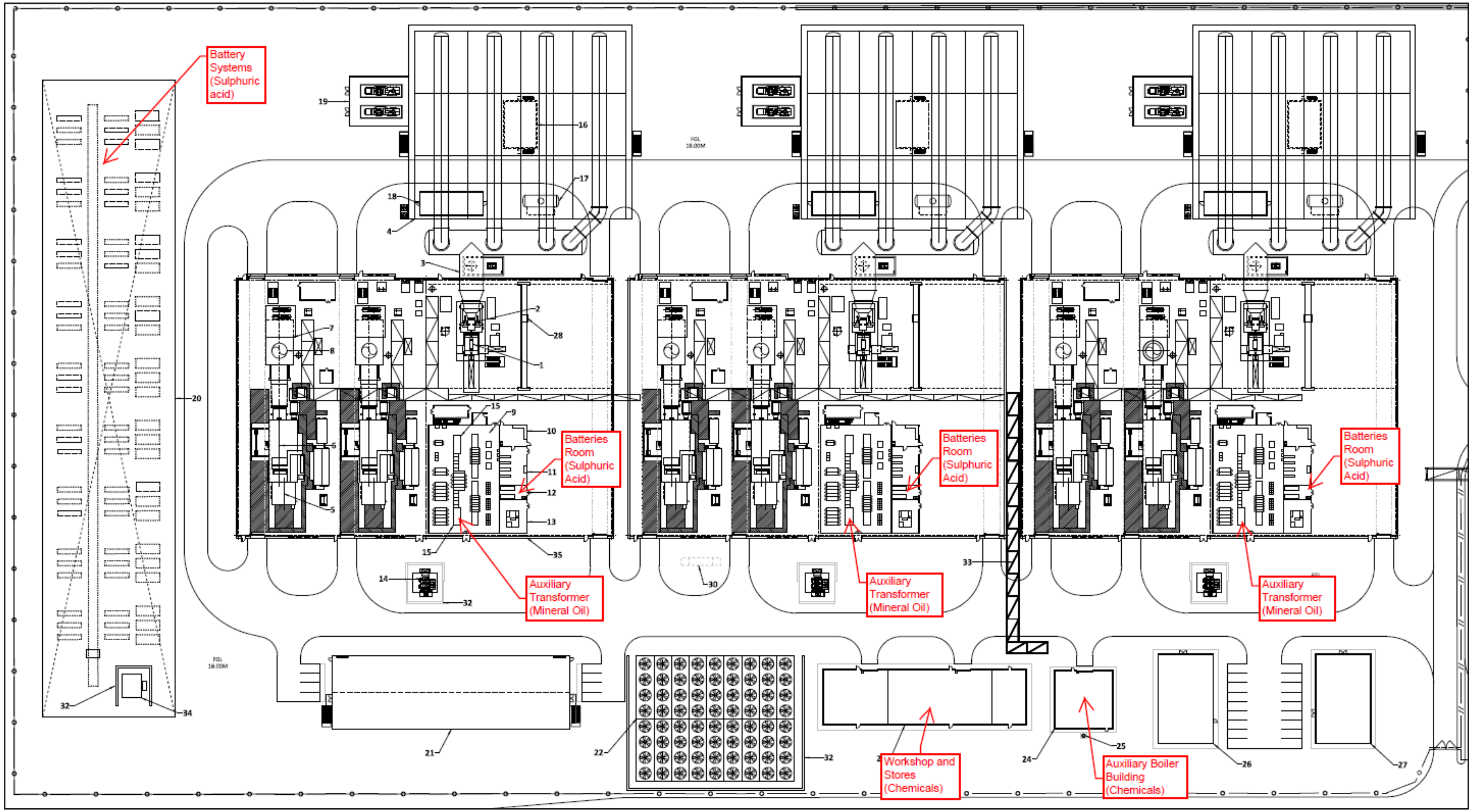


Figure 4-2: Power Plant Storage Areas

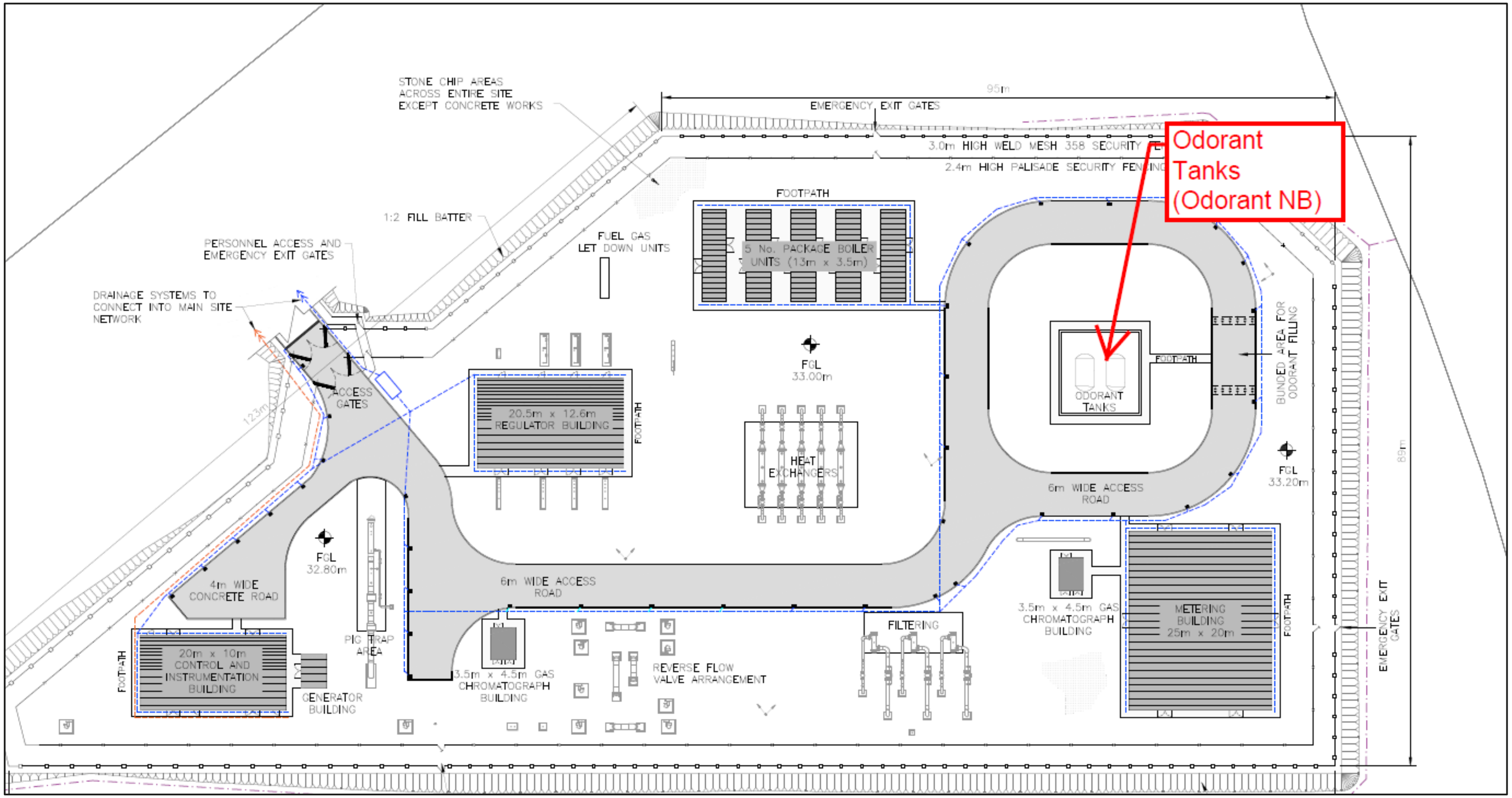


Figure 4-3: AGI Odorant Location

4.2 Pathways

Pathways may have a number of features; including the initial release of material, secondary failures and local factors.

Possible sources of release of materials that may be hazardous to the environment are primarily due to failure of containment. A range of possible causes of loss of containment exist and are typically due to:

- Impact by vehicle, machinery or dropped object;
- Dropped or punctured container;
- Corrosion, erosion or chemical attack;
- Overpressurisation or vacuum;
- Overfilling of equipment;
- Internal explosion (where flammable materials are present);
- Runaway chemical reaction or mixing of incompatible chemicals;
- Overheating or overcooling of equipment;
- On site events such as fires or explosions; or,
- Offsite events that may affect the area, such as earthquakes, landslip, flooding or extreme weather;

Secondary factors are those where some barrier or safeguard fails. For releases of liquids a secondary failure may be a damaged drain or bund, or the failure to treat a material if discharged into an effluent treatment system.

Pathways will also depend upon the type of surface onto which a material is released and drainage systems.

Local factors that influence pathways are often related to environmental conditions. For example, where releases could enter rivers, the hydraulic state of the river may be a factor. For releases to air, the atmospheric conditions (wind speed, stability and direction) and rainfall could influence the consequences of a release. Releases to air may also include vapours generated by pools of spilt liquid.

A review of the processes undertaken and measures provided on the site has identified the following possible onsite pathways (refer to subsections 4.2.1 through to 4.2.8), which have been considered, where appropriate, for the assessment of MATTE scenarios.

4.2.1 Drainage systems on site

The Environmental Impact Assessment Report (EIAR) [4] describes the details of the drainage systems on the site, which is summarised in this subsection.

A surface water drainage network consisting of piped drainage and swales/ catch basins will be constructed to collect, convey, and attenuate the surface water runoff generated.

All stormwater collected from paved and impermeable areas will pass through a class 1 hydrocarbon interceptor prior to discharge to the Shannon Estuary. Stormwater collected from roof drains and permeable areas will discharge directly to the estuary via the final discharge monitoring station. All bunded areas within the Proposed Development site will have valved discharge points as part of their connection to the drainage network (Figure 4-5 below).

Groundwater seepages from springs or at the toe of cut slopes will be collected via a groundwater drainage network which will then discharge directly to the Shannon Estuary via the same discharge outfall pipe as the surface water.

Silt traps will be incorporated in all groundwater drainage points prior to discharge.

During the operational phase, all drainage from the Proposed Development site will be controlled and monitored in compliance with the terms of the IE licence.

A firewater retention pond is included in the Proposed Development and sized according to EPA Guidance on Retention Requirements for Firewater Runoff, as the most effective and suitable measure for retaining firewater. The retention pond will be rendered impermeable by use of an appropriate liner, and integrity-tested in line with the requirements of the site's licence. All process area site drainage will pass through the retention pond. An automatic shut-off valve linked to the site's fire detection system will be installed on the drainage outlet point.

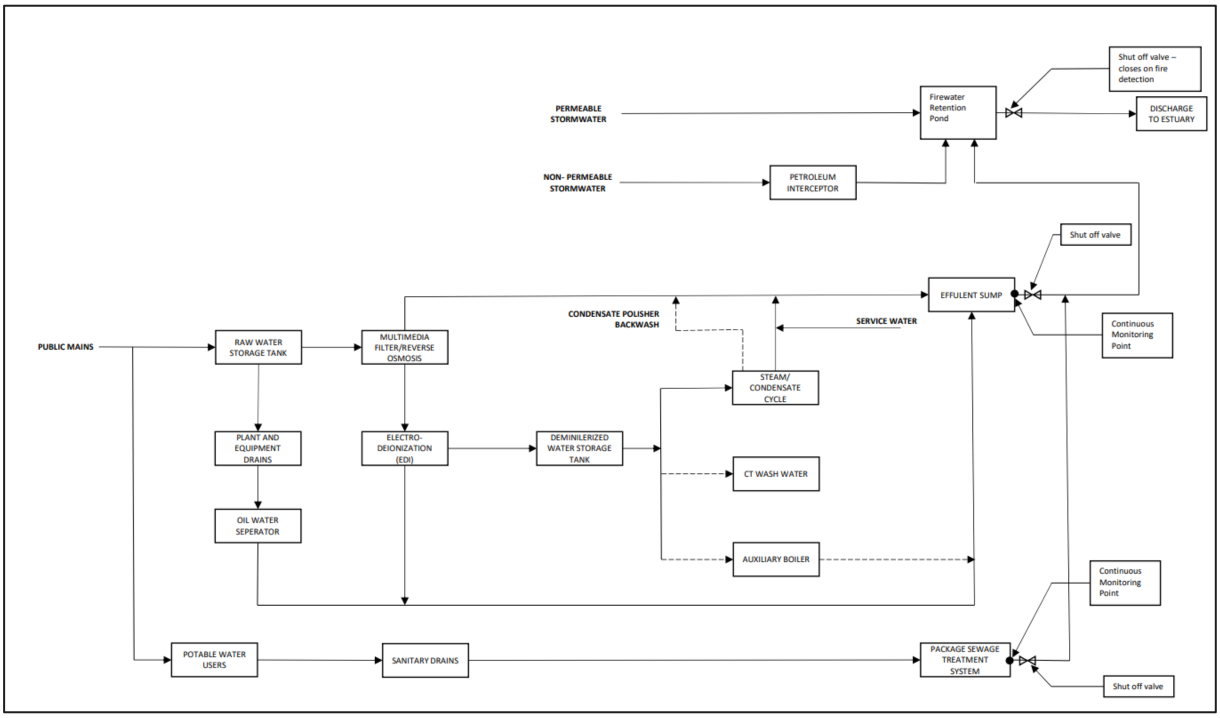


Figure 4-4: Drainage Network

4.2.2 Releases into Bunded Areas

Bunds are designed to contain liquid releases from bulk storage tanks. Where bunds are correctly designed, operated and maintained, the only release to the environment will be due to evaporation from liquid that is contained in the bund. All bunds will be sized to contain the full storage tank inventory plus an additional allowance for safety where appropriate. These bunds will have valved discharge points as part of their connection to the drainage network. Prior to draining of rainwater from bunded areas, checks will be carried out to ensure that the material discharged is not contaminated.

Possible failure of bunds may be due to poor design, substandard construction, damage, overtopping, overfilling and the failure of systems for rainwater removal. Depending upon the failure type and location, possible outcomes of bund failure could be a release to unmade ground below the bund, release onto plant areas that are covered in broken stone, or release into the surface water drains. Bund failures that are coincident with a release of dangerous substance from the primary containment, while discussed in this assessment, are considered to be very low probability events.

4.2.3 Releases in the Power Plant Area

All stormwater collected from paved and impermeable areas within the Power Plant will pass through a class 1 hydrocarbon interceptor prior to discharge to the Shannon Estuary.

At the end of the system there is a valve which is normally open to allow rainwater to discharge to the estuary but can be closed in an emergency to prevent discharge.

Stormwater collected from roof drains and permeable areas within the power plant will discharge directly to the estuary via the final discharge monitoring station.

4.2.4 Releases to the Storm Water Drain System

Water collected on the paved and impermeable areas of the site will be collected and discharged to site storm water drainage system (refer to Figure 4-5). All discharges will incorporate a Class 1 hydrocarbon interceptor. Perimeter areas outside of the site storm water drainage systems (those areas beyond the perimeter roads) will discharge directly to the estuary.

All drainages from the site will be controlled and monitored as part of the discharge licence for the facility.

Releases to the Shannon Estuary are only possible of there is a failure to control discharge from the sumps or through the drains.

4.2.5 Releases to Ground/Ground Water from permeable areas

Ground water from permeable areas will be collected by means of a ground water drainage network that will collect the ground water and discharge where possible into either the existing stream/drainage ditches within the site or directly to the estuary via same discharge outfall pipe as the storm water. Silt traps will be incorporated onto all groundwater drainage points prior to discharge.

As the site groundwater drains are only located along the outside perimeter of the developed site, away from process equipment, roadways and buildings it is thought that a release into these drains is not possible.

4.2.6 Releases into Storage Buildings/Warehouses

Building areas used for chemical or hydrocarbon storage on the site, Power Station and AGI will have impermeable floors with no drains. Therefore, any spillage in these building areas should be contained.

4.2.7 Releases at the AGI Area

Water collected on the paved and impermeable areas of the AGI will be collected and discharged to the storm water drain system after passing through an inceptor located at the AGI. The drainage route from the AGI Interceptor through the LNG Terminal storm water drains pass through a second interceptor located near the instrument air package prior to discharge into the fire water retention pond. The fire water retention pond discharges to the estuary.

4.2.8 Fires

Any fires on site will release combustion products, and in some cases may release unburned material to atmosphere. Systems will be installed on site for preventing and mitigating fires (e.g. inerting systems, minimisation of ignition sources and water or firefighting systems).

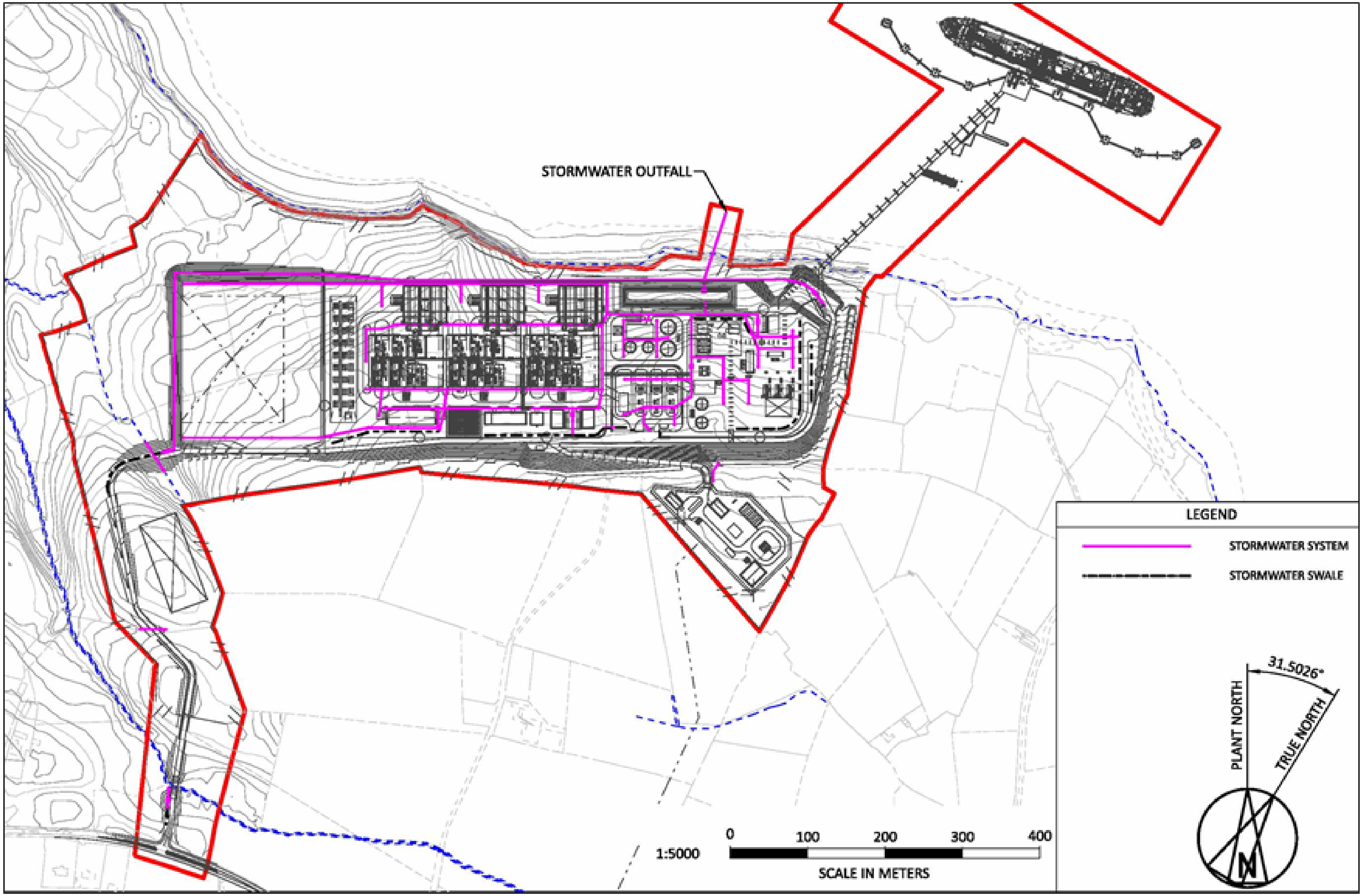


Figure 4-5: Proposed Site Drainage

4.3 Receptors

The Proposed Development site is in pasture, comprising primarily improved grassland with some wet grassland adjacent to the Shannon Estuary, as shown on the aerial photograph in Figure 4-6.

Figure 4-6 Proposed Development Site

The Lower Shannon Special Area of Conservation (SAC) is partly within and adjacent to the site along the northern/ north-western boundary and also along part of the eastern boundary of the Proposed Development site (see Figure 4-8). The Ballylongford Bay Natural Heritage Area (NHA) is adjacent to a part of the north-western boundary of the Proposed Development site (see Figure 4-7). The Shannon-Fergus Estuary Special Protection Area (SPA) is to the west of the Proposed Development site (at a distance of approximately 750 m from the western extremity of the terrestrial elements of the Proposed Development site). The jetty will extend into the Lower River Shannon SAC and the River Shannon and River Fergus Estuaries SPA.

For the purpose of this assessment only the possible impacts to the most sensitive receptors will be considered (NHA, SPA and SAC). It is recognised that there are criteria for harm to other receptors but the criteria for extent and duration of harm for these receptors is less stringent than those for SACs, SPAs and NHAs.

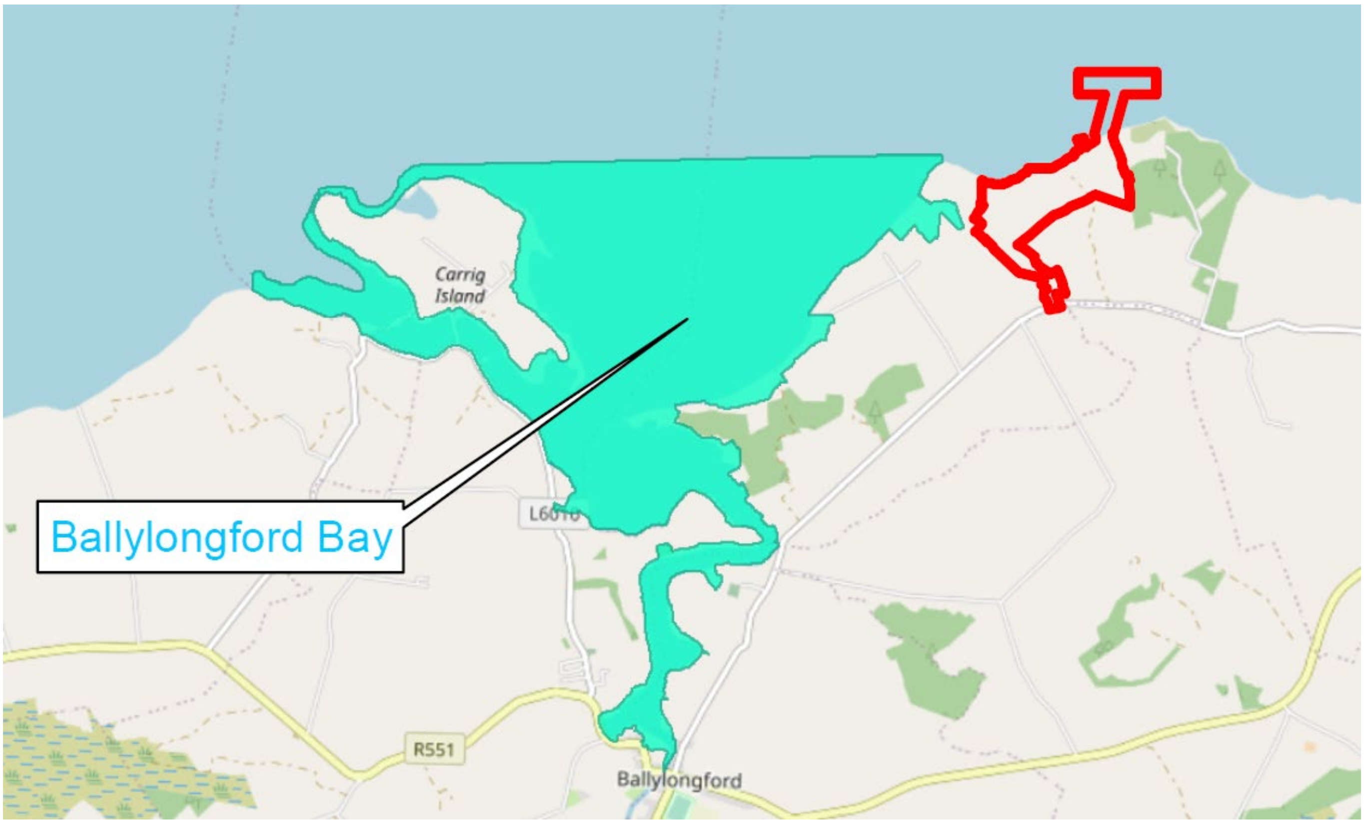


Figure 4-7: Proposed National Heritage Areas (NHA)

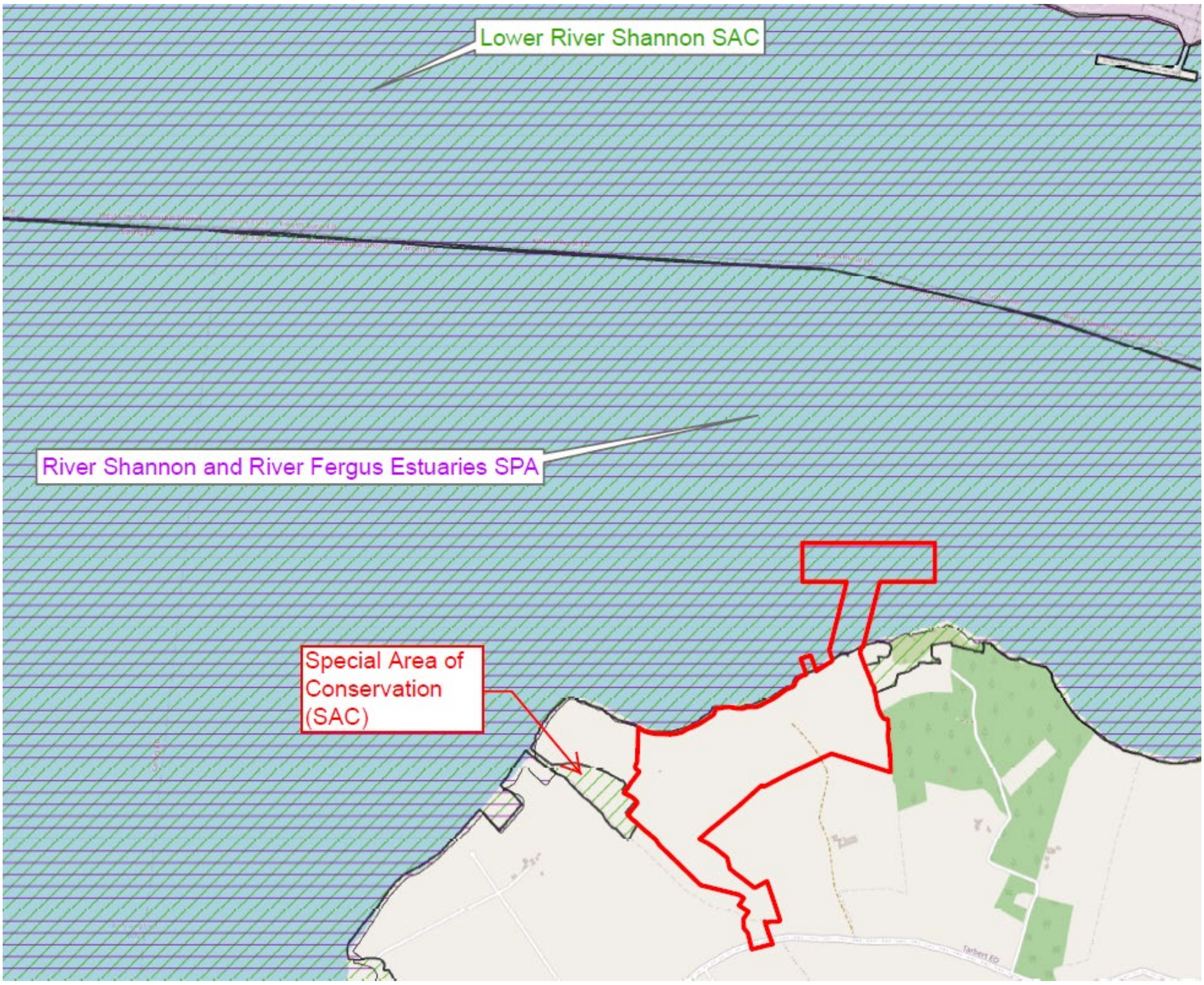


Figure 4-8: SPA and SAC

5. MATTE Assessment

5.1 COMAH Materials

Materials that are covered by the COMAH Regulations as either Named Substances or by their hazardous characteristics, such as flammability or toxicity require specific assessment as their release may lead to a MATTE, as detailed in the 'COMAH Classification' column of Table 4-2.

Materials that fall into this category are:

- LNG and natural gas;
- Odorant NB;
- Ammonia hydroxide;
- Diesel; and,
- Transformer oil.

5.1.1 LNG and Natural Gas

LNG is stored on the FSRU and LNGC site as a liquefied gas and when released to its surroundings it vaporises rapidly to form natural gas, leaving no residue. LNG (methane and other light hydrocarbons) is classed under the COMAH Regulations as 'Liquefied Flammable Gasses'.

As LNG and natural gas are not toxic to the environment, hazards are associated with exposure to low temperatures from an LNG release (cryogenic burns), or fires if a release of LNG or natural gas is ignited. Environmental receptors at risk are flora and fauna.

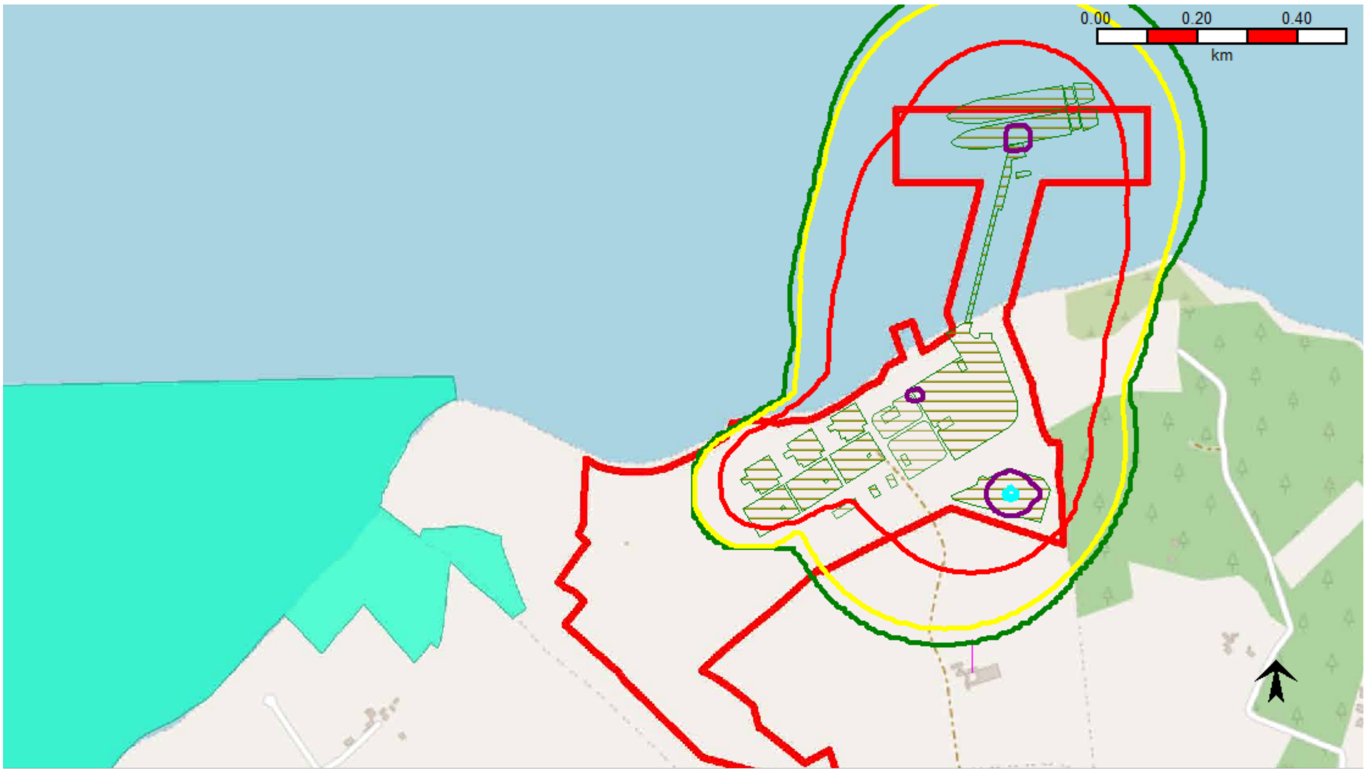
A thermal flux of 5 kW/m^2 has been used as the threshold for consideration in this analysis. This level of thermal flux is below the level that could cause secondary fires at a receptor (piloted ignition of wood occurs at a thermal flux of 12.5 kW/m^2) and is also below the HSA's dangerous dose for people (7 kW/m^2 for a 75 s exposure). The use of 5 kW/m^2 as an end-point is therefore considered to be conservative.

In terms of the low temperature effects of a dispersing cloud, an end-point of -5°C has been considered. This corresponds to cold winter conditions and is therefore unlikely to result in significant environmental impact.

Possible events identified for LNG and natural gas assessment are discussed in the subsections below.

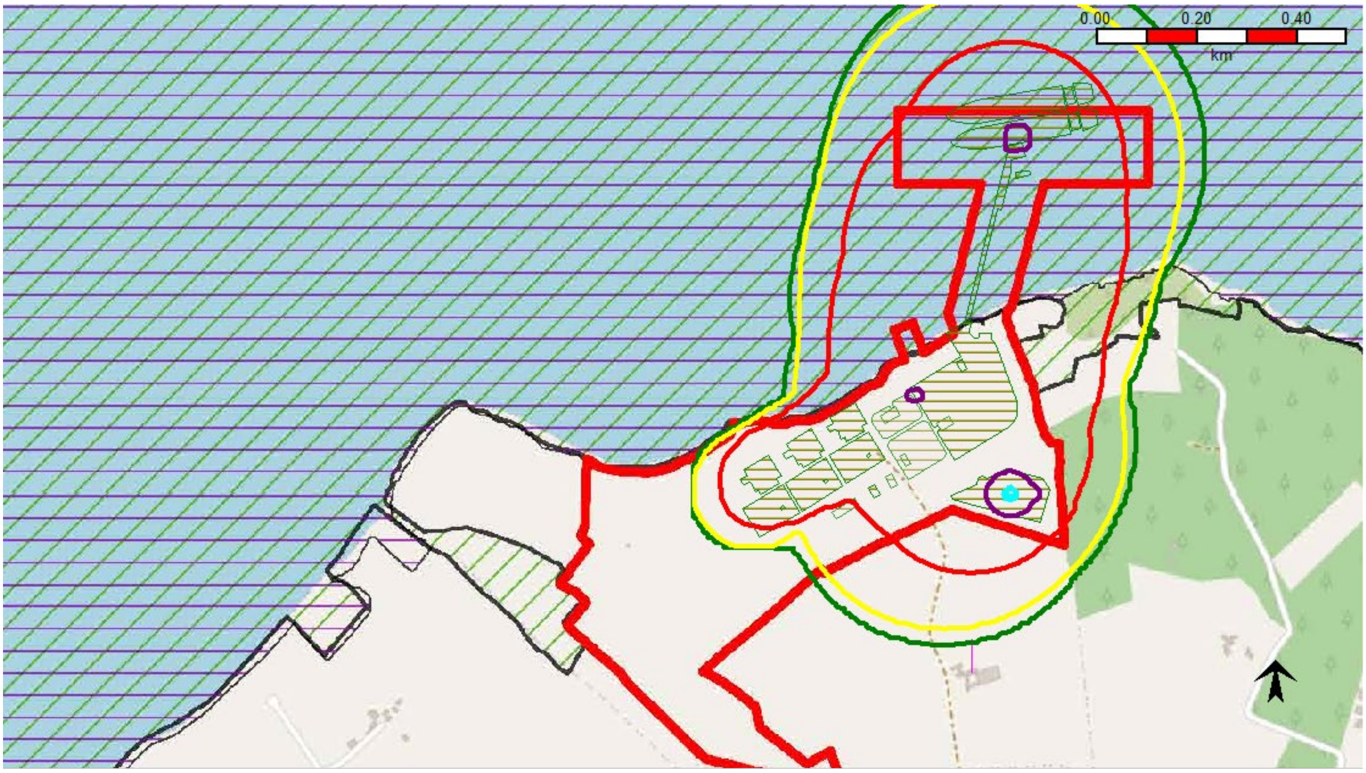
5.1.1.1 Thermal Radiation

The Safeti 8.4 Software Package used for Quantitative Risk Calculations (QRA) for STEP [5] has been used to produce isocontours showing the 5 kw/m^2 thermal intensity for jet fires and pool fires that could occur following release of LNG or natural gas. These contours are shown below overlaid on maps showing the receptors (identified in Section 4.3).



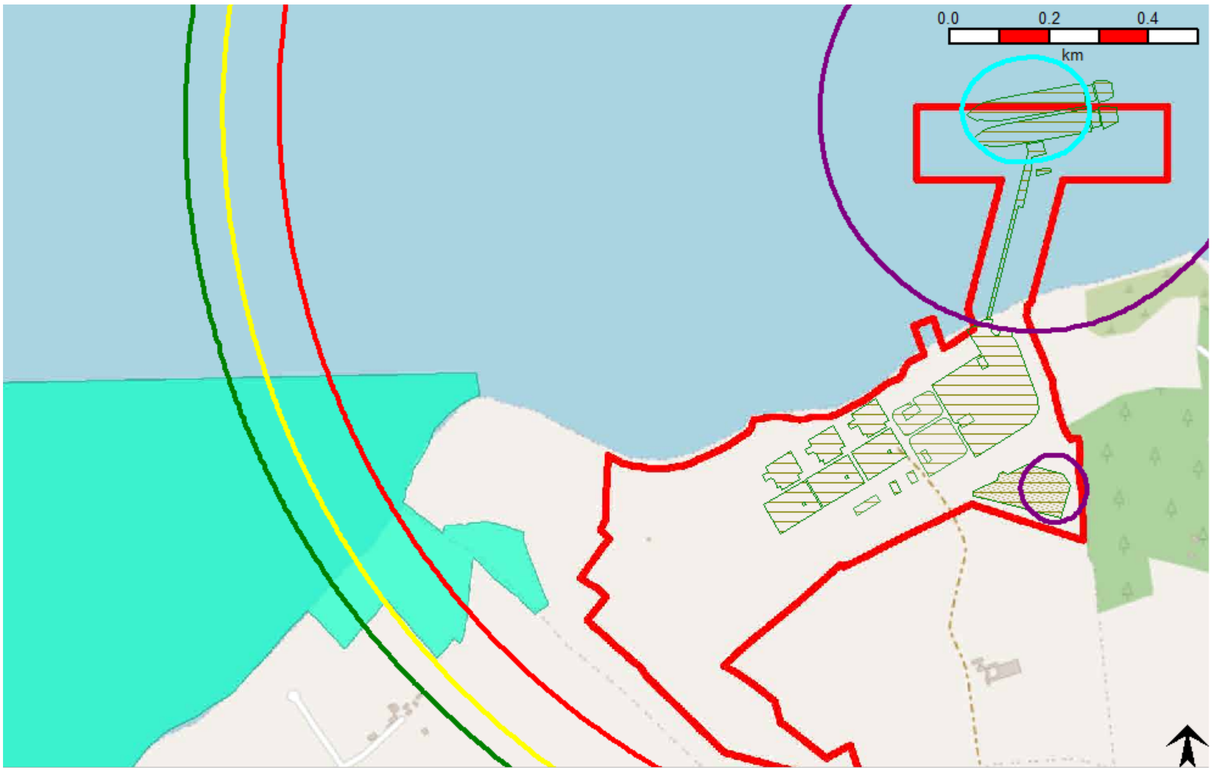
Key: Blue $1x10^{-4}$/y, Purple $1x10^{-5}$/y, Red $1x10^{-6}$/y, Yellow $1x10^{-7}$/y, Green $1x10^{-8}$/y

Figure 5-1: 5 kw/m^2 Jet Fire Thermal Radiation (NHA)



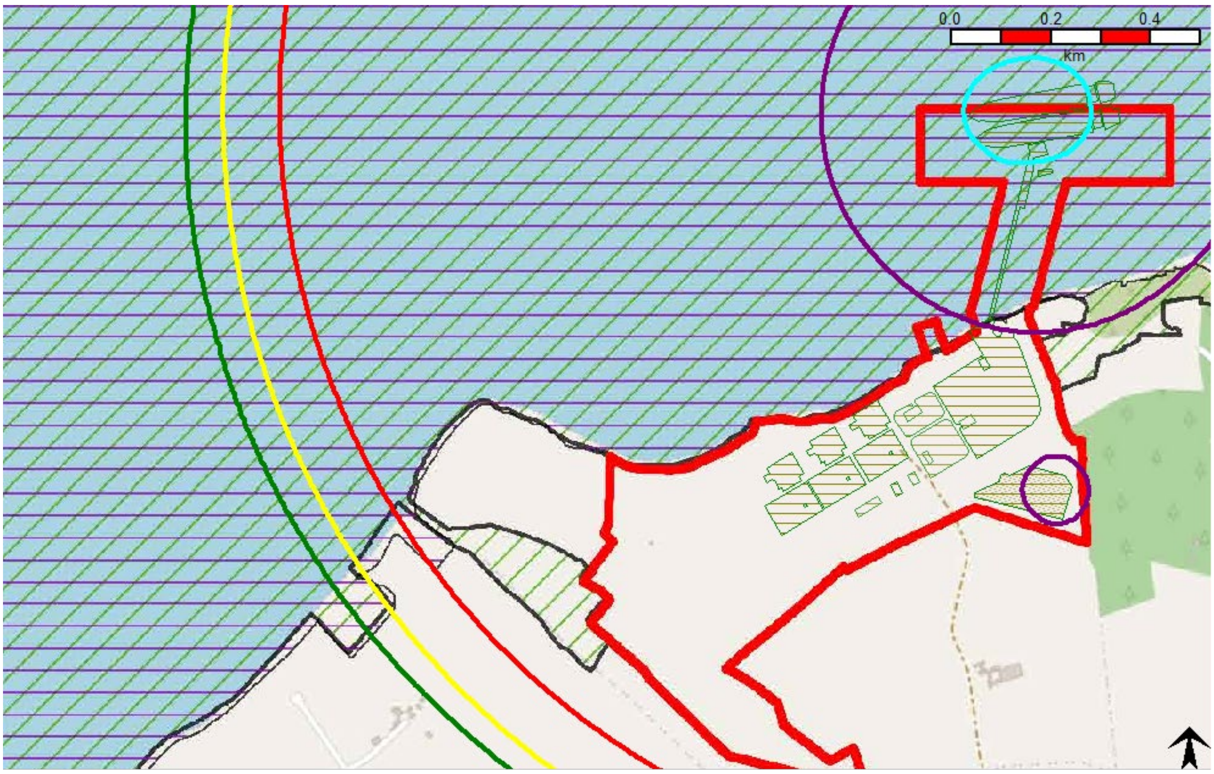
Key: Blue $1x10^{-4}$/y, Purple $1x10^{-5}$/y, Red $1x10^{-6}$/y, Yellow $1x10^{-7}$/y, Green $1x10^{-8}$/y

Figure 5-2: 5 kw/m^2 Jet Fire Thermal Radiation (SPA and SAC)



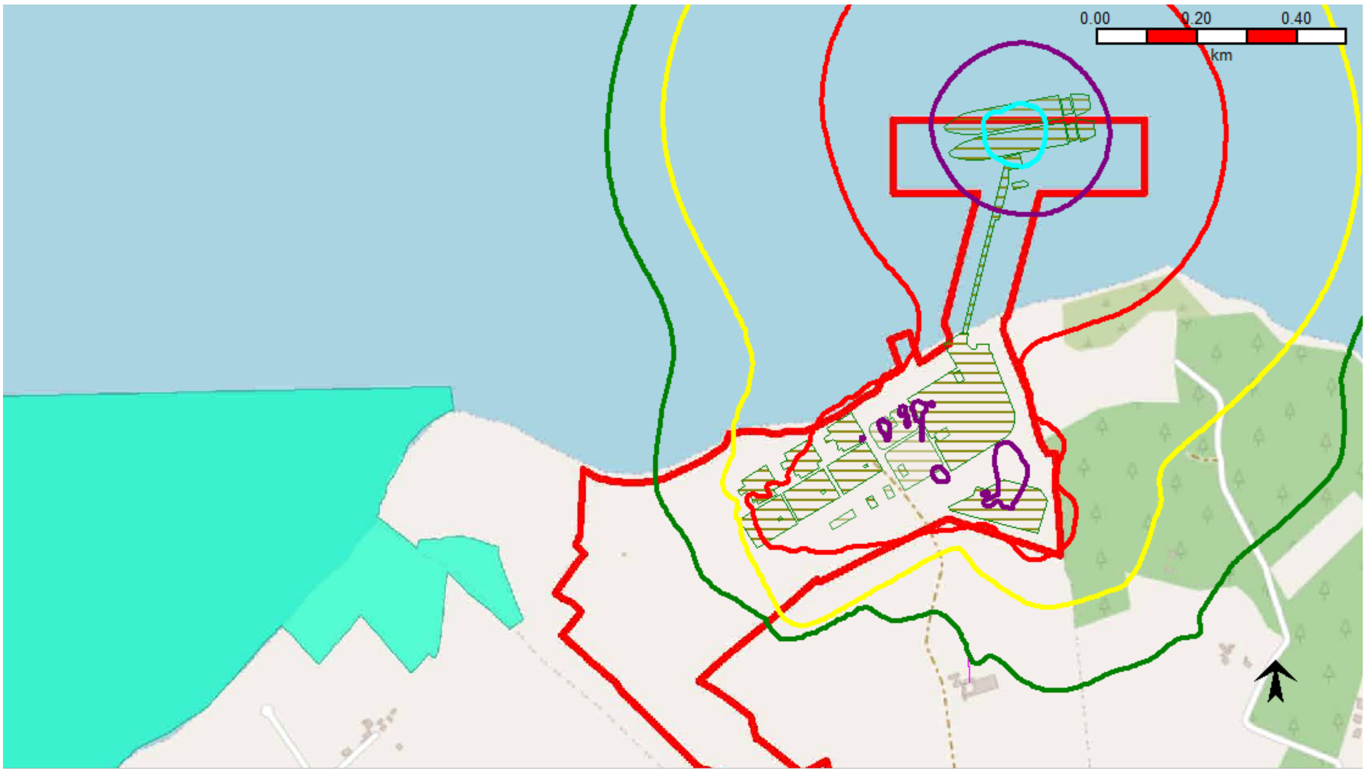
Key: Blue 1x10^{-4}/y, Purple 1x10^{-5}/y, Red 1x10^{-6}/y, Yellow 1x10^{-7}/y, Green 1x10^{-8}/y

Figure 5-3: 5 kw/m^2 Pool Fire Thermal Radiation (NHA)



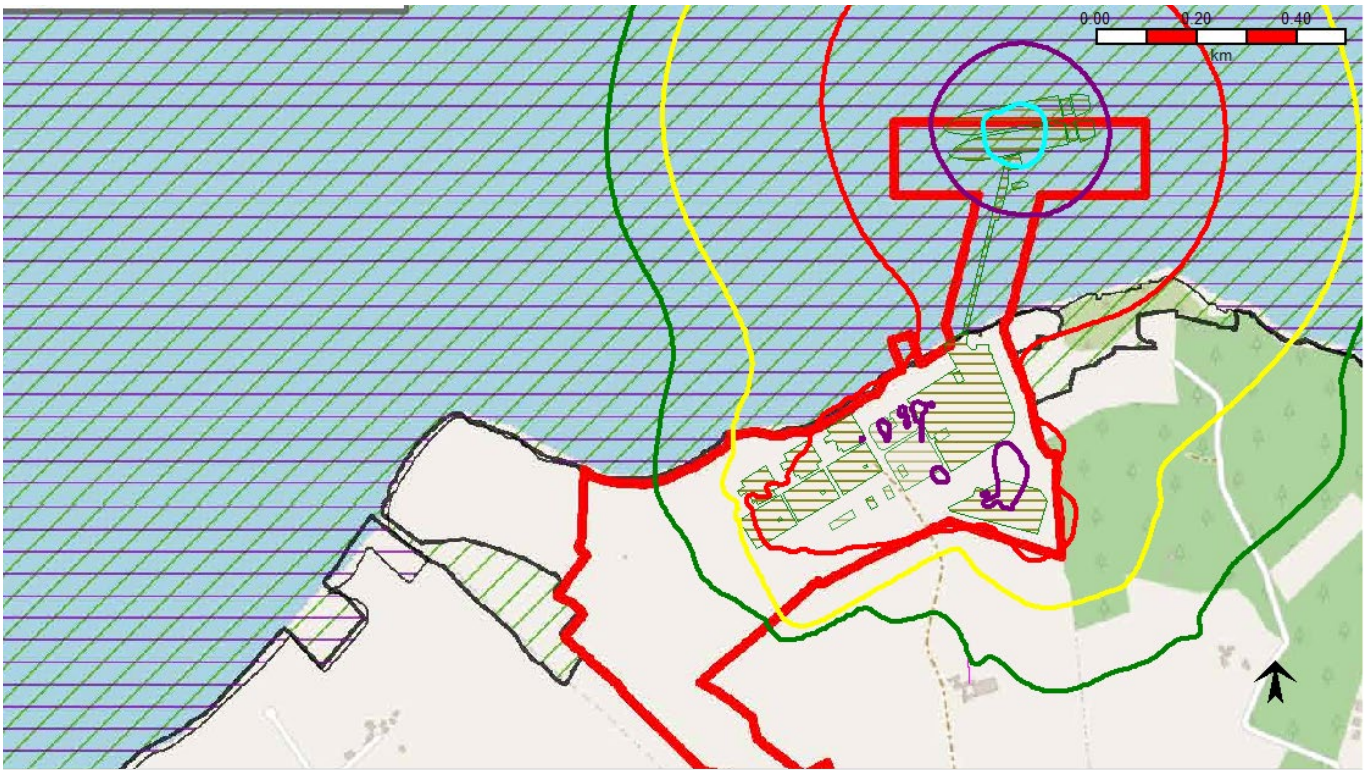
Key: Blue 1x10^{-4}/y, Purple 1x10^{-5}/y, Red 1x10^{-6}/y, Yellow 1x10^{-7}/y, Green 1x10^{-8}/y

Figure 5-4: 5 kw/m^2 Pool Fire Thermal Radiation (SPA and SAC)



Key: Blue 1x10^{-4}/y, Purple 1x10^{-5}/y, Red 1x10^{-6}/y, Yellow 1x10^{-7}/y, Green 1x10^{-8}/y

Figure 5-5: 5 Flash Fire Extent (NHA)



Key: Blue 1x10^{-4}/y, Purple 1x10^{-5}/y, Red 1x10^{-6}/y, Yellow 1x10^{-7}/y, Green 1x10^{-8}/y

Figure 6: Flash Fire Extent (SPA and SAC)

It can be seen that thermal radiation from jet fires and flash fires will not affect the NHA and onshore SAC to the West of the site.

LNG Pool fires on the sea surface could lead to thermal radiation effects at the NHA and onshore SAC to the West of the site. The frequency of these events have been calculated within the Safeti QRA Model and are at most 3.7 x 10^{-6} per year (once in 270,270 years) at the closest point of the onshore SAC. This frequency is considered to be very low. It should be noted that the 5 kw/m^2 thermal radiation intensity is below that which would lead to a fire and therefore recovery from this type of event would be less than three years (Refer to Table 3-1).

Modelling indicates that the jet and pool fire contours of 5 kW/m^2 reach areas of the estuary that forms part of the SAC and SPA close to the jetty/terminal. While harm to birds present on the estuary surface close to the STEP may be possible in the event of a fire, bird surveys undertaken for the STEP EIAR [5] have identified that there are no significant populations of bird species at the jetty/Terminal vicinity.

Based on the definition of a MATTE in Section 3, jet fires and LNG pool fires are not considered credible MATTE events.

5.1.1.2 Low Temperature Effects

Very low temperatures will occur close to the location of spillage of LNG. Review of data from the QRA [5] shows that the maximum spill sizes of LNG are those associated with loss of containment of LNG following a ship collision or the failure of Ship to Ship Transfer (STS) hoses during transfer of LNG between the LNGC and FSRU.

Loss of LNG following a ship collision could lead to low temperature effects on the estuary surface up to a distance of approximately 315 m. A collision resulting on a spill of this size is a very infrequent event (calculated as approximately 6.6 x 10^{-6}/y (once every 151,515 years).

Total failure of an STS transfer hose could lead to low temperature effects on the estuary surface up to a distance of approximately 84 m.

None of these effects would reach the wetlands associated with NHA to the west of STEP. Low temperature effects on the surface of the estuary would be of short duration, be localised to the FSRU and LNGC, and are not considered to be credible causes of a MATTE.

5.1.2 Odorant NB

Odorant NB is a mixture of tertiary butyl mercaptan (78-82%) and dimethylsulphide (18-22%). The material will be used to odorise natural gas exported from the facility. It is classed as highly flammable and toxic to the aquatic environment under the COMAH Regulations. The primary hazards of Odorant NB are due to its flammability, toxicity to the aquatic environment and odour.

The material will be stored and used on the AGI in two bunded tanks of 22.7 m^3 volume. Possible worst case releases for Odorant NB would be the loss of the entire contents of a tank or a release during offloading of a supply tanker (approximately 18 m^3). Ignition of this material in the event of a release could result in fires or explosions.

5.1.2.1 Releases to the Aquatic Environment

In the event of damage to the odorant storage tanks, or tanker offloading system, the material would be contained in the bunded area surrounding the tanks and tanker offloading containment area. However, overtopping of the bund or secondary failures of the bund or offloading containment area could possibly lead to release into the AGI storm water drainage system. The quantity of Odorant NB that could be released will depend upon the cause and duration of the release. A conceivable release quantity could be the release of a 50% of a tank of Odorant NB, which is approximately 10 tonnes of Odorant NB.

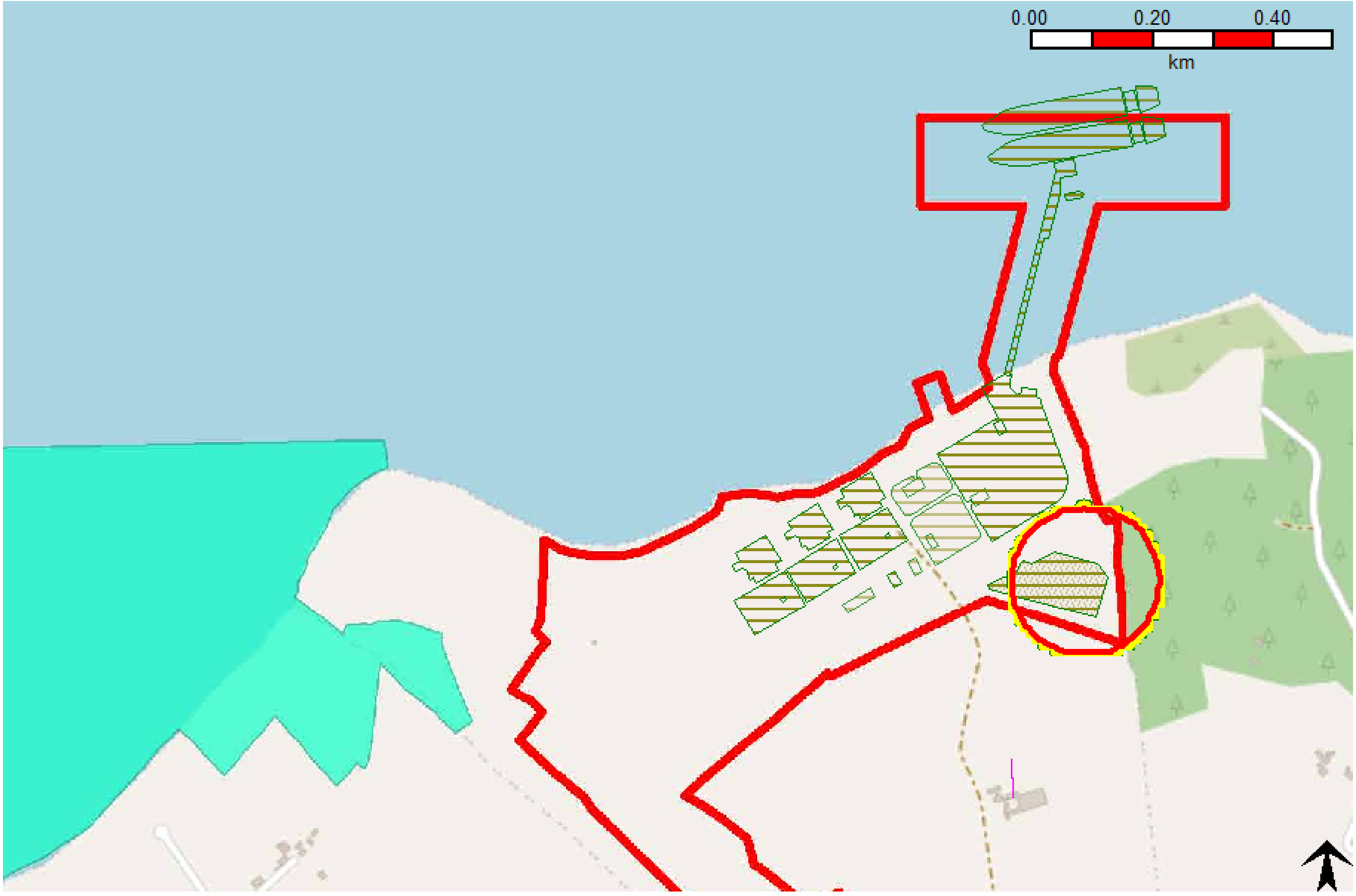
As Odorant NB is highly toxic to the aquatic environment a large release could potentially lead to a MATTE and the areas which are most likely to be affected in the case of a large release are the SAC and the SPA. Odorant NB is insoluble in water and has a lower density than water. It is therefore possible that a surface layer of Odorant NB could form on the estuary surface. The extent of the surface layer would depend upon the conditions in the estuary at the time of release. Odorant NB is biodegradable and has no bioaccumulation potential.

Isolation or containment of a spillage at either the AGI plant drain interceptor or the instrument air Petroleum Interceptor would prevent a release to the estuary via the fire water retention pond. Even if a release was to enter Fire Water Retention Pond, the isolation discharge valve would be closed containing the spill. Finally a floating layer of Odorant NB could be contained by deploying a surface boom.

The likelihood of a MATTE from Odorant NB is considered to be very low, as events involving large releases of Odorant NB are very low frequency events, and secondary and tertiary failure of the systems for containing releases of Odorant NB would also have to occur for a discharge to occur into the estuary.

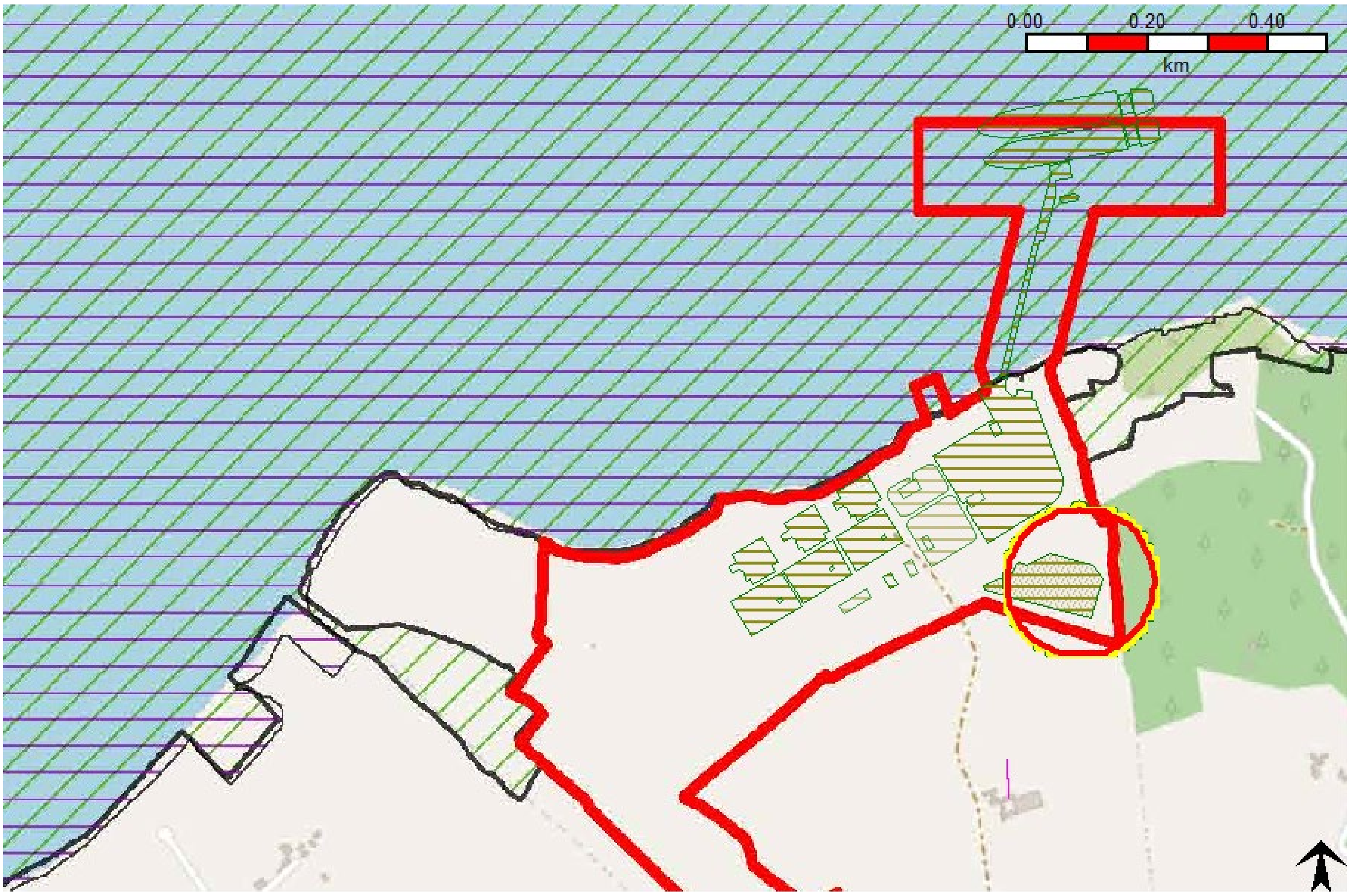
5.1.2.2 Fires or Explosions

Odorant NB is highly flammable and if ignited could lead to localised fires with a possible Boiling Liquid Expanding Vapour Explosion (BLEVE) of a storage tank (if engulfed by fire) Figure 5-7 shows the extent of thermal radiation contours to 5 kw/m^2 for the fireball resulting from a BLEVE. It can be seen that areas designated as SAC, SPA and NHA would not be affected. It is therefore is considered that events related to the direct consequences of the fires or BLEVE of Odorant NB will not present significant offsite hazards and will not lead to a MATTE.



Key: Red 1x10^{-6}/y, Yellow 1x10^{-7}/y, Green 1x10^{-8}/y

Figure 5-7: 5 Fireball Thermal Radiation Extent to 5 kw/m^2 (NHA)



Key: Red 1x10^{-6}/y, Yellow 1x10^{-7}/y, Green 1x10^{-8}/y

Figure 5-8: 5 Fireball Thermal Radiation Extent to 5 kw/m^2 (SPA and SAC)

5.1.2.3 Odour

Evaporation from a spillage of Odorant NB will lead to a pungent odour. As the odour of Odorant NB is noticeable at very low concentrations the extent of the effects could be considerable for large releases under unfavourable atmospheric conditions.

While the odour would be unpleasant it is considered that the effects of the odour would not result in significant harm to flora or fauna and would not result in a MATTE.

5.1.3 Ammonia Hydroxide

Up to 4 tonnes of ammonia hydroxide solution will be stored at the Power Plant in 1,500 litre totes. It will be used for Power Plant feedwater treatment.

Ammonia hydroxide solution is considered to be toxic to the environment under the COMAH Regulations as it classified as H400 “Very toxic to aquatic life”.

A possible worst case release for ammonia solution is the loss of the contents of a tote. This could occur during offloading or during storage. Any releases within the storage building would be contained by the building’s impermeable flooring or bund and could be cleaned up (e.g. using absorbent material) and disposed of safely. Releases outside the building onto roadways could possibly enter the roadway storm water drains and flow through the drainage system to the estuary. However action can be taken to contain spillages and prevent flow to the estuary by closing the storm water drainage system valve.

The loss of the contents of a Tote of ammonia solution to the estuary is likely to have short term environmental effects at the point of discharge. However, it is thought that the release would not be of sufficient size to result in a MATTE.

Spillages onto ground covered in broken stone have not been considered as possible events, as ammonia solution is not used or transported over areas with this surfacing.

Spillage of ammonia solution will lead to a pungent odour close to the spillage. For a release of a tote of ammonia hydroxide solution the odour will not lead to off-site concentrations of concern as the solution is an aqueous solution and only small quantities of ammonia will be released from it to atmosphere.

5.1.4 Diesel

Diesel is present onshore within the STEP in a number of locations, provisionally identified as:

- LNG Black Start/Standby Diesel Generator; 3,200 litres;
- LNG Diesel Fire Pump; 2,000 litres;
- Power Plant CCGT Standby Diesel Generator; 3,200 litres (three off); and,
- Power Plant CCGT Diesel Fire Pump; 1,400 litres.

Diesel is considered to be toxic to the environment under the COMAH Regulations as it classified as H411 "Long-term (chronic) aquatic hazard".

The use of localised small inventory storage tanks for the items of equipment listed above means that the largest credible spillage of diesel would be 3,200 litres. Regulations for the storage of diesel such as the "Control of Pollution (Oil Storage) Regulations (Northern Ireland) 2010" and "HSG 176 Storage of flammable liquids in tanks", detail specific requirements for diesel storage that, if followed, mean that a release of diesel is an unlikely event.

Even if there was a release of diesel in a storage building the material would be contained by the impermeable flooring or bund and could be absorbed and disposed of. Release of diesel into the storm water drainage system would be contained by the Class 1 petrol interceptor. If the interceptor was unable to contain the release and the shut off valve on the storm water drainage system was not closed, there could be a discharge of oil to the estuary. This discharge could possibly result in a surface layer of hydrocarbons on the estuary. In unfavourable conditions it is conceivable that this could affect the SAC/SPA, although the limited quantity of diesel that could be released means that a MATTE is not considered to be possible.

5.1.5 Transformer Oil

Transformer oil is present onshore within the STEP in a number of locations, provisionally identified as:

- Generator step-up transformer (CCGT): 4 Transformers 25,000 litres each; and,
- Auxiliary Transformers (LNG Terminal): 4 Transformers, 2,500 litres each.

For the purpose of this assessment Transformer is considered to be toxic to the environment under the COMAH Regulations as it classified as H412 "Harmful to aquatic life with long lasting effects". It should be noted that assumption of this classification is conservative as transformer oils that do not pose a significant effect to the environment are available.

If a release of transformer oil was to enter into the storm water drainage system it would be contained by the Class 1 petrol interceptor. If the interceptor was unable to contain the release and the shut off valve on the storm water drainage system was not closed, there could be a discharge of transformer oil to the estuary. Possibly resulting in a surface layer of hydrocarbons on the estuary. In unfavourable conditions it is conceivable that this could affect the SAC/SPA. A MATTE is therefore considered to be possible, but only if the release of transformer oil was very large.

5.2 Non-COMAH Materials

Materials that are not rated as hazardous to the environment under the COMAH Regulations require MATTE assessment where it is credible that they could be released, as the result of an incident involving a material that is covered by the COMAH Regulations.

The conservative assumption that incidents involving LNG or natural gas could lead to the release of any of the non-COMAH materials listed in Table 4-1 has been made. It should be noted that, due to the separation distances between the LNG or natural gas systems and areas where these materials are present, the likelihood of secondary releases of this type are very low.

Materials considered are:

- Tri-Sodium Phosphate;
- Sodium Bisulphite (30% - 50%); and,
- Sulphuric Acid (77-100%).

In addition, releases of cleaning chemicals, laboratory chemicals, paints and fires have been considered at a high level.

5.2.1 Tri-sodium Phosphate

Tri-sodium phosphate will be used for feedwater treatment. It is a is a solid material that will be stored in 1,500 kg Totes at the Power Plant water treatment store. It is not classed as hazardous to the environment under the COMAH Regulations. The material has been identified as being toxic to fish.

A possible worst-case release for tri-sodium phosphate solution is the loss of the contents of a tote. This could occur during offloading or during storage. Any releases within the storage building would be contained by the building's impermeable flooring or bund and could be cleaned up (e.g. using absorbent material) and disposed of safely. Releases outside the building onto roadways could possibly enter the roadway storm water drains and flow through the drainage system to the estuary. However action can be taken to contain spillages and prevent flow to the estuary by closing the storm water drainage system shut off valve.

The loss of the contents of a Tote of tri-sodium phosphate ammonia solution to the estuary is likely to have short term environmental effects at the point of discharge. However, it is thought that the release would not be of sufficient size to result in a MATTE.

5.2.2 Sodium Bisulphite

Sodium bisulphite solution will be used for feedwater treatment. It is a is a liquid material that will be stored in 1,500 kg Totes at the Power Plant water treatment store. It is not classed as hazardous to the environment under the COMAH Regulations. The material has been identified as being toxic to fish.

A possible worst-case release for sodium bisulphite solution is the loss of the contents of a tote. This could occur during offloading or during storage. Any releases within the storage building would be contained by the building's impermeable flooring or bund and could be cleaned up (e.g. using absorbent material) and disposed of safely. Releases outside the building onto roadways could possibly enter the roadway storm water drains and flow through the drainage system to the estuary. However, action can be taken to contain spillages and prevent flow to the estuary by closing the storm water drainage system shut off valve.

The loss of the contents of a Tote of sodium bisulphite solution to the estuary is likely to have short term environmental effects at the point of discharge. However, it is thought that the release would not be of sufficient size to result in a MATTE as it is limited to a single tote.

Even if a pathway between the material and an environmental receptor could be identified, release of the material would not result in a MATTE.

5.2.3 Sulphuric Acid

Approximately 3 m^3 of sulphuric acid will be present on the Power station, and also used within uninterruptable power supply (UPS) batteries.

Sulphuric acid is a mineral acid that is corrosive and toxic to the aquatic environment at low levels. As sulphuric acid is not classified as being dangerous to the environment under the COMAH Regulations, as events requiring consideration are those that are due to an incident involving a COMAH material. In the Power Plant area this could be due to an incident involving natural gas that damaged the sulphuric acid containment systems or batteries.

A possible event taken for MATTE assessment is the release of sulphuric acid on the Power Plant. A worst case scenario would be the release of the entire tank contents due to failure of both the tank and leakage from or overtopping of the bund. In this scenario up to 3 m^3 of acid could be released. As the tank is located approximately at some distance from the buried natural gas supply line to the Power Plant, the likelihood of a release of this size is considered to be very unlikely. However, in such an event, a release of sulphuric acid into the storm water drains may be possible.

At the end of the storm water system there is a shut off valve which is normally open to allow the rainwater to discharge to the estuary. This valve can be closed in the event of spillage, as required. A spillage of sulphuric acid could potentially be released to the estuary through this route if the shut off valve was not closed. As the quantities released would be small, and sulphuric acid is not highly toxic to the environment, it is judged that a MATTE from a leak of sulphuric acid is not credible.

5.2.4 Cleaning Chemicals, Laboratory Chemicals and Paints

Various types of laboratory chemicals, paints and cleaning materials will be stored in Maintenance & Warehouse Buildings and will be used throughout the STEP. Details of the properties of these materials are not available but it is likely that some of the materials will be hazardous to the environment or flammable.

These types of materials are commonly stored and transported on site in small containers and if accidentally spilled can be treated, absorbed into inert materials and disposed of safely. Any releases in storage areas will be contained by impermeable flooring. On this basis it is concluded that a MATTE from the release of laboratory chemicals, paints and cleaning materials is not credible.

5.2.5 Storage Building Fires

A variety of materials such as laboratory chemicals, paints, cleaning materials, oils and process chemicals will be present in storage buildings on the LNG Terminal and Power Plant. Storage building fires may occur as a consequence of an LNG or natural gas fire and a range of materials stored in the buildings could combust, be carried into the atmosphere in the smoke plume, be released to the building floor (liquids) or enter firewater.

In the event of a storage building fire the materials being released to atmosphere will be primarily carbon dioxide, carbon monoxide, water vapour, soot and unburned materials that may be carried in the smoke plume.

Local environmental factors such as wind speed and direction will influence which environmental receptors are likely to be affected and the potential for dry deposition of materials in the plume. Washout of material from the plume may occur if it is raining, leading to deposition of materials.

The primary combustion products (carbon monoxide, carbon dioxide and water vapour) in fire plumes will have short term environmental effects as they are not considered to be highly hazardous to the environment and will not produce long term contamination. Soot deposited from the plume may lead to short term marking of vegetation but is also unlikely to lead to long term or acute environmental damage. Therefore, a MATTE from a storage building fire smoke plume is not thought to be a credible event.

Fire water run-off from a storage building fire will be expected to be contained on site and will only reach the Shannon estuary if a very large quantity of firewater is used. In this event, water contaminated with materials that may be hazardous to the environment could enter the estuary. If such a release was prolonged, and contained materials that are ecotoxic, it is possible that the local SAC/SPA could be affected, possibly leading to a MATTE. With the measures proposed for preventing building fires and controlled discharge of fire water to the estuary, the risk of a MATTE from fire water run-off is considered to be very low.

6. Conclusion and Recommendations

The results from the MATTE assessment are summarised in Table 6-1 below.

Qualitative assessment of possible scenarios for accidental releases associated with the STEP has indicated that releases or accidents of large quantities of some materials have the potential for causing a MATTE; specifically Odorant NB and Transformer Oil. Release of firefighting water to the estuary could result in a MATTE if it is contaminated with ecotoxic materials.

Table 6-1: MATTE Summary

Material	Potential MATTE	Evaluation	Risk of MATTE
Odorant NB	**Yes**	This material is classed as being hazardous to the environment under the COMAH Regulations and any scenarios where large quantities of the material are released to the aqueous environment can be considered a MATTE.	**Very low** – measures on site would prevent the material entering the estuary
Transformer Oil	**Yes**	Transformer oil may be hazardous to the environment depending on its chemical composition and a significant release to the estuary could result in a MATTE.	**Very low** – measures on site would prevent the material entering the estuary
Firefighting Water	**Yes**	Firefighting the water may be contaminated with materials that are toxic to the environment and, as such, a release of a large quantity of firefighting water into the Shannon estuary may lead to a MATTE.	**Very low** – measures on site would prevent the material entering the estuary
Liquefied Natural Gas / Natural Gas	**No**	This material is highly flammable and, if ignited, thermal radiation from large pool fires located at the FSRU or LNGC could lead to thermal radiation levels at a Special Area of Conservation (SAC) to the west of the STEP site**.** As the duration of recovery from these consequences would be short the consequences are not considered to be a MATTE.	N/A – not a MATTE
Ammonia Hydroxide	No	Small quantities of material that is not significantly ecotoxic with low possibility of entering the marine environment.	N/A – not a MATTE
Tri-Sodium Phosphate	No	Small quantities of material that is not significantly ecotoxic with low possibility of entering the marine environment.	N/A – not a MATTE
Sodium Bisulphite	No	Small quantities of material that is not significantly ecotoxic with low possibility of entering the marine environment.	N/A – not a MATTE

Material	Potential MATTE	Evaluation	Risk of MATTE
Sulphuric Acid	No	Small quantities of material that is not significantly ecotoxic with low possibility of entering the marine environment.	N/A – not a MATTE
Diesel	No	Material categorised as being toxic to the environment but present in small quantities with well-developed measures to prevent release to the environment	N/A – not a MATTE
Cleaning materials, laboratory chemicals and paints	No	Materials may be harmful to the environment but only present in small quantities with low possibility of entering the marine environment.	N/A – not a MATTE

All of the MATTE events identified are considered to be low frequency and consequently low risk, as the initiating event for release would be a significant fire or explosion on the LNG Terminal or Power Plant.

Measures for prevention of fires and explosions and systems for prevention of discharge to the estuary are present within the plant design and operating philosophy.

7. References

[1] Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015. SI No. 209 of 2015.

[2] Guidance on the Interpretation of Major Accident to the Environment for the Purposes of the COMAH Regulations, DETR, 1999.

[3] Chemicals and Downstream Oil Industries Forum (CDOIF). Guideline – Environmental Risk Tolerability for COMAH Establishments v2.0.

[4] Globally Harmonized System of Classification and Labelling of Chemicals (GHS). About the GHS | UNECE

[5] Shannon Technology and Energy Park Environmental Impact Assessment Report. Aecom, 2021

[6] Shannon Technology Energy Park (STEP) Land Use Planning QRA HSA (2010). Policy and Approach of the Health and Safety Authority to COMAH Risk-based Land-use Planning. Report 11100246513-R01. Vysus Group, 3/8/2021.

[7] Olin Chlor Alkai Products Material Safety Data Sheets. www.olinchloralkali.com

[8] Sciencelab Material Safety Data Sheets. www.sciencelab.com

[9] Sigma Aldrich Material Safety Data Sheets. www.sigmaaldrich.com

[10] Robinsons Brothers Material Safety Data Sheet for Odorant NB. 3/03/2013 Revision No. 7.

[11] Air Liquide Material Safety Data Sheets. www.uk.airliquide.com

Shannon Energy Park

Oil and Hazardous and Noxious Substances (HNS) Spill Plan

Development Framework

Developed by:	Karl McManus	14-05-2021
Reviewed by:	Agnes McLaverty & Martin Iversen	17-05-2021
Approved by:	Martin Ahern	20-05-2021

Contents

1. Introduction:

Shannon LNG Ltd. operator of the Shannon Energy Park fully recognizes it has a moral, legal and business obligation to provide a process, procedures and resources to respond to unintentional releases of hazardous substances including hydrocarbons, chemicals and gases into the environment within its area operational responsibility.

This document describes the framework in which Shannon Energy Park will develop plans to provide a graduated and tiered response process to fulfil these obligations and to provide a robust and coordinated response to release incidents in the unlikely event they should occur. The assessment of likelihood and consequences of these release events are set out in the following documents are outside the scope of this document

- Marine Navigation Risk Assessment
- QRA and associated MATTE
- Environmental Impact Assessment Report for the proposed development
- Construction Environmental Management Plan

The developed plans will follow international best practice guidelines of the International Maritime Organization (IMO), The Society of International Gas Tanker and Terminal Operators (SIGTTO), and International Petroleum Industry Environmental Conservation Association (IPIECA) while taking into account relevant Irish legislative and regulatory approval requirements. In particular the plans will follow the requirements made within the National Maritime Contingency Plan Oil and HNS Spills 2019 (NCP) and the National Framework for the Management of Major Emergencies. Developed Plans will interface with other emergency management frameworks, key stakeholders, and mutual aid partners.

The plan will be developed to cover both In-Land (onshore) and Marine based releases and shall cover the Construction and Operational Phases of the project.

2. Scope:

The Shannon Energy Park will be responsible for the response, control and mitigation of pollution incidents within its area of jurisdiction. This will include the onshore installation, jetty facility, FSRU and discharging vessels, including a marine-base area to be agreed with the Shannon Foynes Port Harbour Master.

Shannon Energy Park will manage the response to any Tier 1 and Tier 2 incident for any pollution on the water within their area of jurisdiction with the full cooperation and integration of the response with the Shannon Foynes Port, the Shannon Estuary Anti-Pollution Team (SEAPT) mutual aid group which includes the three local authorities of Kerry, Clare and Limerick and other agencies as appropriate.

3. Objectives:

The primary objectives of Oil and HNS Contingency Plans under the framework are:

- To assess the pollution risk from Shannon Energy Park operations and ensure sufficient preventative and response measures are in place to ensure the risk of a pollution incident "as low as reasonably practicable" (ALARP);

- To ensure the safety of Shannon Energy Park employees, contractors, response personnel and the community/members of the public throughout the response to a pollution incident;
- To detail the internal and external notification processes and set-in motion practices for an integrated efficient pollution response;
- To ensure the timely mobilisation of resources, both personnel and equipment, to combat a pollution incident within the geographical scope of this plan;
- To have in place actions and procedures to ensure the response to a pollution incident is both timely and effective in mitigating any adverse impact on vulnerable socio-economic and environmental receptors; and,
- To be compliant with regulatory and best practice guidance on pollution preparedness and response.

4. Interfacing Plans:

The Shannon Energy Park Oil and HNS spill Contingency Plan will interface with the plans as shown in the example below. Depending on the severity of the pollution incident, one or all the plans shown will be implemented to support this plan.

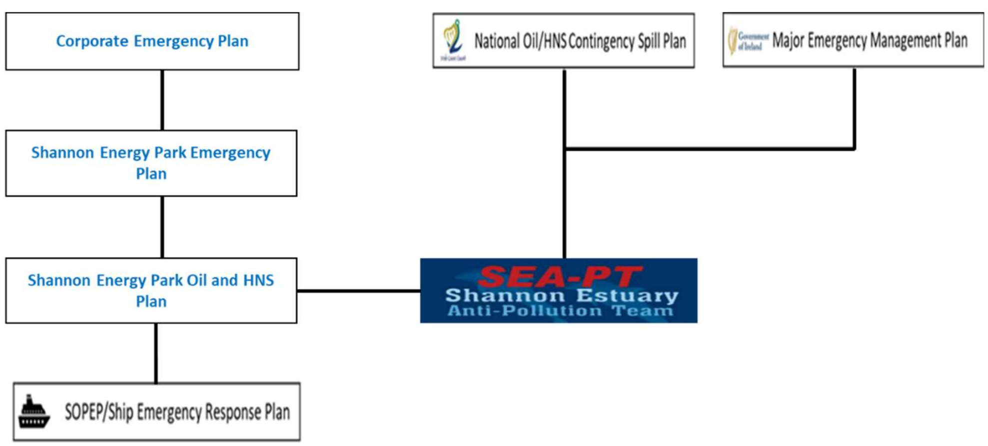


Figure 1 Interface of Oil/HNE Response Plans

5. Oil and HNS Spill Plan Format:

In accordance with the requirements of the National Contingency Plan (NCP) Standard Operation Procedure 05, the Plan will be developed around the five operational phases of the core document:

Phase 1 – Discovery and Notification, Evaluation, Identification and Activation

Phase 2 – Development of an Action Plan

Phase 3 – Action Plan Implementation

Phase 4 – Response Termination and Demobilisation

Phase 5 – Post Operations, Documentation of Costs/Litigation

Additional technical, tactical and guidance information shall be held in the accompanying Chapters and Annexes:

CHAPTERS:

1 Abbreviations and Definitions
2 Irish Coast Guard notification
3 Incident Command Structure
4 Risk Assessment
5 Training and Exercising Regime
6 Shoreline Clean-up Assessment Technique
7 Response Strategies and Guidance
8 HNS Response Guidance
9 Dispersant Use
10 Occupational Safety and Health
11 Wildlife Rescue and Rehabilitation
12 Evidence Collection and Cost Recovery
13 Waste Management
14 Place of Refuge
15 Stakeholder Engagement and Media
16 Financial Management Protocols
17 Documentation procedures

ANNEXES:

1 Contact List
2 Certifications of Employees
3 Equipment and Resources
4 Communication Protocols
5 Service Contracts and MOU's
6 Incident Command Forms
7 Modelling Tools

The developed plans will identify realistic Tier 1 and Tier 2 scenarios, and the capability to deal with these. They will describe any escalation to Tier 3 and as discussed above interface with the National Marine Oil/HNS Spill Contingency Plan. A training and exercising programme forms part of Chapter 5, an example of which is given below.

The completed plan(s) will be submitted to the Irish Coast Guard and EPA for appropriate approvals.

6. Shannon Estuary Anti-Pollution Team:

The Shannon Estuary Anti-Pollution Team (SEAPT) is a Mutual Aid Group and the primary response organisations for oil and HNS spills within the Shannon Estuary. The SEAPT consists of the Shannon Foynes Port company, Kerry, Limerick and Clare Local Authorities and commercial and industrial entities operating within the Shannon Estuary. SEAPT was initiated to form a unified coordinated response to pollution incidents on the Shannon Estuary.

SEAPT is a member's organisation. Members contribute annually to maintain equipment, carry out exercises and training and purchase new and replacement equipment. SEAPT holds a significant stockpile of equipment. This equipment is available to respond to any pollution incident or threat thereof. Shannon Energy Park would also be able to avail of spill dispersion modelling capability held by SEAPT. SEAPT are also the custodians of the Shannon Estuary Oil/HNS Contingency Plan developed in accordance with the NCP and approved by the Irish Coast Guard.

Shannon Energy Park have consulted extensively with SEAPT and the intention is to join the SEAPT organisation on successfully receiving development consents and prior to commencement of the construction phase.

Membership of SEAPT will enable Shannon Energy Park to interface directly with the approved Shannon Estuary Oil/HNS Plan and access additional response equipment to augment that held within the terminal.

Through the membership process, Shannon Energy Park will additionally be contributing to the on-going development and strengthening of the SEAPT organisation .

7. Emergency Management System:

It is expected that Shannon Energy Park will be designated as a Upper tier COMAH/Seveso site. As such a comprehensive Emergency Management system will be developed and implemented. This system shall define and describe the Emergency Management organization, systems, processes and the actions to be taken when dealing with emergency situations including spill response. The Emergency Management system documents will contain

- Roles and responsibilities for emergency preparedness and response in the event of an emergency at the Shannon Energy Park
- A process to identify, assess emergency scenarios together with appropriate strategies and tactics to control and mitigate such events
- Local Emergency plans, organization, procedures and resources
- Requirements for testing of systems, procedures and personnel
- Checklists for specific response scenarios

The Emergency Management system will be reviewed annually or following alterations to the facility that will result in significant changes to the requirements. The plan may also be updated following lessons learned from exercises onsite. The Shannon Energy Park review and audit programme will include emergency management.

8. Estuary and Marine based Oil/HNS Spills:

The Oil Pollution Preparedness, Response Co-operation Convention defines the following response levels for oil spills in Ireland:

- **Tier 1 Local** (within the capability of the operator on site): A Tier 1 response is the lowest response level and requires resources to be available locally. Depending on the characteristics of the oil this may or may not include the use of dispersants. By definition these resources must be at or near the incident site. It is expected that these resources will be deployed as quickly as operational circumstances allow.

- **Tier 2 Regional** (beyond the in-house capability of the operator): For larger pollution incidents, local resources may be insufficient to deliver a proper response. In these cases it may be that resources from a regional centre will be required. A key component of IRCG offshore Tier 2 response is that operators are expected to have this capability mobilised and applied within 2 to 6 hours of an oil pollution incident.

- **Tier 3 National** (requiring national resources): For very large pollution incidents, resources supplied from national and international sources may be required. A key component of IRCG offshore Tier 3 response is that operators are expected to have this capability mobilised and applied within 6 to 18 hours of an oil pollution incident.

Oil spill emergency involves contacts and co-operation with local and/or regional authorities and governmental bodies and, depending on its size, may require the assistance of other operators, national, or international resources. An oil spill contingency plan or a checklist will be used to create the oil spill response plan.

Following the guidance of the NCP the Oil and HNS contingency plan will contain chapters covering the identification and assessment of spill and release scenarios and the response strategies, tactics and actions to be employed, in particular the following chapters:

Chapter 4 – Risk Assessment

Chapter 7 – Response Strategies and Guidance

Scenarios Identified

A marine navigation risk assessment took place in March 2021 which assessed numerous scenarios which could potentially result in oil spills on the river or estuary from the Shannon Energy Park. The following worst credible outcomes from the report will form a significant part of the Chapter 4 Risk Assessment to identify spill and release scenarios and appropriate response strategies:

Event	Potential Outcome
A Tanker collides with a LNGC or FSRU while underway in the vicinity of anchorages or within the narrows as a result of mechanical defect / failure, master / pilot error, etc. with 3rd party vessel.	• A glancing blow: Tier 1 may be declared but criteria not necessarily met • Head-on collision. Tier 2 spill criteria reached but capable of being limited to immediate area
A Tanker collides with cruise ship on estuary passage.	• Tier 3 criteria reached with pollution requiring national support.
A dolphin watch vessel fails to take avoiding action and collides with the FSRU	• Small operational oil spill with little environmental impact;
Collision during pilot boarding and landing or when tug on route to LNGC fails to take appropriate avoiding action	• Head-on collision or Small Commercial / Port Services Vessel being overrun / sunk. Tier 1 / Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity
Mechanical failure causes tanker to drift across the estuary and strikes the FSRU	• Potential for Tier 3 Criteria to be reached
A Vessel runs heavily aground.	• Tier 2 spill criteria reached but capable of being limited to immediate area within the site

Event	Potential Outcome
Vessel sinks at berth or at anchor.	• Tier 2 may be declared but criteria not necessarily met
Fire breaks out on berthed FSRU or LNG Supply Vessel	• Large persistent vessel fire while undertaking discharge operations. Tier 3 support required.
Spill during Bunking operations	• Release of product in marine environment. Tier 2 criteria reached.

Table 1 Scenarios Identified from NRA

Mitigation methods:

The developed plans will detail potential spill or unintentional release scenarios (Chapter 4) and appropriate response strategies and guidance, Chapter 7.

Response strategies will follow best practice hierarchy described in the references shown:

Spill Response Hierarchy

Control of Source	Operating and Emergency SPO's are activated to stop release at source.
Monitor and Evaluate	Monitoring is a systematic process of collecting and recording information on the oil spill, while evaluating is the process of drawing together the information and making judgements
Shoreline Protection	If oil is expected to impact sensitive areas, booms may be used as a barrier to protect the shoreline.
Contain and Recover	The containment and recovery of an oil spill uses floating barriers (booms) to contain the oil in sufficiently concentrated quantities to enable recovery devices (skimmers) to remove the oil from the surface.
Wildlife Response	Wildlife response requires the knowledge and skills of experienced responders and handlers. Wildlife response will be addressed in detail in Chapter 11.
Waste Management	During an oil spill there are many streams of waste that have to be managed to ensure that operations can continue, and environmental impact is reduced. Waste management will be addressed in detail in Chapter 13.

Release of LNG:

A release of LNG as a gaseous cloud is seen as an unlikely marine pollution incident and the core strategy would be to monitor and evaluate as operational and emergency protocols are implemented.

9. LNG Releases into the Estuary or at Sea:

Due to the rapid vaporisation rate of spilled LNG on the sea, the likelihood of harm to the marine environment (if unignited) is minimal due to its dispersion. The main risk posed on unintentional release remains that of fire, which is addressed in the site emergency plans.

Technical information on LNG, its characteristics and behaviour on release into the environment is provided in Appendix B. The assessment of likelihood and consequences of a release of LNG into the Estuary are set out in the following documents are outside the scope of this document

- Marine Navigation Risk Assessment
- QRA and associated MATTE
- Environmental Impact Assessment Report for the proposed development

The information in these documents will be used to formally assess pollution risk scenarios and response strategies. This information will be used in the development of Chapter 4 Risk Assessment and Chapter 7 Response Strategy and Guidance.

10. Spills and Releases on Land:

Shannon Energy Park expectation is that a major release of hazardous or noxious substances into the marine environment is not likely to occur.

The assessment of likelihood and consequences of spills and releases on land are set out in the following documents are our outside the scope of this document

- QRA and associated MATTE
- Environmental Impact Assessment Report for the proposed development
- Construction environmental management plant

Typical incident scenarios have been identified and are provided as a conservative framework to ensure decisions are based on knowledge of the potential range of events and effects, as well as allowing Shannon Energy Park to prepare for the worst-case scenarios in its emergency response preparations as required by applicable regulations and its prevailing duty of care.

Event	Potential Impact
Fire at Facility	Product contaminated firewater impacts offsite and enters Estuary via groundwater, drains and culverts.
Incident involving lorries delivering to site via security gate on R612 resulting in spill of materials	Product impacts areas along R612 and enters Estuary via culverts/drain in roadside
Leak/spill due to damage caused to storage containers during folklift truck operations in off-loading area.	Product enters Estuary via surface water drains and Waste Water Treatment Plant.
Release of Diesel from emergency generator storage tanks	Product enters Estuary via surface water drains and Wastewater Treatment Plant.

Event	Potential Impact
Spill/ release of odorant at AGI	Pungent-smelling gas at low concentrations (ppm) released to the environment. Highly flammable substance

Table 2 Events on Land and Potential Impacts

Stopping the spill at source:

The ESD system will continually monitor inputs from process field devices, including the ICSS and fire and Gas detection system. If a leak is detected by changes in the levels monitored, then the system initiates appropriate output actions to bring the plant to a safe condition. In addition to being automatically activated by the ICSS or F&G system, the ESD can also be manually initiated by the control room operator. Each part of the process equipment that contains hazardous liquids will be contained within a bund. In the event of a spill, trained personnel are to use the nearest available spill kit to contain the spill. Once confirmed safe to do so, the Emergency response team are deployed to clean up the spill. If unsafe to do so the emergency services are contacted, and the emergency response plan follows.

11. Personnel & Equipment:

Shannon Energy Park will develop, train and have in place emergency management and response teams in order to manage and response to any incidents including spills and unintentional releases. The teams will be trained in accordance with training schedule given below.

Response teams will have access to equipment and other resources for Tier1 and Tier 2 incidents. Equipment stockpile specifications will be developed as part of the risk assessment, scenario planning and response strategy sections on the spill response plan. The stockpile will include fixed and mobile equipment for protection, containment and recovery and will be augmented by the Tier 2 equipment stockpile held by SEAPT at Shannon Foynes Port.

12. Training and Exercises:

As per the NCP, the Irish Coast Guard has adopted the International Maritime Organisation (IMO) levels of model Oil and HNS Spill courses; these form the basis of the national courses organised by Irish Coast Guard and will form the core Shannon Energy Parks maritime spill response training regime. Associated Inland Spill training in line with IPIECA best practice for non-marine based releases. In addition to the IMO suite of spill response training, appropriate Incident Management Training will also be undertaken to ensure personnel's knowledge and understanding of specific roles and the corresponding responsibilities.

Example Technical Training Courses	Trained Staff
IMO 1 Operations Staff	
IMO 2 Supervisors and On-Scene Commanders	
IMO 3 Senior Management Personnel	

IMO HNS Operational Level (First Responders, Supervisor and On-Scene Commanders),	To be determined
IMO HNS Manger Level (Administrators and Senior Managers)	
ICS 100 - An Introduction to the Incident Command System	
ICS 200 - Applying the Incident Command System	
ICS 300 - Incident Command System	

Table 3 Example of technical Training Courses

Exercises form a fundamental part of training and competency development. Members of Incident Management and Response Teams must be familiar with spill and other emergency procedures and be prepared to carry out emergency response operations in a safe, rapid, effective, and efficient fashion.

This level of familiarity and preparedness is achieved through regular and routine drill and exercises. Below is an example of the type of Exercise program that will be implemented.

Type of Exercise	Monthly	Every 3 Months	Annually	Every 2 Years
IMT Communications Test	✓			
Full Communications Exercise		✓		
Tabletop/ Command Room Exercise		✓		
Limited Exercise			✓	
Full Scale Exercise				✓

Table 4 Example of Exercise training Schedule

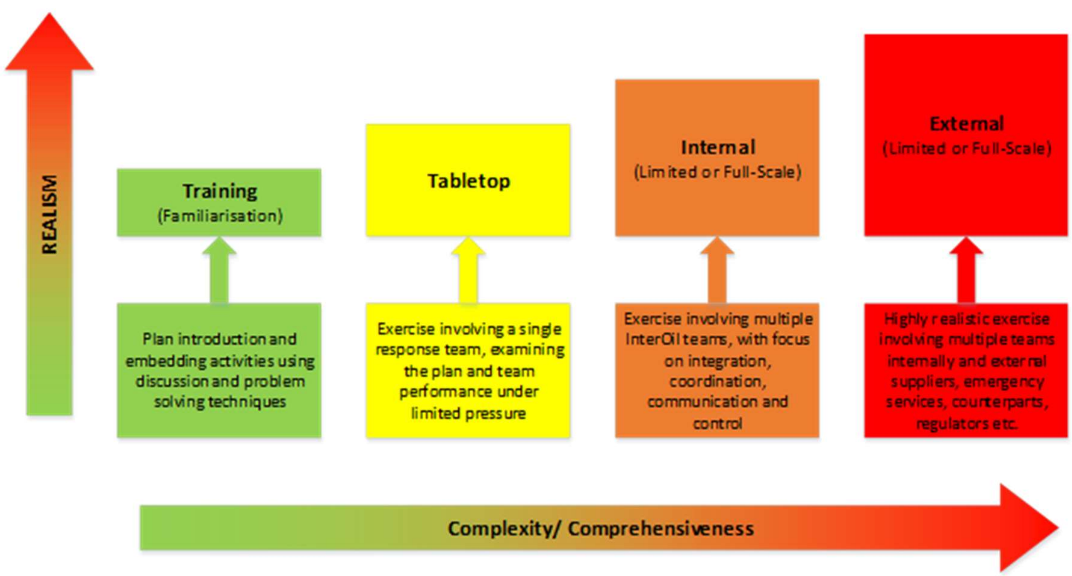


Figure 2 Description of Training and Exercise Content

13. References:

International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) 1995

Sea Pollution Act 1991, Sea Pollution (Amendment) Act 1999

National Maritime Contingency Plan for Oil and HNS Spills 2019 – Department of Transport. Irish Coast Guard: Gov.ie. NCP

International Petroleum Industry Environmental Conservation Association – Technical Document Series https://www.ipieca.org/resources/

The Society of International Gas Tanker and Terminal Operators: www.sigtto.org/publications/

International Tanker Operators Federation Limited (ITOFT) – Technical document Series

https://www.itopf.org/knowledge-resources/

A Framework for Major Emergency Management: www.MEM.ie

Shannon Energy Park Navigation Risk Assessment March 2021

MARPOL, Entry into force (1973). MARPOL The International Convention for Prevention of Marine Pollution for Ships. Adoption: 1973 (Convention), 1978 (1978 Protocol), 1997 (Protocol - Annex VI); Entry into force: 2 October 1983 (Annexes I and II).

European Union Control of Major Accident Hazards (COMAH) Involving Dangerous Substances Regulations 2015

LNG Risk Based Safety, Modelling and Consequence Analysis, Woodward and Pitbaldo, 2010

Sandia Laboratories, Information Day Report, 2009

CFD methodology for simulation of LNG spills and rapid phase transition (RPT), Horvat, MMI Engineering Ltd, 2018 Institution of Chemical Engineers, Process Safety and Environmental Protection 120 (2018)

Shannon Estuary Anti-Pollution Team: Shannon Estuary Oil and HNS Spill Contingency Plan: http://www.seapt.ie

Environmental Protection Agency Guidance Assessing and Costing Environmental Liabilities (2014).

SOLAS; Safety of Life at Sea
https://www.imo.org/en/KnowledgeCentre/ConferencesMeetings/Pages/SOLAS.aspx

Shannon Energy Park QRA study, Vysus UK Limited

EIAR Shannon Energy Park QRA, AECOM

14. Appendix A: Letter of Intent for SEAPT Membership

Harbour Office
Mill House, Foynes
County Limerick, Ireland

Tel: +353 69 73100
Fax: +353 69 65142
Email: info@seapt.ie

SEA-PT
Shannon Estuary Anti-Pollution Team

Martin Ahern
Shannon Energy Park,
Listowel,
Co. Kerry.

06th May 2021.

Dear Martin,

Thank you for your recent enquiry regarding Membership of Shannon Estuary Anti- Pollution Team.

I am very pleased to confirm that Shannon Energy Park will be able to join SEAPT when they are ready.

Membership of SEAPT fulfils requirements for Tier 2 obligations with respect to the National Maritime Contingency Plan for Oil and HNS Spills in terms of inclusion in the Shannon Estuary oil and HNS plan, access to pollution control equipment, training and exercises. The current Shannon Estuary contingency plan is approved by the Irish Coast Guard. SEAPT equipment is available to members to augment Tier 1 response as per the arrangements of the membership.

Detail on membership and associated subscriptions can be confirmed at a later date.

Yours Faithfully,

Hugh Conlon

Director.

15. Appendix B: LNG Release Technical Data

LNG Marine Safety

Safety consideration associated with the marine transportation of LNG differ from those associated with land based handling and processing of LNG. During marine transportation, only containment within non- pressurised ships storage tanks is involved. Any loss of containment resulting in an LNG spill onto water, would spread in an unconfined manner with rapid vaporisation and dissipation due to heat input from the sea/river water in the estuary. The emphasis in marine transportation is therefore on providing secure marine containment systems and protecting them from the perils of the sea and navigational incidents.

The international Maritime Organisation (IMO) has developed standards for the design, construction and equipment for all classes of ships. These standards published as specific codes governing design, materials, construction, equipment, operation and training include a code covering "Ships Carrying Liquified Gases in Bulk" with specific references to LNG. Safety and crew training are further addressed in IMO conventions such as Safety of Life at Sea (SOLAS) and Standards of Training, Certification and Watchkeeping for Seafarers (STCW). The US coast guard (USCG) has developed additional requirements for LNG ships trading to US ports and in order to provide unrestricted trading flexibility all owners include USCG items in their Ship specifications.

Independent International Classification Societies, such as Lloyds Register of Shipping and the American Bureau of Shipping, issue rules and regulations for the construction and routine survey of LNG ships These rules and regulations are designed to ensure the structural strength and watertight integrity if the hull, the safety and reliability of propulsion and steering machinery, and the safety and effectiveness of the systems installed to protect cargo and crew.

Strict adherence to IMO, USCG and classification society standards has enabled the marine industry to compile an outstanding record of safe LNG shipping operation spanning more than 40 years. In addition, industry bodies such as the Society of International Gas Ship and terminal Operators (SIGGTO) have developed voluntary safety guides and codes best practice covering all aspects of operation and maintenance of the marine transportation link in the LNG supply chain.

Incident History

Since the inception of LNG maritime transportation there have been very few major incidents involving LNG ships, none of which have resulted in spills or loss of containment due to breaching of cargo tanks. Many occurring in the earlier years of the industry, more than 40 years ago, and lessons learnt coupled with technology improvements have either eliminated or engineered out many of the root causes. The most significant LNG shipping incidents are described below together with comments on their likelihood of re-occurrence.

- **Pollenger** had an LNG spillage onto the steel cover of cargo tank during unloading at Everett, Massachusetts in April 1979. The spill caused a cracking of the steel plate. [The leakage was from a faulty valve spindle gland. Current operational and maintenance practices plus improved valve gland materials have reduced the risk of re-occurrence]
- **Mostafa Ben Boulaid** had LNG leakage from the spindle of a swing check valve during unloading at Cove Point, Maryland in 1979. The spillage caused minor cracking on the steel deck plating. [Improvements in modern cryogenic valve design have eliminated the spindle aperture through which leakage occurred]

- **El Paso Paul Kaiser** grounded on a rock in the Straits of Gibraltar whilst proceeding at speed on loaded passage from Algeria to the US in June 1979. Despite extensive damage to eh flat bottom and ballast tanks over a length of almost 500 feet and distortion of the inner hull of the cargo tanks did not fail and there was no release of cargo. After re-floating the complete cargo was transferred to a sister ship and subsequently delivered to its destination. [Major advances in radar and GPS technology have reduced the risk of navigational errors of the type which led to this incident]
- **LNG Libra** experienced a fracture of the propeller shaft whilst proceeding on loaded passage from Indonesia to Japan in October 1980. The ship was taken under tow to a safe location, the complete cargo was transferred to a sister ship and subsequently delivered to its destination. [Improved technology for the manufacture , inspection and testing of materials has reduced the risk for this type of mechanical failure]
- **LNG Taurus g**rounded on the rocks at the entrance to Tobata harbour in Japan with a full cargo of LNG from Indonesia in December 1980. The ship suffered extensive damage to the ballast tanks but the cargo tanks were not affected and there was no release of LNG. [The incident occurred during an attempt to enter harbour in high winds. Improved knowledge of the wind effects on LNG ships, improved pilotage and tractor tug capability have all reduced the risk for this type of incident]
- **Tellier** experienced failure of moorings and was blown out of the berth at Skikda, Algeria during severe winds in February 1989. Movement of the hip damaged the loading arms which subsequently spilled LNG onto the deck fracturing the steel plating. Cargo transfer had been stopped before the vessel moved but the arms had not been drained or disconnected. [Improved mooring arrangements, ESD systems linked with Powered Emergency Release couplers (PERCs) as employed at modern terminals remove the risk of this type of incident]
- **Norman Lady** was struck by the nuclear submarine “USS Oklahoma City” in November 2002. The LNG ship was on ballast passage having just discharged cargo in Barcelona, Spain, the submarine was rising to periscope depth near the Straits of Gibraltar. Norman Lady sustained damage to her outer hull and small leakage of seawater into a ballast tank but no damage to the cargo tanks. [Commercial shipping can do nothing to avoid this type of incident but it cannot happen in a navigational channel, port or shallow water area]
- **Tenaga Lima** had fishing lines foul her propeller shaft seal on departure in ballast from Korea and contacted underwater rocks after deviating to effect repairs in April 2004. Sustained extensive damage to the outer hull forward side shell but minimal damage to the inner hull.
- **Al Khattiya** a LNGC had two ballast tanks breached with the loss of some ballast water after the ship was hit by an oil tanker February 2017. Cargo tank pressures were stable and there was no loss of LNG from the cargo tanks.
- **ASEEM LNG Carrier,** collided with a VLCC in the passage channel of the Fujairah anchorage area, UAE, 2019. The hulls of both vessels were breached below the waterline, the VLCC sustained extensive damage. The VLCC was proceeding at speed which reduced the time available to take avoiding action while another small vessel crossed ahead of her. No LNG was released in the incident.

Over the years there have been several incidents involving small releases of LNG, such as minor leaks from seals and gaskets, some of which have required transfer operations to be temporarily suspended in order to effect repairs. None have been of a major nature nor have threatened the integrity of the cargo containment system.

There is no direct means by which to compare the overall environmental and safety performance of LNG shipping with that of oil shipping but the historical records of oils spills and pollution provides a striking contrast with the unblemished record of LNG shipping operations. The table below shows a record of oil spills between 7 and 700 tonnes and separately spills over 700 tonnes for the years 1974 through 2002 as recorded by the internationals ships owners Pollution federation (ITOPF). The incidence of spills is compared with those involving LNG for the same periods, documented by Poten & Partners Inc., none of which were as large as 7 tonnes or involved spills onto water.

Incidence of Spills by Cause (1974-2002): OIL & LNG

	<7 tonnes	7-700 tonnes >700 tonnes	Total Oil	Total LNG* <7 tonnes
OPERATIONS				
Loading/discharging	2772	318	3039	7
Bunkering	542	25	567	0
Other operations	1167	47	1214	1
ACCIDENTS				
Collisions	164	347	511	0
Grounding & Stranding	222	310	532	0
Hull, Machinery & Engine failure	563	121	684	0
Fires, Steering & Explosions	150	35	185	0
OTHER/Unknown	2221	218	2424	0
TOTAL	7801	1421	9207	8

Source: International Ship Owners Pollution Federation, Poten & Partners, Inc.

LNG Ship Construction

All LNG vessels are of double hull construction. The LNG containment tanks occupy the entire centre of the vessels hull, all the structural strength steel is concentrated in the side shell and bottom. This concentration of strength makes the sides and bottom of LNG vessels more resistant to collision or grounding damage than conventional oil ships. The LNG cargo is contained within independent tanks or membrane barrier systems located well inside a ships protective double hull structure. The space between the hulls is used to carry ballast water when the cargo tanks are empty.

Cargo containment systems fall into two discrete types. One is of thick walled aluminium or cryogenic steel tanks, externally insulated, self supporting and mounted inboard and independently from the LNG ships hull. The tanks can be either spherical or prismatic. The other type is the membrane type where membrane barriers of stainless steel or Invar metal are supported by rigid insulation housed with the vessels inner hull. In this design, there are two containment layers, a primary containment membrane and a 100% backup secondary membrane, each separated by a thick layer of insulation. The secondary membrane is separated from the inner hull by another layer of rigid insulation, further distancing the cargo and primary containment for the LNG ships hull. In both designs the LNG cargo is contained within tanks or membranes well inside the LNG ships protective double hull structure. In effect, there are multiple hulls or barriers between the sea and the LNG cargo.

The insulation spaces of both designs are filled with inert gas, usually nitrogen and continuously monitored by sensitive gas detection and temperature monitoring equipment set to alarm if any abnormality is detected. In additional the completely surrounding the cargo, nitrogen is extensively used as an inert safety barrier in compressor shaft seals, for jacketing gas fuel line to the LNG ships boilers, for purging cargo transfer manifolds, and generally to ensure that cargo vapours and air are never allowed to meet. This hold true through all operational phases, including loading, ocean voyages and final discharge, where the LNG cargo is at no time exposed to allow mixture with air. As a result of the design characteristics of LNG ships and as has been demonstrated in service, marine incidents such as groundings, low energy collisions or jetty contacts which would not result in penetration of both hulls, insulation material and cargo containment systems of LNG ships.

LNG Ship Berthed

The potential for another vessel to allide with a LNG ship when it is moored in the berth has to be taken into consideration. The proposed terminal is located on the south bank of the estuary well clear of the channel used by shipping transiting to and from up river ports. The possibility of a vessel of sufficient displacement tonnage, alluding with a LNG ship in the proposed berth with sufficient energy to breach the cargo containment system is considered not credible. Any passing traffic will also be sufficiently far to the north of any wake effects experienced at the LNG berth to be minimal. For safety and security reasons when a LNG ship is moored at the berth a limited exclusion zone will be imposed around the LNG jetty to restrict all passing traffic, fishing vessels and pleasure craft from approaching too close.

Summary of LNG Ship Safety

The successful risk management of LNG shipping and of operations in LNG ports can be attributed to the combination of special construction features and unique operational controls which have been applied to LNG ship movements within ports. These include:

- Independent cargo containment systems located within an outer double hull structure
- Effective vessel traffic systems restricting other vessel movements
- Use of escort and guard vessels
- Provision of adequate tug power to control LNG ships (even in dead-ship condition)
- Strictly enforced operating conditions (wind force, tidal currents, visibility)
- Strict training and qualification standards for crew and pilots

LNG discharge on Water

Some small pipe leak events have occurred during transfer operations and these have led to localised hull cracking events. This highlights one of the issues of cryogenic materials- spillages can cause embrittlement of normal marine steels and allow residual stresses to cause cracking. Both large and small discharges are rare. Much design and operational effort goes into assuring this rarity. LNG discharges can be envisaged from three distinct types of events:

Event	Potential Outcome
Accidental collision, grounding or allision damaging the vessel structure and puncturing the containment; in this content allision is a marine term referring to collision events with solid objects such as bridges or wharves	Potential LNG Spill to estuary
Unloading hose failure allowing up to full pumping rate discharge	Release of LNG to estuary
Intentional events due to terrorism often involving weapons, but potentially deliberate	Release of LNG to estuary, fire, explosion etc

Table 5 LNG releases to the marine environment

LNG Risk Based Safety, Modelling and Consequence Analysis, Woodward and Pitbaldo, 2010 terms three puncture zones types 1,2 and 3 respectively. In each case the LNG outflow and water inflow are determined primarily by the size of the hole and the liquid head of LNG or water above the hole.

- **Type 1:** LNG spills from holes above the waterline penetrate to some depth in the sea. There could be cascading damage to the vessel inter-hull gap and structures due to exposure to cryogenic LNG.
- **Type 2:** LNG from holes at the waterline would initially be pulled along with seawater into the double hull area, and subsequently when the hull space fills, LNG flows over the surface of the sea.
- **Type 3:** Punctures below the waterline develop back pressure by compressing the remaining air space. Compression acts to limit further inflow rates of seawater and LNG. Ice formation in the double hull space is possible. Water inflow in the LNG tank is possible but would contribute to pressure rise in the tank, opposing further in-flow.

Each case would be expected to generate significant LNG/water interactions with the potential for rapid phase transition (RPT). RPT is the term used to describe a phenomenon recognised in some LNG release experiments involving the nearly instantaneous transition from the liquid to vapour phase and an associated rapid pressure increase. When LNG forms a pool on water, the heat from the water rapidly vaporises the LNG; however, this boiling is not the phenomenon referred to as RPT. In an RPT, a portion of the spilled LNG changes from liquid to gas virtually instantaneously. Although the physical mechanism is not completely understood, RPT is attributed to the superheating of the LNG due to the lack of nucleation sites (sites that help with the formation of gas bubbles and promote boiling). An RPT may result in two types of effects:

1. overpressure resulting from the rapid phase change; and,
2. dispersion of the 'puff' of LNG expelled into the atmosphere.

Rapid phase changes have not resulted in any known major incidents involving LNG. In view of this and the fact that the jetty structure for the proposed facility is relative open, RPTs have not been modelled within the Shannon Energy Park QRA or considered further in this assessment.

In each case type identified above, LNG spilled into the interhull gap could potentially lead to metal embrittlement, but in type 2 and 3 spills, the lower structures would be protected against cryogenic damage by water ingress.

A type 1 LNG release spills into the sea. The figure below describes how the LNG spreads and evaporates on the surface of the sea/river/estuary.

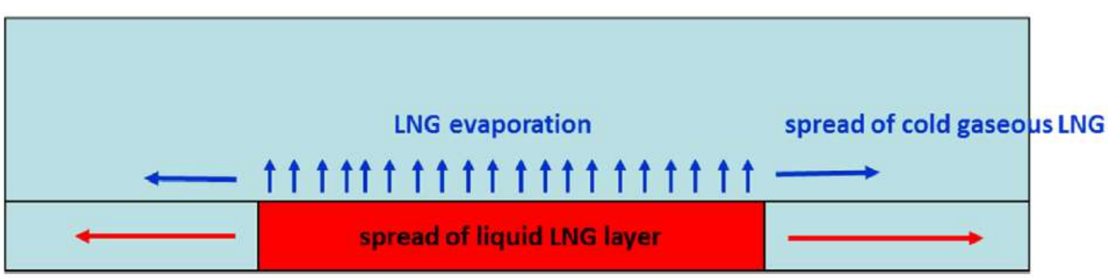


Figure 3 Spread of gaseous LNG due to negative buoyancy

If the LNG jet spills into the water it can penetrate to some depth and mix, thereby increasing the area of LNG/water contact and the evaporation rate. Type 2 and 3 spills will mix LNG and water in the double hull space. The dominant mechanism for heat transfer to a LNG pool on water is from conduction from the substrate. The heat gain from air convection or by solar and long wave radiation accounts on average less than 5% of the total heat transferred to LNG pools.

The LNG unloading/transfer scenario is assessed in the Shannon Energy Park QRA report. Process analysis software such as DNV PHAST or CFD models can simulate the rainout fraction and vaporisation rate.

LNG Spill Prevention:

Hoses developed for transfer of LNG between ships are specialist items of equipment with design, certifications and approval according to EN 13766 and EN 1474-II. LNG transfer hoses are pressure tested prior to operation and continuously monitored throughout the transfer operation.

LNG transfer hoses are fitted with a range of safety devices, including:

- Vessel Separation Device (VSD) – multi wire systems connected between the LNGC and FSRU that separate when the acceptable distance between the LNGC and FSRU is exceeded, initiating alarms, and emergency shut down of the LNG transfer system.
- Dry break couplings that do not release LNG when disconnected.
- Powered Emergency Release Coupling (PERC) – providing rapid disconnection and isolation of the hose by either emergency shut down signal, manual override or overstressing the hose.
- LNG transfer between the LNGC and FSRU is performed under procedure and strictly monitored

Critical onshore terminal/ jetty emergency shutdown signals and status will be shared with the FSRU and vice versa. The following are key initiators in the triggering of Emergency shutdown of the facility as per SIGGTO guidance

- Emergency response coupler ERC isolation – HP Gas arms ESD level 1.1
- Emergency response coupler ERC disconnection – HP Gas arms ESD level 1.2
- High High pressure at regulation valves
- Loss of open position indication on any of the valves that could block gas supply
- UPS low voltage
- Ship to shore link failure
- Fire and Gas detection

CHAPTER 02
Project Description

Shannon LNG Limited
August 2021

Shannon Technology and Energy Park
Environmental Impact Assessment Report

Table of Contents

Figures

Tables

2. Project Description

2.1 Introduction

This chapter describes the design, construction, operation, commissioning and decommissioning of the Proposed Development. It should be read in conjunction with the drawings in Volume 3 of the EIAR. The chapter provides an overview of the following:

- Site Location and Area Land Use (Section 2.2);
- Shannon Estuary Navigation and Port Operation (Section 2.3);
- Main Features of the Proposed Development (Section 2.4);
- Discharges and emissions (Section 2.5);
- Site Management (Section 2.6);
- Process Control and Monitoring (Section 2.7);
- Health, Safety and Environmental Aspects (Section 2.8);
- Construction Phase including environmental protection measures (Sections 2.9);
- Commissioning Phase (Section 2.10); and
- Decommissioning (Section 2.11).

2.2 Site Location and Area Land Use

The Proposed Development site is shown in Figure 2-1 (below) and Figure F2-1, Vol. 3. The Proposed Development site is located within the boundary of two townlands: Kilcolgan Lower and Ralappane, Co. Kerry.

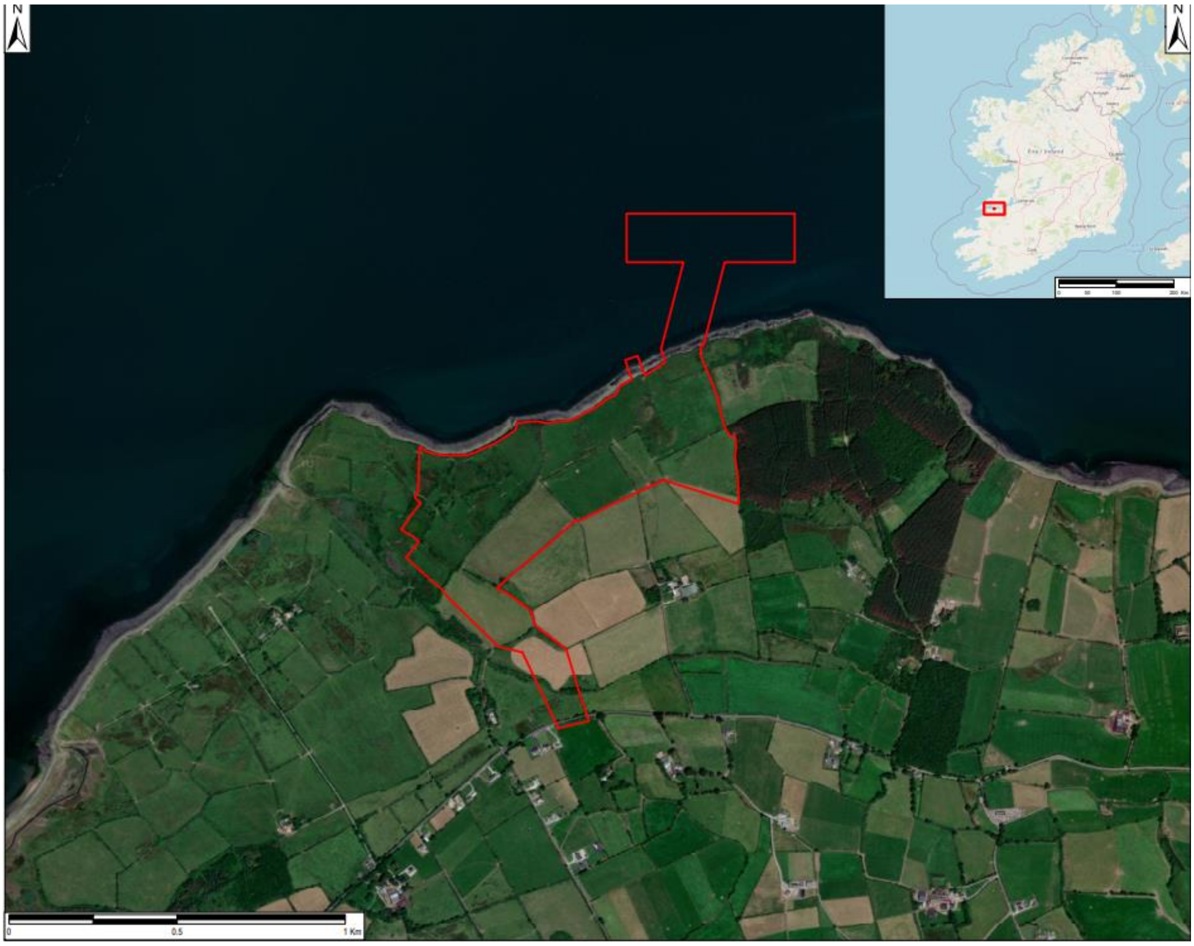


Figure 2-1 Site Location

The Proposed Development will be located on the Shannon Estuary, approximately 4.5 km from Tarbert and 3.5 km Ballylongford in the townlands of Kilcolgan Lower and Ralappane, Ballylongford, Co. Kerry. The site for the Proposed Development is 52 hectares (ha) (including both the onshore and offshore elements). The Shannon Landbank on which the site is located has a total area of 243 ha. The Proposed Development site is zoned for marine-related industry use by Kerry County Council (KCC) (County Development Plan 2015-2021), and has been identified as a Strategic Development location in the Shannon Integrated Framework Plan 2014-2020, the Regional Spatial and Economic Strategy (RSES) for the Southern Region 2020, the Kerry County Development Plan 2015-2021, and the Listowel Municipal District Local Area Plan 2020 (refer to Chapter 04 – Policy (Energy and Planning) for further detail).

The Proposed Development site has access to deep water (approximately > 13 m depth) in the Shannon Estuary, which is suitable for navigation by large vessels. Given the natural depth of the water, no dredging is required for the Proposed Development. The Proposed Development site is also close to national gas and electricity transmission grids; 220 kilovolt kV and 110kV electrical transmission are available from the Electricity Supply Board Network (ESBN) / EirGrid Kilpaddoge 220 kV substation located approximately 3 km east of the Proposed Development site and a Gas Network Ireland (GNI) owned gas transmission pipeline located approximately 26 km east of the Proposed Development site, presenting a suitable location for an liquified natural gas (LNG) terminal and power plant. Planning permission exists for the development of a 26 km 30” natural gas pipeline which will facilitate connection from the Proposed Development site to the GNI transmission network at Foynes in Leahys, Co. Limerick.

The Lower River Shannon Candidate Special Area of Conservation (cSAC) is partly within and adjacent to the site along the northern/ north-western boundary and also along part of the eastern boundary (see Figure F7-1, Vol. 3). The Ballylongford Bay proposed Natural Heritage Area (pNHA) is located adjacent to a part of the north-western boundary of the Proposed Development site. The Shannon-Fergus Estuary Special Protection Area (SPA) is to the west of the Proposed Development site (at a distance of approximately 750 m from the western extremity of the terrestrial elements of the Proposed Development site). The jetty will extend into the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA. Refer to Figures 7-1 and 7-2 in Chapter 07B – Terrestrial Biodiversity for the locations of these designated areas.

The Proposed Development site is in pasture, comprising primarily improved grassland with some wet grassland adjacent to the Shannon Estuary, as shown on the aerial photograph in Figure 2-2.

Figure 2-2 Proposed Development Site

The Proposed Development site is currently drained by a number of shallow drainage channels. Several longer drainage features cross the southern portion of the Proposed Development site, generally flowing in a west or northwest direction. The drainage features along the access road all ultimately drain to a single surface water course, the Ralappane Stream, which discharges into the Shannon Estuary. The Proposed Development site is bordered to the north by the Shannon Estuary and to the south by the Coast Road L1010, connecting Tarbert to Ballylongford. Fields in pasture and forestry lie beyond the eastern boundary and the Shannon Development Landbank extends westward beyond the Proposed Development site's western boundary.

The topography of the land within the Proposed Development site is generally undulating. Some of the fields are waterlogged in wet weather and there are pockets of marshy ground. There are a number of old disused farm buildings and structures on the Proposed Development site.

The Strategic Integrated Framework Plan for the Shannon Estuary (SIFP) is the inter-jurisdictional land and marine based framework to guide the future development and management of the Shannon Estuary. The SIFP states:

'*Ballylongford benefits from a significant deepwater asset and extant permission for a major LNG plant, the availability of natural gas, the proximity to the national grid and the potential for refrigeration from the regasification process, combined with the additional physical infrastructure in terms of roads and water. This makes the lands a very attractive location for other industries to locate in the future. There is also potential for gas fuelled electricity generation in the future. The SIFP proposes a Strategic Development Location around the Tarbert-Ballylongford complex to accommodate further development of the energy infrastructure and allow for economic development that will be attracted to such a significant site by virtue of its energy provision and deepwater facilities*'.

The Proposed Development site is currently owned by Shannon Commercial Enterprises DAC (formerly Shannon Free Airport Development Company Limited) registered at Shannon Airport, Co. Clare. The Applicant has entered into an agreement for the purchase of the land from Shannon Commercial Enterprises DAC.

There are a small number of residential properties located within 500 m of the onshore facilities on the Proposed Development site. Residential properties are also located along the existing L1010 (Coast Road) immediately south of the Proposed Development site, with additional residential properties to the east and west along the L1010.

Tarbert Power Station is located approximately 5 km to the north east of the Proposed Development site, with Moneypoint Power Station located on the northern shore of the Shannon Estuary, approximately 3 km to the north of the Proposed Development site.

2.3 Shannon Estuary Navigation and Port Operation

The Shannon Estuary comprises 500 square kilometres (km^2) of navigable water extending from Loop Head, in Co. Clare, and Kerry Head, in Co. Kerry, eastwards to the city of Limerick, a distance of 100 km. The naturally occurring deep and sheltered waters of the estuary are connected to the Atlantic Ocean and are accessible to large ocean-going vessels of varying types and sizes of up to 185,000 dwt (deadweight tonnes).

Within the estuary there are existing port facilities currently handling approximately 850 ships per year amounting to a total of 10 million dwt of shipping activity:

- Shannon Airport fuel jetty – 20 ships/ year, typically 6,500 dwt ships;
- Limerick Port – 220 ships/ year, typically 5,000 dwt general cargo ships;
- Aughinish Alumina – 50 ships/ year, typically over 75,000 dwt Panamax bulkers (bauxite import) and 220 ships/ year to 40,000 dwt (caustic import, process materials and supplies import and alumina export);
- Foynes Port – 325 ships/ year, typically from 4,000 to 50,000 dwt general cargo ships, bulk carriers and petroleum and chemical tankers;
- Tarbert Power Station (oil) – 4 ships/ year, typically 150,000 dwt bulkers and up to 185,000 dwt maximum size; and
- Moneypoint Power Station (coal) – 4 ships/ year, typically 150,000 dwt bulkers and up to 185,000 dwt maximum size.

Recently there has been an increase in Post Panamax Vessels, Oil Tankers in addition to Mini Cape and Cape size vessels.

Limited small vessel traffic includes local trade to Cappagh pier near Kilrush, with no ships recorded in recent years, though Kilrush has a large marina. A regular vehicle ferry service operates across the estuary between Tarbert on the south shore and Killimer on the north. Mariculture is a feature of the estuary.

Recreational marine activities include dolphin watching with over 500 trips per annum (see Marine Navigation Risk Assessment in Appendix A2-2, Vol. 4) operating out of Carrigaholt and Cappa. The Shannon Estuary is a cSAC) and is home to more than 100 bottlenose dolphins (which are one of the qualifying interests of the site).

Shannon Foynes Port Company (SFPC) is responsible for all maritime activities on the estuary. The Harbour Master & Pilotage Superintendent has authority over all matters related to pilotage, direction to vessels and movement of vessels. There are a total of 68 lights and shapes in the Shannon Estuary, making SFPC the second largest lighthouse authority in Ireland after the national authority. British Admiralty charts are used in Ireland, the relevant Shannon ones being numbers 1547, 1548 and 1819.

All vessels entering the Shannon have to cross the Ballybunion Bar, clearance over which is regulated for deep draught (>17 m) vessels. A wave rider buoy is positioned on the bar to provide real time information on the height of the swell which is used by SFPC in a customized computer programme to present 'go/ no-go' information. The maximum draft[1] of the proposed LNG ships is approximately 13 m, which will not pose any problems at the bar. The Atlantic swell is not experienced inside the Shannon Estuary and wind generated waves are restricted by the length of fetch available.

[1] The distance between the surface of the water and the lowest point of the vessel.

From Ballybunion Bar, the Beal Bar Channel leads into the estuary where arriving vessels transiting east, pass to the south of Scattery Island. Designated anchorages are available to the north of the main channel for vessels waiting to transit to berths upriver at Foynes and Limerick.

Port operations are managed on International Organization for Standardization (ISO) methods and a formal risk assessment is carried out for all trades. A Vessel Traffic Management Information System (VTMIS) employing three radar stations is able to observe, record and replay traffic movements in the estuary.

There are eight First Class Pilots licensed by the Port Authority who operate from Cappa Pier employing a 15 m, 20 knot pilot boat. The pilot boarding position varies depending upon the size of ship and for large displacement/ deep draught vessels the boarding station is outside Ballybunion Bar. Pilots can monitor some types of vessels on radar and talk/ guide them into the shelter of the Estuary on a shore-based pilot system if the weather is too bad for safe pilot boarding. Pilots regularly carry Pilot Portable Units (PPUs) which will operate independently of ships' navigational equipment and assist pilots in the safe navigation and berthing of ships.

The tidal range in the Estuary is 4.5 m and the maximum observed current is approximately 4 knots on the spring ebb off Moneypoint jetty. The prevailing winds are from the west and south west and seldom reach hurricane force within the Shannon Estuary. An average of 9.8 days/ year experience gales, and 32 days/ year experience fog.

Two tugs are based at Foynes and are available to assist vessels berthing and sailing at all the existing facilities in the Estuary, however they are not suitable for the Proposed Development due to limited size and power. Appropriate tugs will be sourced by the Proposed Development and licensed separately by the Port Company. Mooring boats and gangs are independently contracted to terminal owners and ship operators.

SFPC is charged with oil pollution prevention and control in compliance with Irish national and international legislation and has established a response team with locally interested parties. The team carries out annual exercises to ensure readiness and swift reaction to any incident. Also, as required by legislation, SFPC in cooperation with the local authorities, the Irish Coast Guard and port users has developed a Marine Emergency Response Plan for the entire Shannon Estuary.

2.4 Main Features of the Proposed Development

The Proposed Development will comprise the following components:

1. A Power Plant;
2. A LNG Terminal;

These components are described in the following sections and shown in Figure 2-3 and Appendix A2-1, Vol. 4. The layouts are provided in Volume 3.

Figure 2-3 Proposed Development Site Layout

2.4.1 Power Plant

The proposed Power Plant, as shown in Figure 2-4, will comprise:

- Three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of approximately 200 megawatts (MW) for a total installed capacity of up to 600 MW (See Section 2.4.1.1);
- Battery Energy Storage System (BESS) (See Section 2.4.1.2);
- High voltage 220 kV Substation (See Section 2.4.1.3);
- Auxiliary Boiler (See Section 2.4.1.4);
- Raw water treatment building (See Section 2.4.1.6.1);
- Firewater storage tanks and fire water pumps (See Section 2.4.3.1.4);
- Fuel storage (See Section 2.4.1.7); and
- Ancillary buildings common to both the Power Plant and LNG Terminal (See Section 2.4.3).

Figure 2-4 Proposed Power Plant at the Proposed Development Site

The Power Plant will be operated using natural gas as its primary fuel, and generate power exported via the 220 kV connection to the national electricity grid. It will also provide electricity for its own needs and for those of the LNG Terminal. The 220 KV connection will have to be installed prior to commencing operation of the Power Plant, as such it is anticipated that the Power Plant will be constructed in parallel with the 220 KV grid connection.

The Power Plant is designed to operate alongside intermittent renewable electricity power generation and is expected to mainly operate at full capacity during periods of low renewable supply, and otherwise to be turned down or turned off. For example, during periods of high wind (renewable) generation it is expected that the Power Plant will be turned off by the system operator (EirGrid) to give priority to renewable power. Similarly, during periods of sudden low renewable generation, the system operator will call on the Power Plant to be ramped up to supply electricity. Due to the design of the CCGT with low minimum generation and the economic advantage of the Power Plant relative to other facilities, it is expected that the Power Plant would be called on earlier by the system operator than other gas plant. A battery system (BESS, see below) will provide electricity into the grid as the Power Plant is being ramped up. Once the Power Plant is up and running the supply from the BESS will be switched off.

The Power Plant will have an installed capacity of up to 600 MW and will be designed in accordance with best available techniques (BAT) for large combustion plants, industrial cooling systems, energy efficiency and emissions from storage.

The fuel supply to the Power Plant will normally be from the LNG Terminal, but it can also be powered from the gas grid via reverse flow through the Above Ground Installation (AGI) as defined in Section 2.4.2.6.

The Power Plant will use up to 2.8 million Sm^3 per day[2] (approximately 25.5 GWh per day) when operating at full capacity. The LNG Terminal will have sufficient capacity to supply gas requirements for the Power Plant.

It is not intended that diesel will be used as a secondary fuel for the Power Plant. However, small amounts of diesel fuel will be available onsite for the emergency power generators. Consequently, the Proposed Development, unlike most other large power plants in Ireland, will not store and combust large quantities of LNG. Avoiding storing, and combusting, large quantities of LNG on site significantly reduces safety and environmental risks. Refer to Section 2.4.1.7 for further discussion.

[2] Million Sm^3/d = Million Standard cubic metres per day of natural gas: cubic metre natural gas at 101,325 Pa and 15°C, dry

A small amount (approximately 20 MW) of the electricity generated by the Power Plant will be used in the LNG Terminal, and in the operation of the Power Plant itself. The balance of the electricity produced is intended for the market and will be sold into the integrated Single Electricity Market (iSEM).

The electricity generated by the Power Plant will be exported through a new substation located between the Electricity Generation Facility and the LNG Terminal. It is anticipated that the new substation will be connected to the 220 kV transmission grid at the ESBN / EirGrid Kilpaddoge 220 kV substation but the location and precise nature of the connection are subject to further discussions between the Applicant and EirGrid and do not form part of the scope of this EIAR. The new substation and grid connection are assessed in the cumulative impact assessment within each technical chapter.

The Power Plant will use CCGT technology (see description in 2.4.1.1 below), and its design will comply with all relevant national and international codes.

The contract to supply and construct the Power Plant will be awarded following a commercial tendering process prior to the start of construction. The tendering process will result in a contract for a particular model of electric generation plant. Therefore, the precise size, configuration, performance, and layout of the equipment will be finalized following the award of the contract and a site-specific detailed design process, however this will not affect the design of the buildings or emissions as described in this EIAR. The construction contract will identify a preferred Contractor to construct the Proposed Development, in accordance with the mitigation and monitoring measures set out in this EIAR. The Client (the Applicant) will administer the construction contract and liaise with the Local Authority to discharge planning conditions as appropriate.

Further descriptions of the main features of the Power Plant are outlined in the following sections.

2.4.1.1 Combined Cycle Gas Turbine Power Block Description

The Power Plant will contain three blocks with one CCGT, each block with a nominal capacity of up to 200 MW (Figure F2-2, Vol.3). The multi-shaft arrangement of each block will provide fast acting response, such as will be required in a system with a low level of stable generation, and is therefore ideally suited to support a high level of intermittent renewable power generation.

Each block will comprise:

- Two gas turbines with generators;
- Two heat recovery steam generators with exhaust stacks;
- One steam turbine;
- Electricity generator;
- One air-cooled condenser;
- Air-cooled heat exchanger (6 m x 2.6 m);
- Generator step-up transformer (GSU);
- Natural gas fuel system;
- Turbine Hall;
- Condenser Polisher Equipment Enclosure;
- Air-cooled condenser (ACC) Air Extraction and Equipment Enclosure; and
- High voltage electrical switchgear and 220 kV substation.

Each proposed power block will use the following process:

- The gas turbine burning natural gas will be connected to a generator for electricity production;
- Exhaust gases from the gas turbine will pass through two heat recovery steam generators to generate steam;
- The steam generated will be routed through a steam turbine, which will also be connected to a generator to produce further electrical power;

- The spent steam exiting the steam turbine will then be directed into the air-cooled steam condenser. The resulting condensate will then be pumped back into the heat recovery steam generator to repeat the steam cycle; and
- Power from the three generators will be combined and the voltage increased to the export voltage by the generator step-up transformer (GSU).

A schematic of the power generation process is presented in Figure F2-3 in Volume 3.

The electricity generated will be fed to a set of transformers where the voltage will be stepped up to the transmission voltage, specified by EirGrid in the, yet to be issued, interconnection offer.

2.4.1.1.1 Gas Turbine Generator (6 m x 15 m)

The gas turbine will consist of an air compressor, a combustion chamber, and a turbine. The air compressor will take in large quantities of filtered air from the atmosphere and compress it. Fuel gas and compressed air will then be injected into the combustion chamber and the fuel/ air mixture ignited. The addition of heat energy and combustion gases in the combustion chamber will raise the temperature of the combined gases to over 1,300 °C. The hot gases will expand through the turbine section. The high velocity gas passing through the turbine will spin the main shaft which drives both the air compressor, which will produce the compressed air, and the generator, which will produce the rated electrical power output. The expansion of the hot gases passing through the turbine, and the extraction of mechanical work from them via the turbine will reduce the temperature of the gases to less than 600°C.

The gas turbine will be coupled to a generator for power generation at 50 hertz (Hz).

2.4.1.1.2 Heat Recovery Steam Generator

A gas turbine, as described above, is referred to as operating in open or simple cycle mode. It will be possible to generate approximately 50% more electricity by operating in combined cycle mode. In combined cycle mode the hot exhaust gases leaving the gas turbine will be directed through the Heat Recovery Steam Generator (HRSG), which will extract heat to make steam. The heat recovery steam generator will be multi-pressure type. The temperature of the hot combustion gases will be reduced in this process to less than 100°C.

The HRSG will discharge the exhaust gases to atmosphere through an integral exhaust stack exiting at approximately 35 m above ground.

2.4.1.1.3 Steam Turbine Generator

Water supply for the heat recovery steam generator is discussed in Section 2.4.6.2. The water treatment facility will provide demineralized water for steam cycle makeup to each CCGT block.

The high-pressure steam produced by the HRSG will flow through inter-connecting pipework to the steam turbine. The steam turbine will be of a multiple stage type suitable for coupling to a generator for power generation at 50 Hz. The low-pressure exhaust steam will flow out of the steam turbine to the ACC.

2.4.1.1.4 Air Cooled Steam Condenser (48.6 x 55.8 m)

The ACC will be of a standard design. Steam from the steam turbine will enter the ACC and pass through air-cooled fin tubes. The steam will not be in direct contact with the air. The heat is transferred from the steam to the surrounding ambient air, which leads to the steam condensing. This condensate represents boiler quality feed water. The condensate will then be returned to the HSRG in a closed loop. i.e. condensate will not be discharged to the environment. The key advantage of an air-cooled steam condensers is that cooling water and associated systems are not required.

Non-condensable gases (i.e. air ingress into the ACC) will be removed from the ACC by use of vacuum pumps located in an equipment enclosure near the ACC. The condensed steam will be collected in the condensate collection tank located below the ACC where it is pumped by the condensate pumps back to the HRSG through the condensate polisher (whose purpose is to remove impurities and reduce corrosion in the water/ steam cycle). The condensate polisher is located in an equipment enclosure near the condensate pumps.

2.4.1.1.5 Generator Step-up Transformer (GSU) (10 m x 10.4 m)

Power from the gas turbine and steam turbine generators will be collected at the generator voltage level and will be connected to the 220 kV GIS substation through one generator step-up transformer for each of the three blocks.

2.4.1.1.6 Natural Fuel Gas System

The gas used to fuel the Power Plant will be supplied from the LNG Terminal via the metering and regulating station at a pressure suitable for the specific gas turbine equipment selected. This fuel gas will pass through gas conditioning equipment dedicated to each block/ gas turbine that is anticipated to be comprised of:

- Filter separator;
- Performance heater;
- Final pressure control station; and
- Gas quantity and quality measurement as required for performance management and environmental protection monitoring.

2.4.1.1.7 Buildings Within Each CCGT Block

Each CCGT Block will include the following buildings and enclosures to house the main plant equipment noted above:

- Turbine hall (65 m x 93 m);
- Condenser Polisher Equipment Enclosure (6.3 m x 16.3 m);
- ACC Air Extraction and Equipment Enclosure (8.5 m x 12.2 m); and
- Air Cooled Condenser Electrical Power Distribution Centre .

These are described in the following sections.

The buildings will be constructed using two main building methods:

- Type 1 will be used for all buildings with the exception of the PDC. These will be steel framed buildings with concrete floor slabs; and
- Type 2 will be used on the PDC. This building will be a pre-manufactured metal equipment enclosure using a steel base and framing to form an all-weather enclosure. The enclosure will be mounted on steel support legs or concrete piers to elevate the enclosure and allow bottom entry for electrical/ control wiring.

Structural and architectural details have been prepared including particulars of the shallow and deep foundations, lifting equipment, steel structures, and protective coatings. The paint colours of the buildings will be selected to minimise the visual impact of the Power Plant. This is discussed further in Chapter 10 – Landscape and Visual Impact. Landscape drawings are provided in Figure F2-4, Vol. 3.

Turbine Hall (65.9 m x 93.7 m)

This building will house the combustion turbine generator (CTG), HRSGs, STG and other balance of plant systems required for a complete CCGT Block. The turbine hall will accommodate the selected OEM's recommended component layout, including laydown and maintenance requirements within the building. A bridge crane will be provided for steam turbine maintenance while the gas turbines are each supplied with an overhead crane for maintenance and removal of the gas turbine engine. The building will have internal rooms to house the necessary electrical and control equipment required for each CCGT Block including a stand-by diesel generator. The diesel fuel tank for stand-by diesel generator will be stored in a bunded area, or in a double walled tank.

Condenser Polisher Equipment Enclosure (6.3 m x 16.3 m)

The condenser polisher equipment enclosure will house the condensate polisher associated with the ACC, as described in Section 2.4.1.1.4.

Air-Cooled Air Extraction and Equipment Enclosure (12.8 m x 15.3 m)

This enclosure will house the electrical breakers and motor control centres (MCC) associated with the ACC.

Air Cooled Condenser Electrical Power Distribution Centre (8.5 m x 12.2 m)

Three PDCs will house electrical and control equipment necessary to distribute power and control throughout the Power Plant. Each PDC will be a pre-manufactured all-weather steel enclosure. The enclosure will be mounted on steel support legs or concrete piers to elevate the enclosure and allow bottom entry for electrical/ control wiring.

2.4.1.2 Battery Energy Storage System Equipment (33.9 m x 163 m)

A 120 MW 1-hour (120 megawatt hour (MWh)) BESS is included in the Proposed Development. The BESS will comprise 27 battery containers, approximately 4.5 MWh each, containing lithium ion batteries. Each battery container is paired with two power conversion system (PCS) skids that contain the electrical systems (inverters, etc.) to deliver the power from the batteries to the grid via a 220 kV generator step-up transformer. Due to its fast response, the BESS allows the power Station to provide electricity during ‘ramp up’ and supports intermittent renewable generation. This was also discussed in Section 2.4.1.1 above.

Once the Power Plant is operating at the necessary capacity the electrical demand is met, the BESS will be shut down and recharged.

2.4.1.3 High Voltage 220 kV Substation (18 m x 60.9 m)

A high voltage 220 kV substation is included in the Proposed Development. The substation will be gas insulated (GIS) and enclosed in a building. The substation will accept the 220 kV output from each CCGT Block and BESS and connect to the national electricity grid. When the Power Plant is not in operation, power from the national electricity grid will backfeed to the Power Plant via this same grid connection.

This Power Plant GIS substation will in turn route power to the LNG Terminal, even when the Power Plant is shutdown.

2.4.1.4 Auxiliary Boiler (within Auxiliary Boiler Building, 14.3 m x 14.3 m)

An auxiliary boiler will be included in the Proposed Development. The auxiliary boiler will burn natural gas, be of a standard design and be enclosed in a building with a separate 32 m high exhaust stack. Steam from the auxiliary boiler will be used by the Power Plant to keep the equipment warm which allows for faster start up to support intermittent renewable generation.

2.4.1.5 Raw Water Storage Tanks (24 m x 18 m)

Water used by the Power Plant will be supplied from the potable water connection. This raw water will be stored in two raw/ service/ fire water storage tanks. The tanks will supply service water to the Power Plant and raw water to the water treatment facility with reserve storage for fire water. The tanks will be field fabricated welded steel tanks.

2.4.1.6 Buildings

The Power Plant will also include the following buildings, common to the three CCGT Blocks and BESS operations:

- Water treatment building;
- Administration building;
- Central control/ operations building;
- Auxiliary boiler building;
- Workshop/ stores/ canteen building; and
- Firewater pumps enclosure.

Buildings and enclosures common to both the Power Plant and LNG Terminal are described in Section 2.4.3.

2.4.1.6.1 Water Treatment Building (18 m x 35 m)

The water treatment building will make demineralized water for steam cycle makeup to each CCGT Block. The demineralized water will be stored in two demineralized water storage tanks (15.5 m x 13 m) which will be field fabricated welded steel tanks.

2.4.1.6.2 Administration Building (14 m x 22.7 m)

The administration building will include offices, training rooms and meeting rooms for the administrative personnel stationed at the Power Plant.

2.4.1.6.3 Central Control/ Operations Building (14 m x 22.7 m)

Operation of the Power Plant will be monitored and controlled from the central control/ operations building. This building will include a control room, meeting room and offices for the operations personnel stationed at the Power Plant. The Power Plant will be operated from the main control room (MCR),. From the MCR it will be possible to monitor and adjust all of the plant equipment and instrument control systems including all safety control systems.

2.4.1.6.4 Auxiliary Boiler Building (14.3 m x 14.3 m)

This building will house the auxiliary boiler stack.

2.4.1.6.5 Workshop/ Stores/ Canteen Building (14 m x 52.3 m)

The workshop/ warehouse/ canteen building will provide storage for equipment and material spares required to maintain an operational facility. The building will also have maintenance offices, a workshop area and canteen.

2.4.1.6.6 Firewater Pumps Enclosure (4.5 m x 10.5 m)

Both the Power Plant and LNG Terminal will house a firewater pumps enclosure.

2.4.1.7 Fuel Storage

A mandate to store defined quantities of fuel onsite is specified in 'Secondary Fuel Obligations on Licensed Generation Capacity in the Republic of Ireland' (CER/09/001), was issued by the CER (now CRU) on 12th January 2009. For power plants, the storage requirement totals one day's worth of fuel consumption, calculated assuming the Power Plant is operating at its maximum capacity. After consultations between the CRU and the Applicant, the CRU has agreed that fuel storage requirements can be met by storing five days' worth of LNG in the FSRU LNG storage tank(s). Avoiding storing large quantities of liquid fuel on site significantly reduces safety and environmental risks as well as increasing the Power Plant's reliability.

2.4.2 The LNG Terminal

The proposed LNG Terminal will comprise (Figure F2-2, Vol.3):

- An LNG ship in the form of a FSRU, with LNG storage capacity of approximately 170,000 m^3 (up to 180,000 m^3). This EIAR considers a capacity of up to 180,000 m^3. The FSRU is a ship that can store LNG onboard, and which also is fitted with an onboard regasification unit which can return stored LNG into a gaseous state. The ship will be up to 300 m long and up to 50 m wide and the height of the vessel including the top of the exhaust stack will be approximately 50 m above sea level. The FSRU will be an existing suitably classified marine vessel that will be modified to ensure it operates in accordance with the terms of the Planning Permission, the Industrial Emissions Licence and all the other relevant statutory approvals required for its operation. Further details of the FSRU is provided in Section 2.4.2.1 below;
- A jetty with an access trestle, with the jetty comprising an unloading platform, mooring dolphins and breasting dolphins with capacity to accommodate up to four tugs. They will facilitate safe mooring operations for the FSRU and visiting LNG carriers as required. Further details are described in Section 2.4.2.2 below;
- Onshore receiving facilities including a nitrogen generation facility, a control room, a security building, workshop and maintenance buildings, instrument air generator, backup power generators fire water system. Further details are described in Section 2.4.2.5 below; and
- An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, chromatography, gas metering and pressure control equipment. The AGI will facilitate the export of LNG to the national gas transmission network via the already consented 26 km 30" Shannon Pipeline. Further details are described in Section 2.4.2.6 below.

LNG will be delivered to the LNG Terminal by a visiting LNG Carrier (LNGC) which will be moored to the seaward side of the FSRU.

A detailed description of the main characteristics of the LNG Terminal are outlined in the following sections.

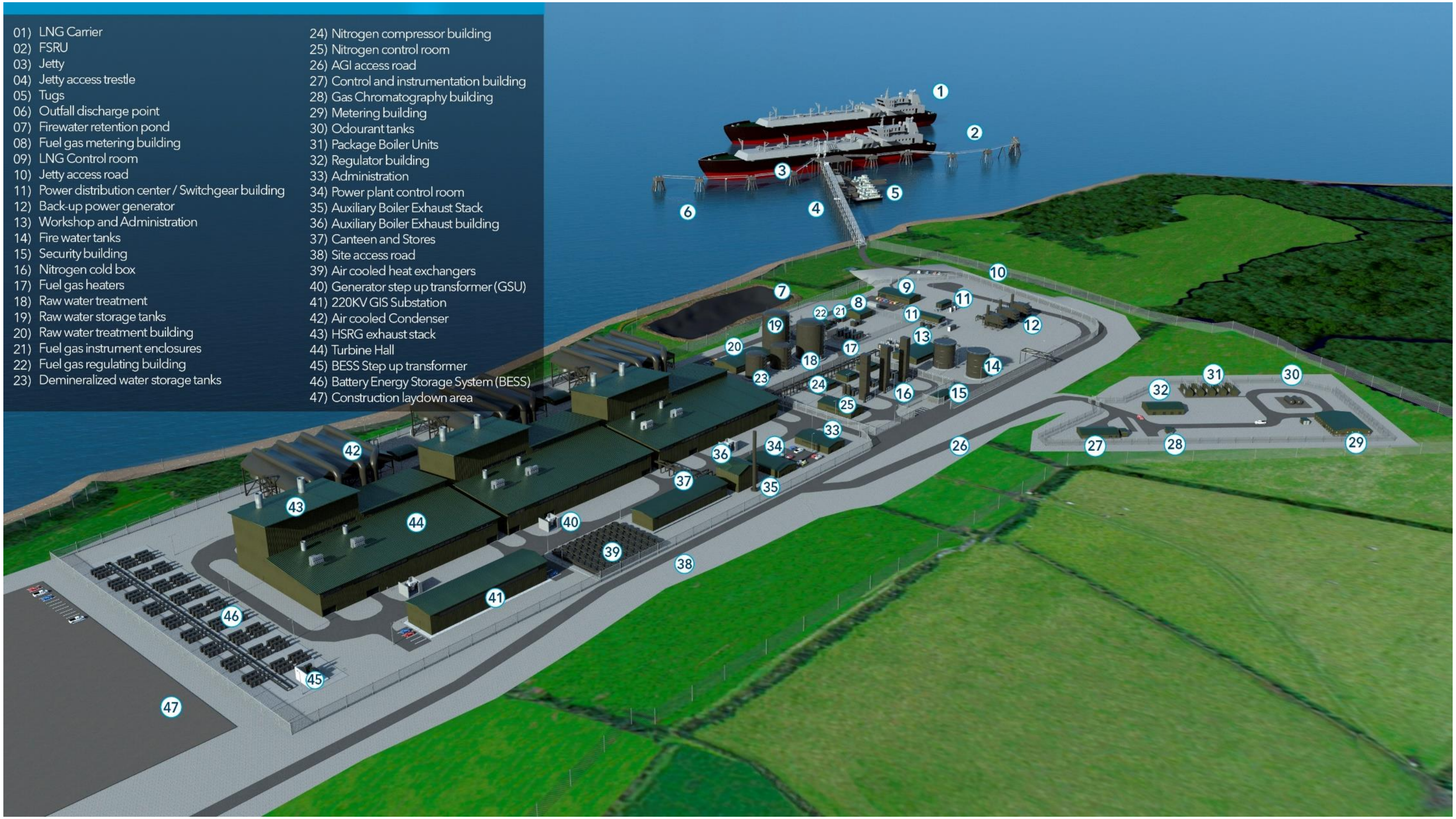


Figure 2-5 Proposed Layout of the Proposed Development

2.4.2.1 Floating Storage Regasification Unit

The FSRU will be berthed at the jetty. Being an oceangoing vessel, the FSRU will have approximately 35 crew members onboard and will be operating under all relevant national and international maritime rules. Further information on the emissions and waste from the FSRU are provided in Section 2.5.

The FSRU will be connected to onshore receiving facilities except when disconnected due to adverse weather conditions, during planned yard maintenance and in the event of emergencies (see planning application drawings for details).

LNG vaporisation process equipment to regasify the LNG to natural gas will be onboard the FSRU. Heat energy necessary for regasification of LNG will be derived from locally drawn seawater, supplemented by gas fired heaters for use during periods when the water temperature is inadequate.

At the time of writing this EIAR, the charter agreement for a specific FSRU for the LNG Terminal at Shannon Technology and Energy Park has not been completed. Therefore, the exact characteristics, equipment layout and details of the technical systems which form an integral part of the FSRU are not known. For the purposes of the EIAR, a worst-case scenario in terms of emissions and the potential for environmental impact, has been derived from a review of a range of vessels on the market from various FSRU suppliers.

The FSRU is anticipated to have an LNG storage capacity of approximately 170,000 m^3 (up to 180,000 m^3), with 180,000 m^3 representing the maximum amount of LNG to be stored. The FSRU will be up to 300 m long and up to 50 m wide with a maximum draft of 13 m. In a deep water channel (approximately 20 m) the FSRU will be located at a nominal depth of 12 m. See Figure 2-6.

The FSRU will float on the water, hence its height will vary due to tides, the amount of LNG cargo onboard and ballasting operations. For example, at mid tide and with a Scantling Draft water line, the top of the highest structure on the FSRU (its communication mast) will be 46.0 m above Ordnance Datum. During Mean High Water Spring (MHWS) tides and with the FSRU unladen (at ballast draft) the height of the FSRU will be 51.4 m above Ordnance Datum. Regardless of tides, cargo and ballasting, the physical height of the FSRU structure as measured from bottom of the hull to the top of the highest structure will be 58.9 m.

The FSRU will be double-hulled and contain LNG cargo tanks designed for storing LNG at very low temperatures, i.e. approximately -163ºC. The tanks will be lined with specialised membranes to allow the storage of chilled LNG. The low temperature and the insulation will keep the LNG cargo in a liquid state until it is required for regasification.

The LNG vaporisation equipment onboard the FSRU will be designed to meet a send-out capacity of up to 22.6 million Sm^3/d (approximately 250 GWh per day) natural gas. Additional information is outlined in Section 2.4.2.1.1 below.

When the FSRU's LNG tanks are empty,[3] another ship will arrive to fill the FSRU. Visiting ships, known as LNG Carriers, will moor alongside the FSRU and refill the FSRU storage tanks via ship-to-ship transfer. The refilling process will take approximately 35 hours, after which the visiting LNG carrier will depart. Further information on this is provided in Section 2.4.2.4 below.

The FSRU will be self-sufficient in terms of producing the necessary electricity and heat to run the ship's systems and the LNG storage and vapourisation process. The vessel will use electricity to power pumps, the regasification equipment, auxiliary systems and for the crew accommodation. Generators will be powered by dual-fuel engines which will use boil-off natural gas from the LNG storage tanks as main fuel. As a pilot fuel, the engines will burn a small amount of marine diesel oil (MDO), estimated at up to 1 m^3/day at maximum.

In the event of an onshore emergency, the FSRU will be disconnected, and its mooring lines automatically released from the jetty, enabling the FSRU to sail quickly to a safe area.

A Process Control System (PCS) and an associated Fire and Gas (F&G) and Emergency Shut-Down (ESD) System will be in place to ensure the integrity of the facility and the safety of personnel. Should

[3] Note that a minimum of 18,500 of LNG will always remain in the FSRU LNG tanks to comply with operational and secondary fuel storage obligations

a loss of containment of natural gas and/ or a fire occur, the F&G System will detect the incident and trigger the operation of the active fire protection system and the ESD system.

The FSRU will operate in accordance with international conventions on safe navigation, i.e. conditions that have been established by the SOLAS Convention and other international conventions accepted within the International Maritime Organization (IMO). Additional information on permitting is outlined in Section 1.5.5 of Chapter 01 – Introduction.

The FSRU will also meet all the relevant requirements of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), as amended (IMO, 1986).

The specification of the FSRU is presented in Table 2-1. The EIAR has considers the maximum values for the purpose of the impact assessments.

Table 2-1 Specification of the Floating Storage Regasification Unit FSRU

	Minimum	Maximum
LNG Storage capacity (m^3)	130,000	180,000
Length (m)	250	300
Width (m)	43	50
Draught (m)	9.0	13
Crew capacity	20	35
LNG storage tank type	Spherical or membrane	
Peak day LNG send out capacity	22.6 million Sm^3/d	

2.4.2.1.1 Liquid Natural Gas Vaporisation Process

When natural gas is needed downstream of the LNG Terminal, i.e. in the gas transmission network, or at the Power Plant, LNG stored onboard the FSRU will be vapourised or regasified onboard the FSRU. The natural gas will then be discharged under pressure via Gas Loading Arms (GLAs) to gas piping on the jetty and onwards to the onshore receiving facilities. From there the gas is routed to the Power Plant, LNG Terminal gas turbine generator and/ or GNI's gas transmission network at the AGI.

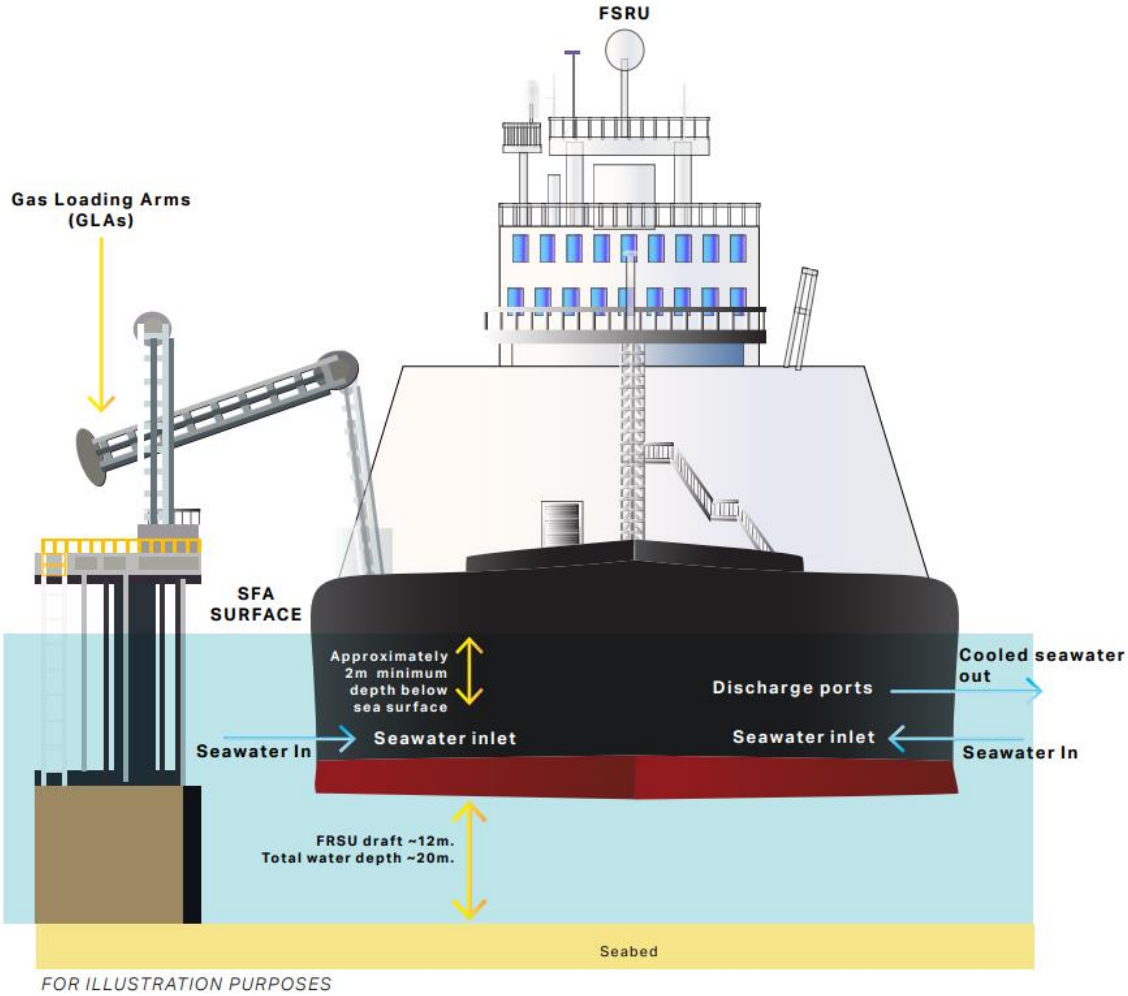


Figure 2-6 FRSU Overview

The onboard regasification unit will have several regasification trains operating in parallel. This enables a degree of turndown, i.e. delivery of varying rates of gas to shore, with the minimum throughput capacity of a single regasification train representing the minimum flowrate and the maximum throughput rate of all of the trains operating simultaneously representing the maximum discharge rate from the FSRU. The number of trains that will be in use at any one time depends on the gas demand. Generally, it is anticipated that the FSRU will be operating with one or two regasification trains running, representing low to medium throughput rates.

The intake and discharge of seawater will be required for the regasification process. Details on the seawater volume, treatment and discharged are presented in Section 2.4.2.1.2.

Seawater needed for the regasification process will be drawn through a seawater intake in the hull of the FSRU located approximately 2 m below water level. Seawater pumps will circulate the seawater at the required rates through heat exchangers in the FSRU regasification trains. The heat exchangers rely on two phases of heat exchange process:

- Between seawater (as the heat source) and an intermediate fluid (for example propane); and
- Between the intermediate fluid and the LNG.

The pumps will be turned on or off as required based upon the number of regasification trains running.

Two modes of regasification will be employed.

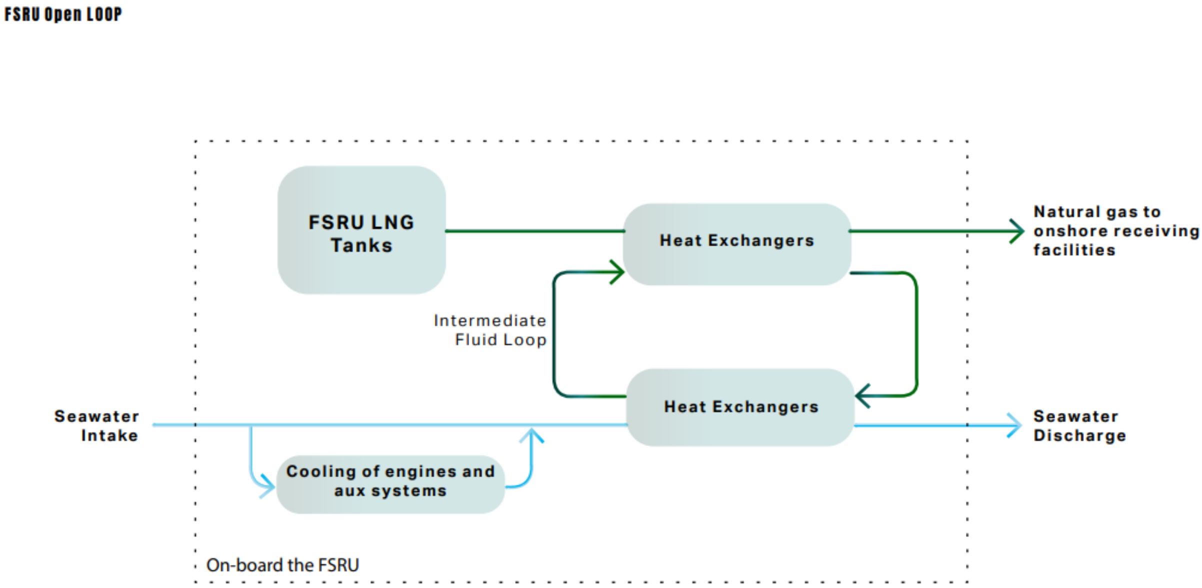


Figure 2-7 Open Loop Regasification

An 'open loop' regasification mode will be used when the seawater intake temperature is approximately 12 °C or higher, and a 'Combined loop' regasification mode will be used when the seawater temperature is below 12 °C.

The charter agreement for a specific FSRU has not been completed. Following a review of a range of vessels on the market from various FSRU suppliers, a range of temperatures between 9 °C to 12 °C were identified at which open loop commences and combined loop stops. For the purposes of this EIAR, a temperature of 12 ^{0}C for commencement of open loop mode was selected. 12 °C is a conservative assumption in terms of emissions and to consider the potential environmental impact. It may be the case that the final FSRU will commence open loop at a lower temperature.

In the open loop regasification mode, the heat provided from the seawater, via the heat-exchangers will be sufficient to regasify the LNG. In the combined loop mode seawater will still be used; however, additional supplementary heat will be supplied into the seawater via steam from gas-fired boilers prior to the seawater entering the heat-exchangers in the regasification system. The gas-fired boilers use boil-off gas (BOG) from the LNG storage tanks as fuel gas.

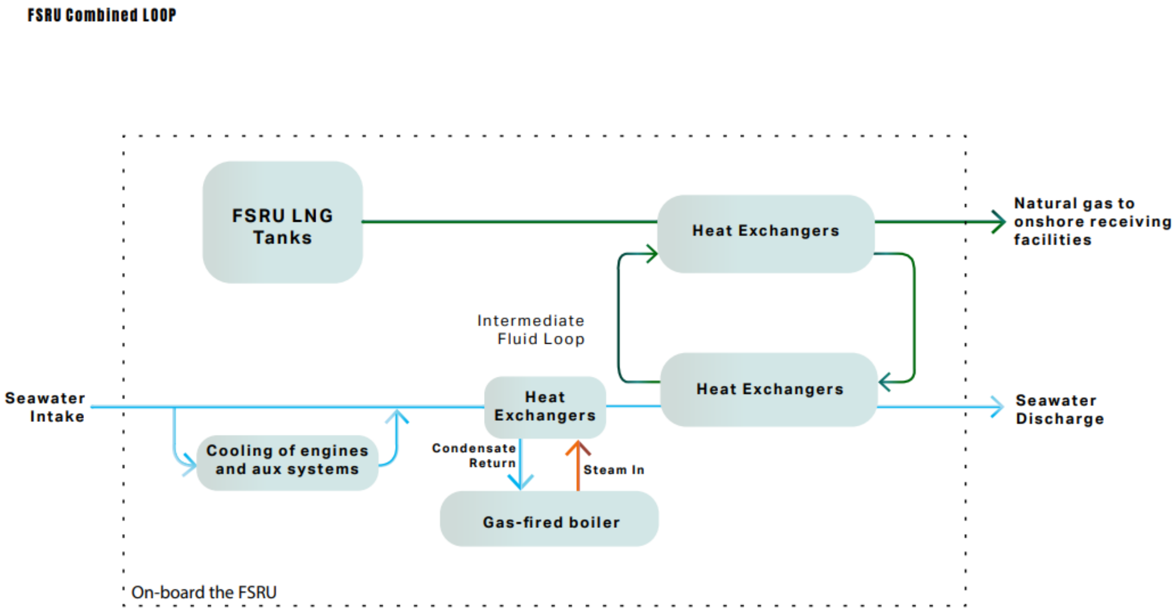


Figure 2-8 Combined Loop Regasification

The seawater that has been used for regasification will be discharged from the FSRU via a subsea pipe located approximately 2.4 m below water level. On discharge, this seawater will be up to 8 °C colder than the receiving ambient seawater. In order to optimise mixing and return of the seawater to ambient conditions, the seawater discharge ports will be orientated to deliver a horizontal water jet below the water surface.

When taking into account local seawater temperature data, it is predicted that the combined loop regasification mode will need to be used from the middle of November to early May. During this period supplementary gas fired heaters will be required. The exact temperature of the river Shannon varies from season to season, so the precise timing of the combined loop operation will vary from season to season. The amount of supplementary heat produced will be proportionally increased/ decreased as the water temperature gets colder/ warmer from the 12 °C open loop setpoint, aiming to use heat from the seawater as much as possible.

Boil-off Gas

Despite insulation of the tanks in which the LNG is stored which will limit the admission of external heat, slight evaporation of the LNG will occur during storage, shipping and loading/ unloading operations. This natural evaporation of small amounts of LNG is known as boil-off gas (BOG) and is removed from the tanks to manage tank pressure.

During regasification, BOG is recovered and used as a fuel source in the power generators onboard the FSRU, with any excess BOG being recondensed back into a liquid and stored as LNG. BOG can also be compressed via a minimum send out compressor (MSO) onboard the vessel and discharged via the jetty to downstream users i.e. the gas transmission network via the AGI or the Power Plant.

Table 2-2 presents a summary of the regasification process.

Table 2-2 Regasification Summary

Regasification Summary	
Peak day send out capacity, Max	22.6 million Sm^3/d
Gas Discharge Temperature	Between 1 °C and 4 °C
FSRU Maximum send out pressure	98 Barg
Seawater temperature for ‘Open Loop’	> 12 °C or 12 °C

Regasification Summary

Seawater temperatures for 'Combined Loop'	<12 ^{0}C
[4] Approximate heat required for LNG regasification	145 MW

2.4.2.1.2 FSRU Water Consumption

The FSRU requires seawater for the following purposes:

Ship systems:

- Main engine cooling;
- Auxiliary machine systems cooling;
- Freshwater generation;
- Ballast; and
- Firewater and service water (intermittent).

LNG Regasification and LNG ship-to-ship transfer:

- Heating/ regasification; and
- Water curtain (during ship to ship transfer from LNG Carrier, intermittent).

The FSRU will manage its draught using untreated ballast water with a maximum capacity of approximately 55,000 m^3. During unloading of LNG i.e. during regasification, the FSRU will take in seawater as ballast to compensate for the reduction of LNG inventory in the cargo tanks as the natural gas is exported to shore. During loading, i.e. ship-to-ship transfer of LNG to the FSRU storage tanks from the LNGC, ballast water will be discharged from the FSRU.

The FSRU will also use seawater for main engine cooling (approximately 1500 m^3/hr), auxiliary systems cooling (approximately 2000 m^3/hr) and onboard freshwater generation (approximately 100 m^3/hr).

There will be intermittent uses of seawater; for example, to test the onboard firefighting systems, intermittent deck washing (approximately 70 m^3/hr), and to create a water curtain when loading LNG from the LNGC (approximately 300 m^3/hr). The water curtain protects the hull from being directly exposed to cryogenic temperatures in the unlikely event that any LNG were to escape during unloading operations. The FSRU firewater system is anticipated to be tested for approximately one hour every 2 weeks.

In addition to the seawater discharge ports for regasification water, several auxiliary discharge ports will be located near the FSRU engine room, including for cooling and ballast as is typical for ocean-going vessels.

Seawater Intakes

Seawater intakes will be located in the hull of the FSRU, approximately 2 m below water level. Screens will be covering the intakes to prevent fish, crustaceans and debris from entering the seawater system within the FSRU. The design of the water intakes will be such that the approach velocity of the seawater entering the screens will not be greater than 0.3 m/s to allow mobile marine biota to swim away. The screen mesh size will be approximately 5 mm x 5 mm. It is anticipated that any silt entering the seawater circulation system will remain in suspension and carry right through the system.

Seawater Discharge

A schedule of FSRU seawater use is presented in Table 2-3 below.

[4] The exact amount of heat depends on each LNG cargo delivered

Table 2-3 FSRU Water Use Summary

Description	Typical (Notes 1, 2)	Maximum	Temperature Difference to Ambient Sea temp.
Seawater for LNG regasification process	11,000 m3/hr	22,000 m^3/hr.	- 8 °C
Seawater for main engine cooling	1,360 m^3/hr	1,500 m^3/hr	+12 °C
Seawater for auxiliary systems cooling	1,040 m^3/hr	2,000 m^3/hr	+5 °C
Seawater for freshwater generation	80 m^3/hr	100 m^3/hr	None
Intermittent use: seawater for onboard firefighting systems and deck washing	70 m^3/hr	70 m^3/hr	None
Intermittent use: Seawater curtain during ship to ship transfer of LNG from the LNGC	300 m^3/hr	300 m^3/hr	None

Note 1 The largest continuous use of seawater is for the LNG regasification process at 22,000 m^3/hr. This flowrate has been calculated for the day peak gas send out of 22.6 million Sm^3/d, which will only happen very infrequently (estimate 1% of the year). On an annual average basis, the FSRU will be send out approximately 14.8 million Sm^3/d of gas. At this annual average rate, the water consumption will be about 11,000 m^3/hr. Refer to Section 2.4.2.1.1 for further discussion on the regasification system.

Note 2 The amount of seawater for engine cooling and auxiliary systems is calculated conservatively with all engines running and all the auxiliary pumps running. Typically, only one main engine and one auxiliary cooling pump will be in operation at the nominal send-out capacity of 14.8 million Sm^3/d.

2.4.2.1.3 Seawater Electrochlorination

A small amount of sodium hydrochlorite is injected into the FSRU seawater systems to control microbial growth. The sodium hypochlorite is generated onboard in an electro-chlorination unit. The electro-chlorination unit will consist of cells housing platinised titanium electrodes between which a direct electric current flows. The sodium chloride salts in the sea water passing between the electrodes dissociate to form residual sodium hypochlorite (chlorine) without the addition of any chemicals. As the seawater passes through the system and is discharged back into the estuary, the chlorine will dissipate back into the sea water from which it will have been produced. The concentration of residual chlorine at the seawater discharge will be monitored and will not exceed 0.5 mg/l.

2.4.2.2 Jetty and Access Trestle

The jetty will be capable of receiving and providing secure berthing for the FSRU as specified above. Its main purposes are for the safe berthing of the FSRU, and for accommodating the necessary gas piping and equipment to safely transfer natural gas from the FSRU to the onshore receiving facilities. The jetty head will comprise (Figure 2-9 and Figure 2-10):

- An unloading platform;
- 8 no. mooring dolphins; and
- 2 no. breasting dolphins.

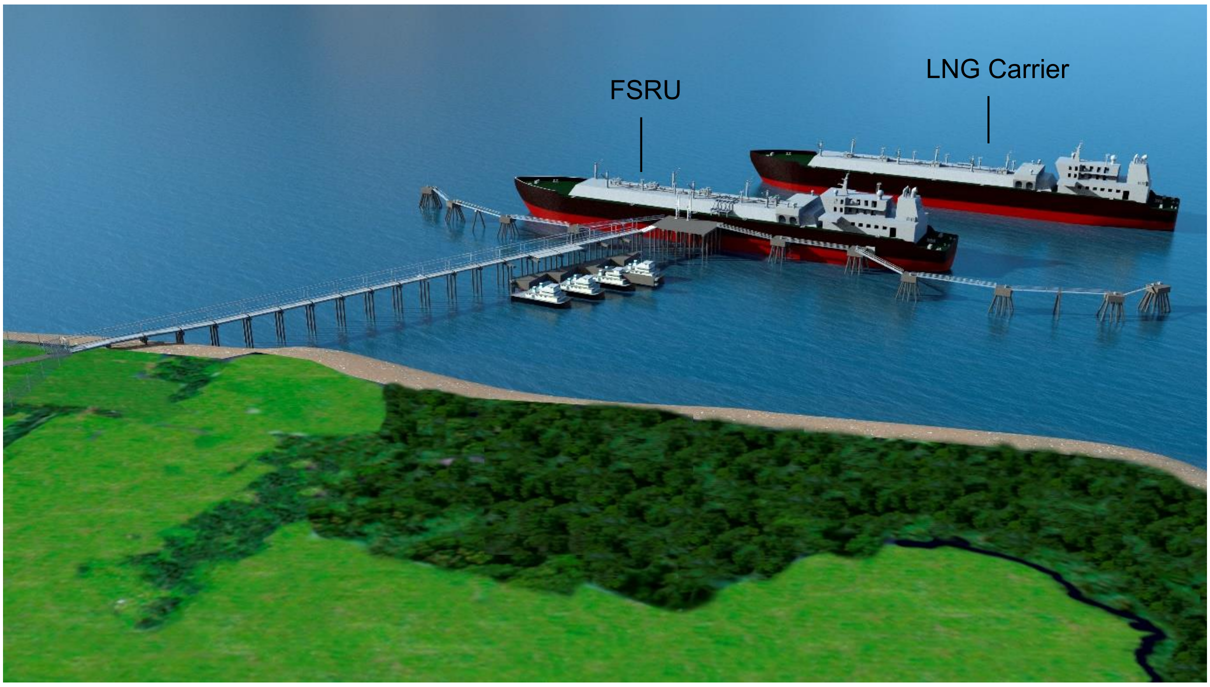


Figure 2-9 Proposed Development Jetty Configuration

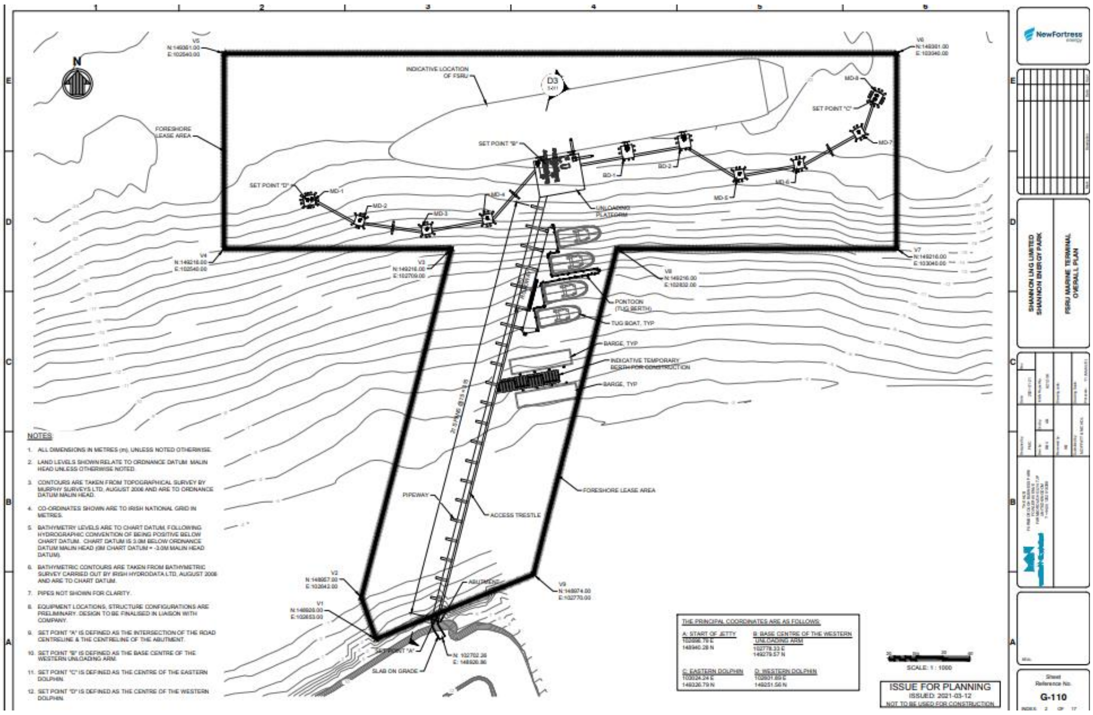


Figure 2-10 FSRU Marine Terminal Layout

The mooring dolphin layout is based on standard industry recommendations for angles of mooring lines (Oil Companies International Marine Forum, 2008). The unloading platform will be supported by steel piles with an additional row of piles along the berthing face to support the weight of the gas unloading arms. The design of the breasting dolphins will take into account the parallel mid-body width of the LNG ships, their various manifold positions forward and aft of mid length, to ensure that ships have adequate fender contact at all times. The unloading platform will also be equipped with fenders. Each of the dolphins will be supported by approximately eight tubular steel piles (see planning application drawings for further detail).

The access trestle, which will connect the jetty head to the shore, will be approximately 315 m in length, and will include a roadway for operational and maintenance access. The trestle will comprise 21 spans of approximately 15 m length with a width of approximately 11 m. The jetty platform elevation will be set at +9 m OD (Malin Head), to be clear of extreme water levels and waves. In total there will be approximately 203 piles inserted into the riverbed for the jetty and the access trestle. Following a constructability review, a temporary loading/ mooring facility has been included in the proposed jetty design which allows a mooring point for the construction of plant. Further details on the construction of the jetty can be found in Section 2.9.4.1.

Given the natural water depth at the site, no dredging is required for the Proposed Development.

The infrastructure to be installed on the jetty will include:

- Two GLAs on the unloading platform;
- A 30” (750 mm) gas pipe. The gas piping will run from the unloading arm on the platform to the onshore receiving facilities via a pipe rack which will be installed on the western side of the trestle;
- Hydraulic gangway tower to access the FSRU from the jetty;
- Power Distribution Centre (PDC);
- Compressed air system;
- Fire-fighting systems;
- Spill containment equipment; and
- Lighting and CCTV security system.

The GLAs will facilitate the connection of the 30” gas pipe described above to the FSRU discharge flange/ connector. The arms will be composed of rigid pipe sections which can swivel to allow a flexible connection between the floating (potentially moving) vessel and the rigid gas piping on the jetty. The top of the unloading arms will be approximately 30 m above the platform of the jetty. The 30”gas piping on the jetty will be designed to withstand the maximum discharge pressure from the FSRU. In the event that the FSRU is disconnected from the jetty, the gas inventory within the piping on the jetty will be isolated at the interface with the GLAs. The gas held in the arms will be vented back to the FSRU before disconnecting.

The FSRU will discharge the natural gas into the GLAs at pressures ranging from 48 to 98 barg at flowrates up to 22.6 million Sm^3/d.

It is anticipated the jetty will be operationally available 24 hours a day. Table 2-4 presents a summary of the key specification of the jetty.

Table 2-4 Key Jetty Specification

Description	Quantity
Number of GLAs	2
Jetty gas pipeline nominal diameter	750 millimetres
Jetty gas pipeline length	315 metres
Fire fighting system	Fire pumps, fire monitors, hydrants
Associated infrastructure	Gangway tower, substation, air compressors, transformer, lighting and CCTV system

2.4.2.3 Tugs

Visiting LNGCs delivering LNG to the Proposed Development will require tug support during both arrival and departure as well as for estuary channel navigation. Figure 2-11 presents the specification of a typical tug, which will be used.

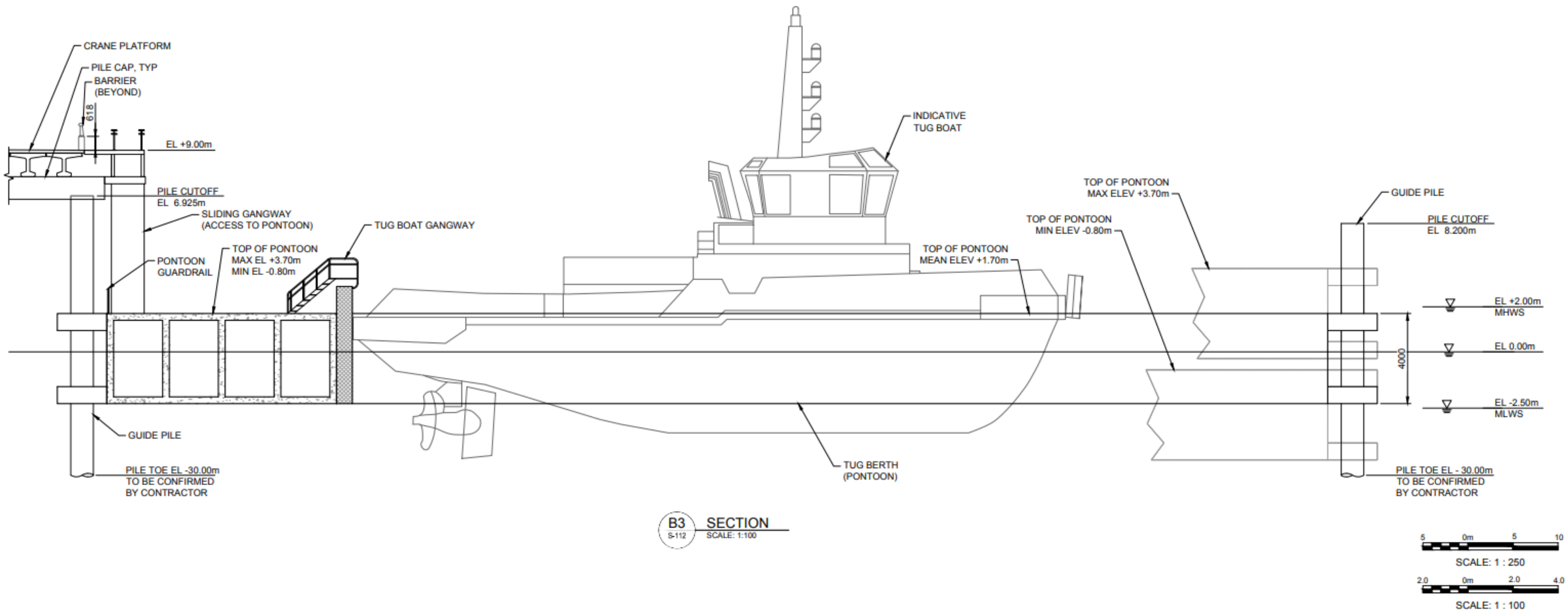


Figure 2-11 Typical Specification of a Tug

The basic functions of the tugs will be for push-pull, escorting, berthing, towing, and in certain circumstances firefighting and pollution control operations. The procedures for towage operations will be developed and written in consultation with and agreed with SFPC.

It is proposed that four new tractor type tugs of about 70 tons bollard pull each are included as part of the LNG Terminal.

The specification of the tug design will be finalised once the FSRU has been selected and contracted. The tugs will be licensed to operate at the Proposed Development by SFPC. The four tugs will be available for FSRU and LNGC mooring operations i.e. typically to safely moor/ unmoor the LNGC alongside the FSRU for LNG transfer. The tugs will be stationed at the jetty in order to meet the necessary service notice requirements, with a minimum of two tugs being moored there. Two fire monitors will be controlled remotely from the wheelhouse of the tug.

When a LNGC is berthed alongside the FSRU, a minimum of one tug will be on standby, underway near the jetty and ready for immediate use. Its primary function will be to provide offshore fire-fighting capabilities during LNG loading operations. A second tug will available at 30 minutes' notice and the third and fourth tugs will be at two hours' notice.

During normal operations when there is no LNGC moored at the jetty, it is anticipated that there will be a minimum of one tug available at the berth, tied alongside but manned and available for immediate use with a second tug at 30 minutes' notice. The third and fourth tugs will be at 2 hours' notice.

The specification of the tugs will be such that at least 2 of the 4 tugs are 'escort notated'. Escort tugs employed in active roles are designed to be capable of operating at speeds of approximately 1.5 times the speed of the approaching LNGC.

2.4.2.4 LNG Supply by LNG Carriers

The LNG in the LNG Terminal will be supplied from visiting LNGCs moored alongside the FSRU in a ship-to-ship transfer configuration. The LNG will then be transferred from the LNG tanks of the LNGC into the LNG storage tanks onboard the FSRU. Once the transfer of LNG is complete, the LNGCs will depart from alongside the FSRU with the assistance of tugs.

Up to 60 LNGC visits per year are anticipated. In addition to the 35 hours required to transfer the LNG, approximately 25 hours in total will be required to moor, berth, unmoor and unberth the LNGC. Ship passage time from the mouth of the Estuary to the Proposed Development is estimated at 4 hours.

The Proposed Development is designed to accommodate LNGCs with a varying capacity ranging from 130,000 m^3 to 265,000 m^3. As of June 2021, 57% of the current world LNGC fleet is between 150,000 and 180,000 m^3 (International Gas Union, 2021). Therefore, it is anticipated that the majority of LNGCs arriving at the Proposed Development will be in the range between 150,000 and 180,000 m^3. See Figure 2-12 for the LNGC berthing plan.

The LNGCs to be used will comprise double hull construction with the LNG containment systems, equipment and insulation typically installed within the inner hull. LNG will be carried in specially designed cargo tanks onboard the LNGC. The natural gas, which consists predominantly of methane, has a boiling point of approximately -163°C, and LNG is stored at -163°C at atmospheric pressure to remain liquid. The LNG storage tanks are insulated to minimise the thermal flow from the environment to the LNG storage tanks and to minimise the amount of evaporation i.e. BOG produced. The tanks are surrounded completely by two insulation spaces. The insulation spaces will be filled with inert gas, typically nitrogen to provide an inert blanket around the tanks whilst also supporting the gas detection systems installed to continuously monitor the cargo.

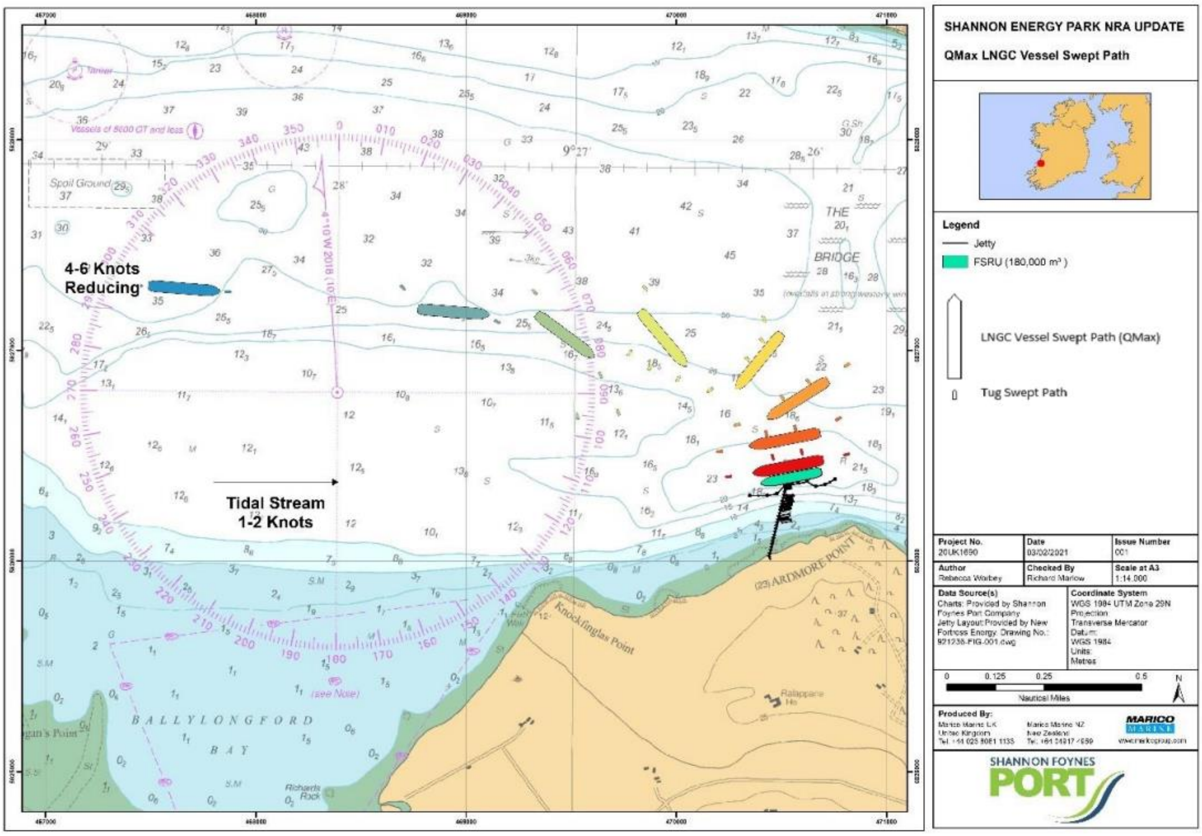


Figure 2-12 LNGC Berthing Plan

The LNGCs will employ either one of two main cargo containment systems:

1. Moss spherical tanks system, identified by its large spheres above deck level; or
2. Membrane tank system with a more conventional flat deck appearance.

Refer to Figures 2-13 and 2-14, for an image of both a Moss type and membrane type ships (respectively).

Figure 2-13 LNG Carrier with Moss Spherical Tank System

Figure 2-14 LNG Carrier with Membrane Tank System

Modern newbuilds have for the most part adopted the membrane type. Specifically, 79% (454) of the LNGC fleet today use membrane tanks, with the remaining 21% (118) being Moss type (International Gas Union, 2021).

The LNGCs that will be employed will be fuelled by natural gas in the form of BOG, diesel, heavy fuel oil, or a combination of BOG with either of the liquid fuels. The current world fleet of LNG ships is predominantly steam turbine powered, having sea service speeds of approximately 19 knots. They are equipped to burn BOG from the cargo in their boilers thus minimizing consumption of fuel oil and avoiding any venting of gas to the atmosphere. Specifically, of the 572 active LNGCs in the world, 92% (526) use either wholly natural gas in form of BOG, or a combination of BOG with either of the liquid fuels. Only 8% (48) exclusively use diesel as fuel (International Gas Union, 2021). All LNGC engines will comply with the emissions standards set by the MARPOL convention, when using liquid fuel. New generation ships now entering service include dual-fuel natural gas burning diesel electric propulsion systems, which also burn BOG, eliminating any venting of gas.

While the frequency of LNGCs accessing the operational facility is currently estimated at up to 60 visits per year, the LNG containment type, size and propulsion system for each visiting LNGC will vary within the limits set out above.

Pilotage of vessels, including the LNGCs, will be provided by Shannon Estuary Pilots under the direction of the Harbour Master.

For details of the procedures for the arrival and berthing of an LNGC, the unloading operation and for departure, refer to Appendix A2-2, Vol. 4 Marine Navigation Risk Assessment (SFPC, 2021).

It is envisaged that the port side of the FSRU will be moored to the jetty, and the LNGC will be berthed by the port side to the FSRU. The main reason for such an arrangement is to point the bow of both vessels to the open sea during the stay on berth so that fast departure of vessels in case of extraordinary circumstances is possible, even without tugs.

Visiting LNGC will arrive full of LNG and there will be no discharge ballast water into the Shannon. The LNGC will take on seawater as ballast as they unload their cargo.

2.4.2.5 Onshore Receiving Facilities

The onshore receiving facilities comprises the following components (Figure 2-15):

- Nitrogen generation plant for gas blending (Section 2.4.2.5.1);
- Buildings (Section 2.4.2.5.2);
- Onsite power generators (Section 2.4.2.5.3);
- Black start diesel generator (Section 2.4.2.5.4);
- Instrument and plant air package (Section 2.4.2.5.5);
- Fire water storage tanks and fire water pumps (Section 2.4.3.1.4); and
- Gas metering and regulation area (Section 2.4.3.1.2 and Section 2.4.3.1.3).

Figure 2-15 Proposed Onshore Receiving Facilities

2.4.2.5.1 Nitrogen Generation Plant

The function of the nitrogen generation plant will be to generate nitrogen from air and store it for use at the LNG Terminal. Nitrogen gas will be required for blending in the event that natural gas received from the FSRU to meet the requirements of GNI. Nitrogen will then be injected into the gas stream to achieve the required specification. Nitrogen will also be required for purging of equipment and piping during operation and maintenance activities.

2.4.2.5.2 Buildings

The LNG Terminal will comprise the following buildings:

- Main LNG control building;
- Nitrogen generation package control building;
- Nitrogen compressor building;

- Electrical switchgear enclosures;
- Continuous emissions monitoring (CEMS) enclosures; and
- Workshop/ warehouse building.

Buildings and enclosures common to both the Power Plant and LNG Terminal are described in Section 2.4.3.

Main LNG Control Building (22.7 m x 14 m)
Operation of the LNG Terminal will be monitored and controlled from the Main Control Building. This building will include a control room, electrical and instrumentation room, meeting room and offices for the personnel stationed at the LNG Terminal.

Nitrogen Generation Package Control Building (24 m x 12 m)
The operation of the nitrogen generation plant (see Section 2.4.2.5.1) will be monitored and controlled from the Control Room in the Nitrogen generation package control building. This building will also comprise an electrical and instrumentation room, meeting room and offices for the personnel associated with the nitrogen generation plant.

Nitrogen Compressor Building(8.6 m X 12 m)
Nitrogen gas compressors to pressurise the nitrogen up to 98 barg for injection into the natural gas will be housed in the nitrogen compressor building. This building will normally be unoccupied.

Electrical Switchgear Enclosures (9 m x 26 m and 18 m x 5 m)
Two electrical switchgear enclosures – main and secondary – will house the electrical and control equipment necessary to distribute power and control throughout the LNG Terminal. The enclosures will be pre-manufactured from all-weather steel. The enclosures will be mounted on steel support legs or concrete piers to elevate the enclosures and allow bottom entry for electrical/ control wiring, and will normally be unoccupied.

Five transformers (3 m x 3 m) will be provided as part of the LNG Terminal equipment.

Continuous Emissions Monitoring Enclosures (1.9 m x 1.9 m)
Three enclosures will house the CEMS.

Workshop/ Warehouse Building (18 m x 28 m)
The workshop and warehouse building will provide storage for equipment and material spares required to maintain an operational facility. The building will also include a number of maintenance offices and a workshop area. A summary of the proposed architectural colour scheme is provided in Table 2-5.

Table 2-5 Summary of Proposed Architectural Colour Scheme

Building Unit	Colour
Fencing, enclosure/ equipment container sides and tops, racks, evaporators, water tanks	RAL 6006 (Grey-Olive)
Building and enclosure façades	RAL 6003 (Olive green)
Building and enclosure roofs	RAL 6020 (Chrome green)
Doors, window frames, auxiliary boiler and fuel gas stacks and cooler pipes	RAL 7043 (Traffic grey B)
Façade for the turbine halls	RAL 6011 (Reseda Green)
Turbine air intakes and diesel generator/ HRSG exhaust stacks	RAL 9023 (Pearl dark grey)

2.4.2.5.3 Onsite Power Generators
It is anticipated that once operational, a small percentage of the electricity generated by the Power Plant will be used to power to the LNG Terminal. Three no 8 MW gas fired electricity generators will be used to provide onsite power generation to the LNG facilities while the 220 kV connection is being constructed in the absence of the 220 kV and medium voltage (10/ 20 kV) grid connections. Fuel gas for these generators will be supplied from gas from the FSRU. However, if there is no gas from the FSRU, the generators will be powered by fuel gas which will be reverse flowed from the consented 26 km 30” Shannon Pipeline.

If the 220 kV and medium voltage (10/ 20 kV) grid connections are consented, these power generators will be used as back up power generation if the grid connections fail, or are unavailable.

Additional information can be found in Section 2.4.6.1.

2.4.2.5.4 Black Start Diesel Generator (5 m x 9.4 m)

A black start diesel generator will be provided to enable start-up of the onsite power generators without a connection to the electricity grid. The diesel fuel for the black start generator will be stored in a bunded or a double-walled tank.

2.4.2.5.5 Instrument and Service Air Package (11.7 m x 4.6 m)

Compressed air for instrument use and for service and maintenance use will be generated onsite. A combined instrument and service air distribution system will be installed and compressed air will be supplied from a compressed air generation unit. This will include a backpressure regulator to prevent loss of pressure in the instrument air system when pneumatic tools are being used, along with associated equipment such as filters.

2.4.2.6 Above Ground Installation

The AGI will accommodate the valves and control equipment to facilitate the connection to the already consented 26 km 30" Shannon pipeline. It will facilitate the transportation of gas to GNI, and will include odorisation, fiscal metering and pressure control of the gas flow prior to it entering the national gas network. The AGI is located in a separate compound within the Proposed Development site covering an area of approximately 11,282 m^2. Once commissioned, GNI will operate the AGI. The indicative layout of the AGI is shown in Figure 2-16. A detailed layout of the AGI is shown in Figure F2-5 in Volume 3.

Figure 2-16 Proposed Layout of the AGI

The details provided on the AGI are based on information provided by GNI and will be typical of existing GNI AGIs on the national gas transmission network. If required, the AGI will be able to supply the LNG Terminal and/ or Power Plant with a gas. In addition to gas piping and associated valves, the AGI will house the following equipment and buildings (see Figure F2-5, Vol. 3):

- Odorisation package including bulk odorant storage;
- Pig-trap (Bi-directional);
- Filtration;
- Fuel gas heaters/ heat exchangers and associated fuel gas skid;
- Metering equipment located in a Metering Building;

- Gas pressure regulation system located in a Regulator Building;
- Gas chromatographs/ Chromatograph Building;
- Generator Kiosk; and
- Control and Instrumentation building.

The AGI compound will be remotely operated and will normally be unmanned.

2.4.2.6.1 Odorisation (12.1 m x 11.7 m)

Natural gas, which mainly comprises methane, has little or no natural smell. The gas entering the transmission network is therefore injected with small traces of a strongly smelling substance, which is added for the purpose of safety and leak detection for consumers. The odorant is stored in odorant tanks, a control system and associated pipework will be installed to enable the injection of carefully controlled volumes of odorant into the natural gas (typically 6 milligrams per m^3).

2.4.2.6.2 Pig-Trap (Bi-directional)

A bi-directional pig-trap (and associated equipment) will be installed to launch (or retrieve) the pipeline inspection gauge (pig). Pigs are in-line tools which are propelled through the pipeline for two main purposes: namely initially during the gassing-up/ commissioning to clean and dewater the pipeline, and later, when the pipeline is operational, to inspect the internal condition such as the wall thickness of the pipeline. This inspection pig is also termed an intelligent pig.

2.4.2.6.3 Pressure Reduction/ Flow Control

The pressure reduction/ flow control equipment, which is to be included in a 20.5 m x 12.6 m regulator building, will enable the pressure and flow rate of the natural gas entering the gas transmission network to be controlled as required by the network operator, GNI.

2.4.2.6.4 Heat Exchangers (31.9 m x 40.5 m)

During times when gas pressure is reduced, as described above, the act of reducing the pressure of the gas causes a drop in gas temperature (through the Joule Thompson effect). The gas is therefore passed through a set of heat exchangers to preheat the gas prior to pressure reduction ensuring the gas is 2 ˚C or higher in temperature before it enters the grid. The heating medium to be used for these heat exchangers will be water heaters in boiler units (see below).

2.4.2.6.5 Fuel Gas Heaters

The heating medium (water) combined with Alphi 11 anti-freeze is heated by gas fired boilers planned to be housed in individual buildings (3 number 18.1 m x 17.1 m).

2.4.2.6.6 Metering Building (25 m x 20 m)

Fiscal metering of the gas will occur in a metering building.

2.4.2.6.7 Regulator Building (20.5 m x 52.7 m)

See Section 2.4.2.6.3.

2.4.2.6.8 Chromatograph Building (3.5 m x 4.5 m)

The gas chromatography building will house a gas chromatograph where the calorific value of the gas is determined prior to entering the grid.

2.4.2.6.9 Generator Kiosk (4.8m x 3.5m)

Generator(s) will be located in the generator kiosk.

2.4.2.6.10 Control and Instrumentation Building (20 m x 10 m)

A control room, normally unmanned, will be located in the control and instrumentation building.

2.4.2.6.11 Pipework

The majority of valves and pipework within the AGI compound will be located below ground level. A short section of the export pipe will extend above ground level to provide the connection for the pig trap (launcher and receiver), which will be required from time to time to allow internal cleaning or inspection of the pipeline.

2.4.3 Ancillary Buildings

The following buildings will be used by both the Power Plant and LNG Terminal:

- Security building;
- Fuel gas regulating enclosure;
- Fuel gas metering enclosures; and
- Fire water storage tanks and fire water pumps.

The buildings will be steel framed buildings with concrete floor slabs. Structural and architectural details have been prepared including particulars of the shallow and deep foundations, lifting equipment, steel structures, and protective coatings.

2.4.3.1.1 Security Building (11 m x 5.8 m)

The security building will include a reception area to check in visitors, along with a break area and toilets for security staff.

2.4.3.1.2 Fuel Gas Regulating Enclosure (12.6m x 13.2 m)

The function of the fuel gas regulating enclosure will be to regulate the pressure and temperature of the gas used by the onsite power generators and the Power Plant.

2.4.3.1.3 Fuel Gas Metering Enclosures

There will be several small unoccupied enclosures included in the gas metering area (12.6m x 13.2m) to house instrumentation, such as a gas chromatograph, to measure the calorific value of the gas for onsite use.

These will include:

- Metering and regulating area kiosk enclosure (3 m x 3 m);
- Metering and regulating area analyzer enclosure (3 m x 4.4 m); and
- Metering and regulating area instrument enclosure (3 m x 4.4 m).

2.4.3.1.4 Fire Water Storage Tanks and Fire Water Pumps

Fire water will be supplied from the municipal water supply system and will be stored onsite in two separate tanks (16 m height x 14 m diameter), which will be field-fabricated welded steel tanks, each with a dedicated capacity representing a minimum of two hours of fire water requirement during firefighting. In addition, One 100% capacity electrically driven fire pump, one 100% capacity diesel engine driven fire pump, and two jockey pumps will be located within the fire water pump enclosure. The pumps will be designed to provide the required volume of firewater needed for any automatic suppression system plus flow for fire hydrants or hose stations. A diesel fuel tank for the diesel driven fire pump will be either located in a bunded area or within a double-walled tank.

In addition to the firewater storage tanks, additional firewater will be stored in the firewater retention pond as described in Section 2.4.7.3.

2.4.4 Roads, Site Access and Car Parking

2.4.4.1 Internal Roads

Internal roadways will be constructed to support delivery of equipment, facility operations, and connection between buildings (Figure 2-17). Main routes in the Proposed Development site will be reinforced as required to support significant loads and vehicles. All permanent road works will be designed, constructed and specified in accordance with relevant applicable Irish standards and codes of practice. The minimum road width is provided in Table 2-6.

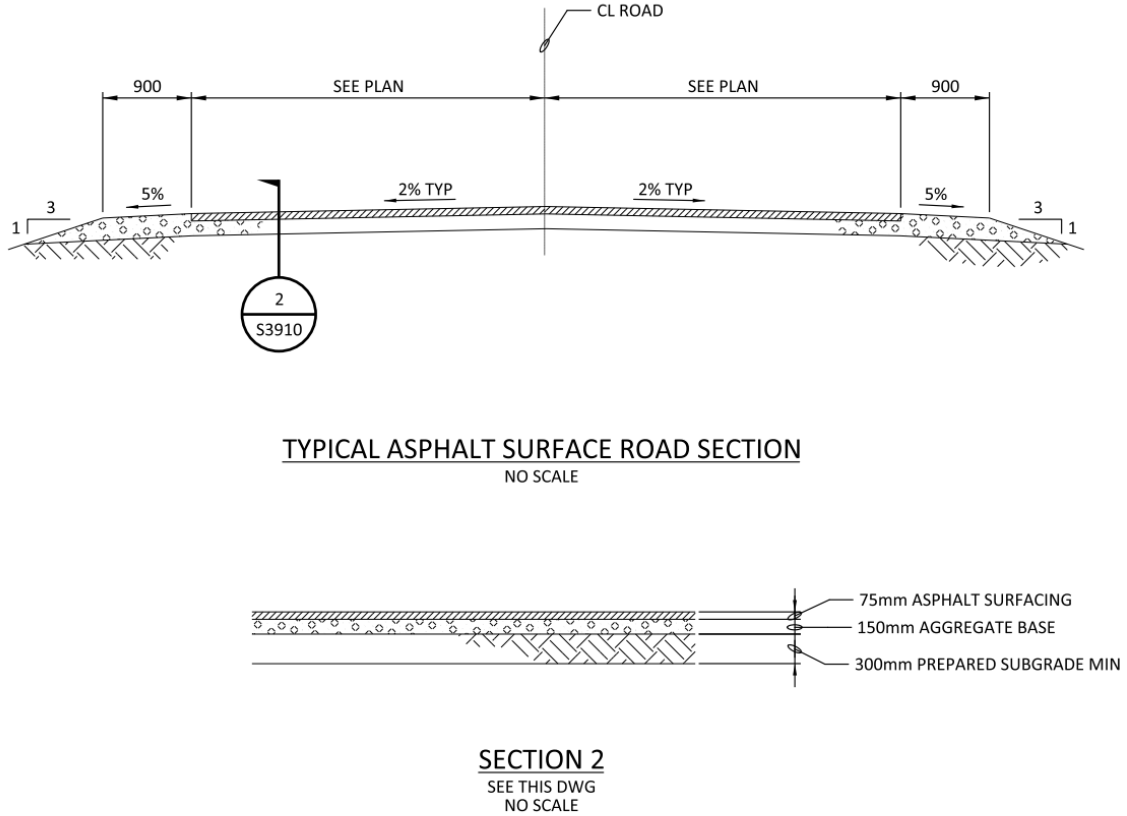


Figure 2-17 Cross Section of Internal Roads

Table 2-6 Internal Road Dimensions

Road	Total Width (m)	Paved Width (m)	Shoulder Width (m)
Paved Interior Roads	7.8	6	0.9

2.4.4.2 Site Access

Site access will be located off the existing L1010 (Coast Road), which is the primary access road to the townlands of Kilcolgan Lower and Ralappane from Tarbert and Ballylongford. Appropriate signage will be installed.

The AGI will be operated remotely by GNI and normally unmanned, but pedestrian access and vehicular access will be required for inspection and maintenance purposes.

See Section 2.4.5 for details of proposed fencing and security gates.

There will be three watercourse crossings within the boundary of the Proposed Development, as discussed in Chapter 06 – Water:

- 600 mm culvert;
- 1200 mm culvert; and
- Pre-cast concrete bridge over the Ralappane Stream (Figure 2-18).

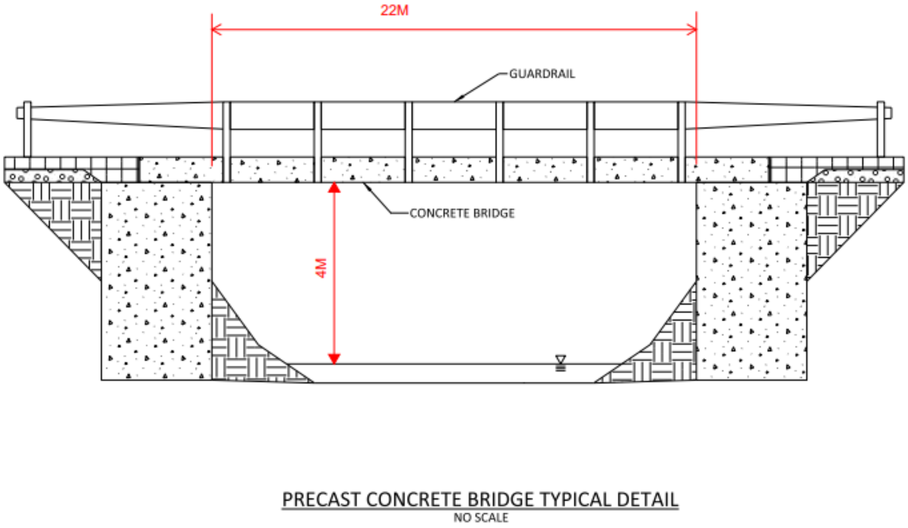


Figure 2-18 Proposed Pre-cast Concrete Bridge over the Ralappane Stream

2.4.4.3 Car Parking

Parking is proposed during the operational phase which will comprise:

- 42 car parking spaces including:
  - A minimum of 2 mobility spaces;
  - A minimum of 2 electric vehicle charging points; and
- A minimum of 40 cycle parking spaces provided throughout the Proposed Development site.

Additional parking is accommodated in the laydown area, which will cover any overflow requirements in the event of maintenance or shutdown.

2.4.5 Security

There are three separate fence lines in the Proposed Development:

1. An outer perimeter fence line surrounding the whole development;
2. An inner security fence line surrounding the operational Power Plant and LNG Terminal; and
3. A separate double fence line surrounding the AGI.

A CCTV system will also be installed.

The fence lines are detailed in the sections that follow.

2.4.5.1 Outer Perimeter Fence

The outer perimeter fence will comprise a 2.4 m high chain link fence, galvanised and PVC coated in evergreen and topped with three layers of barbed wire (see Figure 2-19). For visual impact mitigation the outer perimeter fence line will be set back from the L1010 road to avoid crossing watercourses as far as possible. The fencing is not expected to impact surface water flow where two watercourses are crossed, as there will not be a requirement for this fencing to be extended below the water's surface.

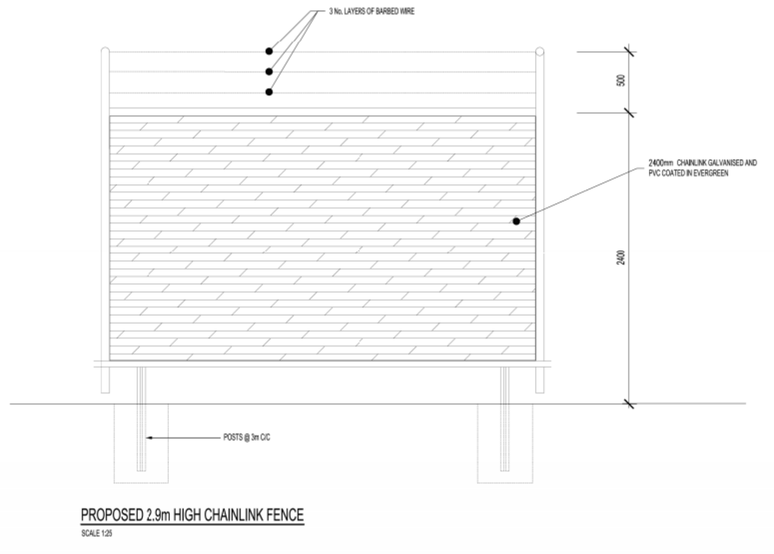


Figure 2-19 Proposed 2.9 m Outer Perimeter Fence

2.4.5.2 Inner Security Fence

A 4 m inner security fence will surround the Power Plant and LNG Terminal (see Figure 2-20). This will comprise a fully galvanised and PVC coated palisade fence in evergreen (2.4 m high), topped with an electric wire fence. The LNG Terminal and Power Plant will be manned for round-the-clock service for operations and maintenance purposes, although planned maintenance activities will predominantly be conducted during the daytime. The inner security fence line will not cross any watercourses.

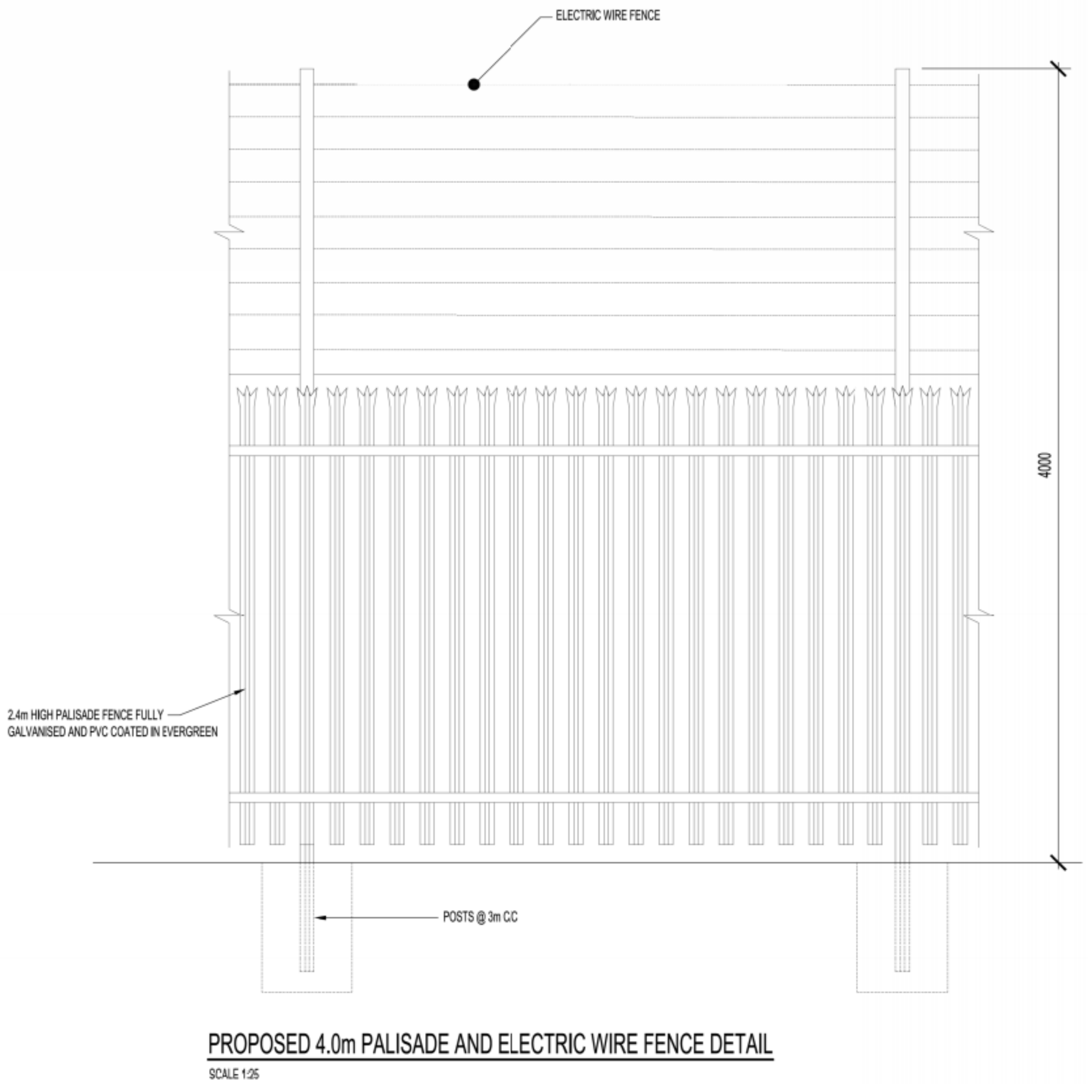


Figure 2-20 Proposed 4 m Inner Security Fence

2.4.5.3 AGI Fenceline

Two layers of fence will surround the AGI (see Figure 2-21). This will comprise a spiked palisade fence, galvanised and PVC coated in dark green, with a weld mesh access security gate and a weld mesh fence in the same colour. The AGI double fenceline will not cross any watercourses.

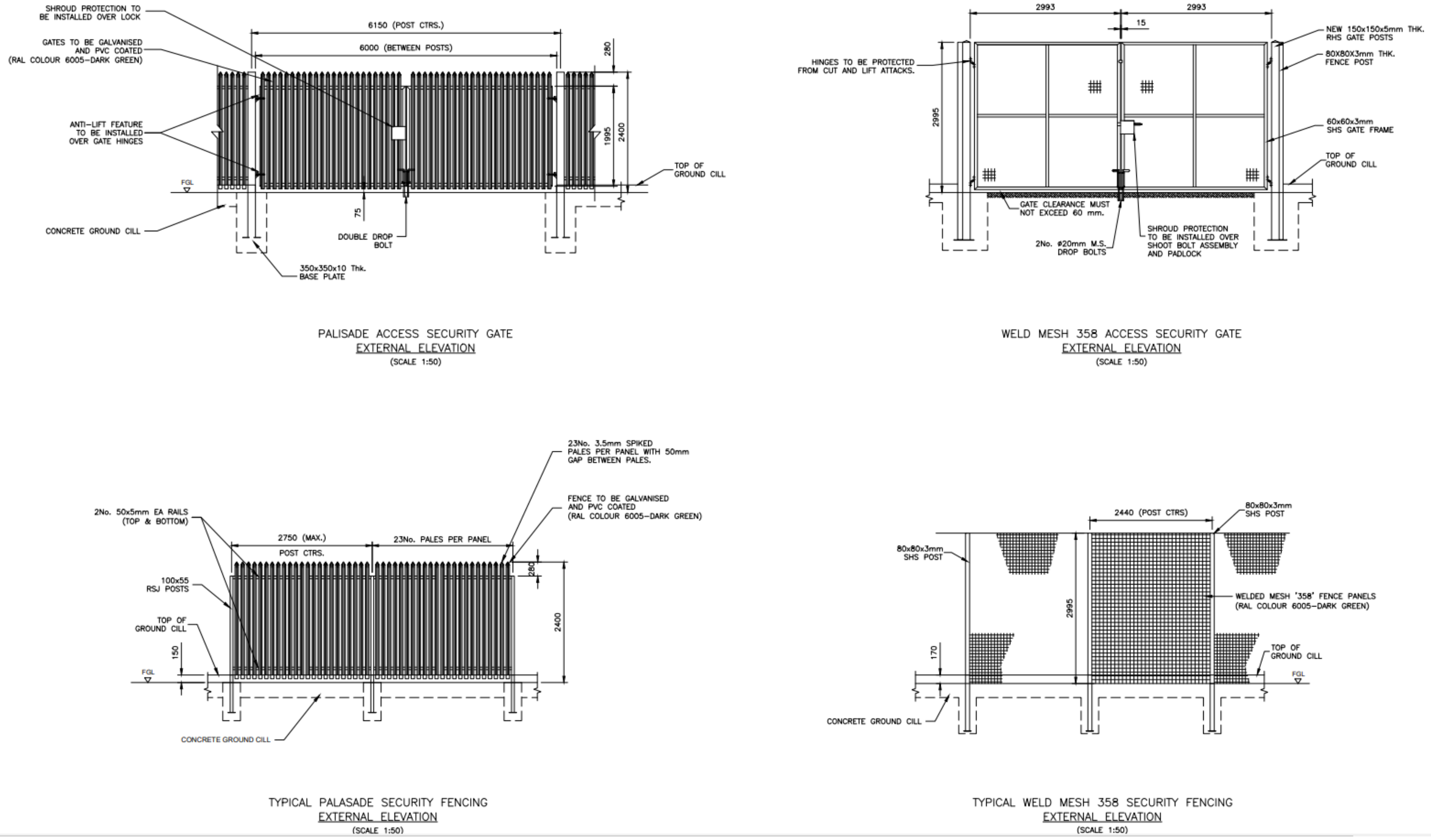


Figure 2-21 Proposed AGI Fenceline

2.4.6 Utilities

The Proposed Development will require connection to the following utilities:

- Electricity;
- Gas;
- Municipal water; and
- Telecommunications.

In addition, the Proposed Development will require stormwater and surface water drainage, sewerage drainage and process effluent drainage infrastructure.

2.4.6.1 Electricity

2.4.6.1.1 Overview

A high voltage (HV) 220 kV grid connection to the national electrical transmission network is required to export power from the Power Plant, when operational. During periods of high wind (renewable) generation it is expected that the Power Plant will be turned off by the system operator (EirGrid) to give priority to renewable power. In this event, the LNG Terminal will require power. At times when the Power Plant is shut down, power may be imported to the Proposed Development site via the proposed future 220 kV high voltage grid connection.

It is currently anticipated that the LNG Terminal will be operational before the Power Plant and the 220 kV grid connection are completed. Therefore, a medium voltage (10/ 20 kV) grid connection will be required to supply power to the LNG Terminal.

Once the Power Plant and/ or future 220 kV grid connection are completed, this medium voltage (10/ 20 kV) grid connection will be reserved as a backup power supply if the Power Plant and 220 kV grid connection are not available. These will be subject to a connection agreement with EirGrid and ESBN. These grid connections will be subject to separate planning applications and do not form part of the Proposed Development.

Additional information on the potential future 220 kV and medium voltage (10/ 20 kV) grid connections are outlined in the following sections.

2.4.6.1.2 The 220 kV High Voltage Connection

An application to connect to the national electrical transmission network was submitted to EirGrid in September 2020 under the Enduring Connection Policy 2 (ECP2) process. An offer has yet to be received so the precise connection details cannot be confirmed at the time of writing. The development of the grid connection will be subject to a separate planning application and associated EIAR by the Applicant once the offer is received, and the precise connection details are known. The aspects and impacts of the construction and operation of the grid connection have been included in the cumulative impact assessments in this EIAR.

It is anticipated that the connection point will be the ESBN / EirGrid Killpaddogue 220 kV substation which is located approximately 5 km east of the Proposed Development site with connection provided via a 220 kV cable(s) under the L1010 road as shown in Figure 2-22. The grid connection will be laid under the L1010 from the Proposed Development to the entrance road to Kilpaddoge 220 kV substation. At the entrance road to Kilpaddoge substation, the grid route will follow the substation access road and connect to the Kilpaddoge substation. No works are anticipated at Kilpaddoge 220 kV substation. The cable route will be approximately 4.6 km in length and is anticipated to be located entirely under private and public roadways. Approximately 3.5 km will be installed under public roadway (L1010). Local access will be maintained throughout the cable installation process.

It is anticipated that the 220 kV grid connection will require an onsite EirGrid 220 kV substation. This is currently proposed to be located onsite and approximately 500 m from the main Proposed Development site entrance. The details of the planned 220 kV substation will be included in the future 220 kV connection planning application.

It is expected that the planned 220 kV substation will comprise lightning protection masts, cable sealing ends, high voltage disconnectors, circuit breaker, current and voltage transformers all contained within a fenced area, approximately 60 m by 50 m. The electrical equipment is not expected exceed 9 m in height with the exception of the lightning protection monopoles which are expected to be between 15 – 18 m in height. A single storey control building of masonry block construction, up to 5 m height, with an estimated footprint of approximately 375 m^2 also is planned within the site boundary.

The planned 220 kV substation will in turn connect to the Power Plant 220 kV GIS substation, as described in Section 2.4.1.3.

2.4.6.1.3 The Medium Voltage Connection (10/ 20 kV)

If the LNG Terminal commences operation before the Power Plant and/ or 220 kV high voltage grid connection are completed or operational an alternative electricity supply is required. Therefore, a separate medium voltage (10/ 20 kV) connection to power the LNG Terminal in the absence of the Power Plant and/ or 220 kV high voltage grid connection will be installed. Once the Power Plant and/ or future 220 kV grid connection are completed, this medium voltage (10/ 20 kV) grid connection will be reserved as a backup power supply. However, the connection is subject to a connection agreement with ESBN and will be considered under a separate planning application. This will be included in the cumulative impact assessment within each EIAR chapter.

If consented, the LNG Terminal medium voltage (MV) connection will be via a new onsite substation and underground cable from the existing ESBN / EirGrid Kilpaddoge 220 kV substation. The onsite substation will be adopted by ESBN post commissioning and will form part of the overall medium voltage (10/ 20 kV) distribution system.

The onsite substation will be located within the Proposed Development site redline boundary approximately 800 m from the Proposed Development site entrance. The onsite substation will comprise a single-storey building size of 10 m x 4.5 m approximately and will include separate ESBN and Customer MV switchrooms. The proposed underground cable route will follow the L1010 route in parallel with the 220 kV cables as described above.

The below sections summarise the power requirements and supply for the LNG Terminal and Power Plant considered under this planning application and EIAR.

2.4.6.1.4 LNG Terminal Power Requirements

It is anticipated that once operational approximately 10 MW of electricity generated by the Power Plant will be supplied to the LNG Terminal. However, as outlined above, the LNG Terminal may commence operation prior to the completion of the Power Plant and/ or future 220 kV high voltage grid connection and medium voltage (10/ 20 kV) grid connection. In this case, power to the LNG Terminal will be supplied via onsite gas generators until the Power Plant or the medium voltage (10/ 20 kV) connection are operational.

The onsite power generation will comprise three 8 MW gas fired electricity generators. Fuel gas for these generators will be supplied from gas from the FSRU. However, if there is no gas from the FSRU, the generators will be powered by fuel gas which will be reverse flowed from the 26 km 30” Shannon Pipeline.

Once the medium voltage (10/ 20 kV) grid connection is available, the onsite gas generators will be utilised as backup power supply in the event that the LNG Terminal’s grid connection fail.

See Appendix A2-3, Vol. 4 for the medium voltage (10/ 20 kV) and 220 kV connections construction information.

2.4.6.2 Municipal Water Supply

The Proposed Development will require water supply for the following:

- Domestic site staff – 3.6 m^3/day; and
- Process water – ranging between 10 m^3/hr and 33 m^3/hr.

The Applicant has made a connection request to Irish Water, which will require connection to a mains water system. It is anticipated that this will be provided along the Coast Road from Ballylongford to the Proposed Development site (Figure 2-22). The water connection does not form part of the scope of this EIAR.

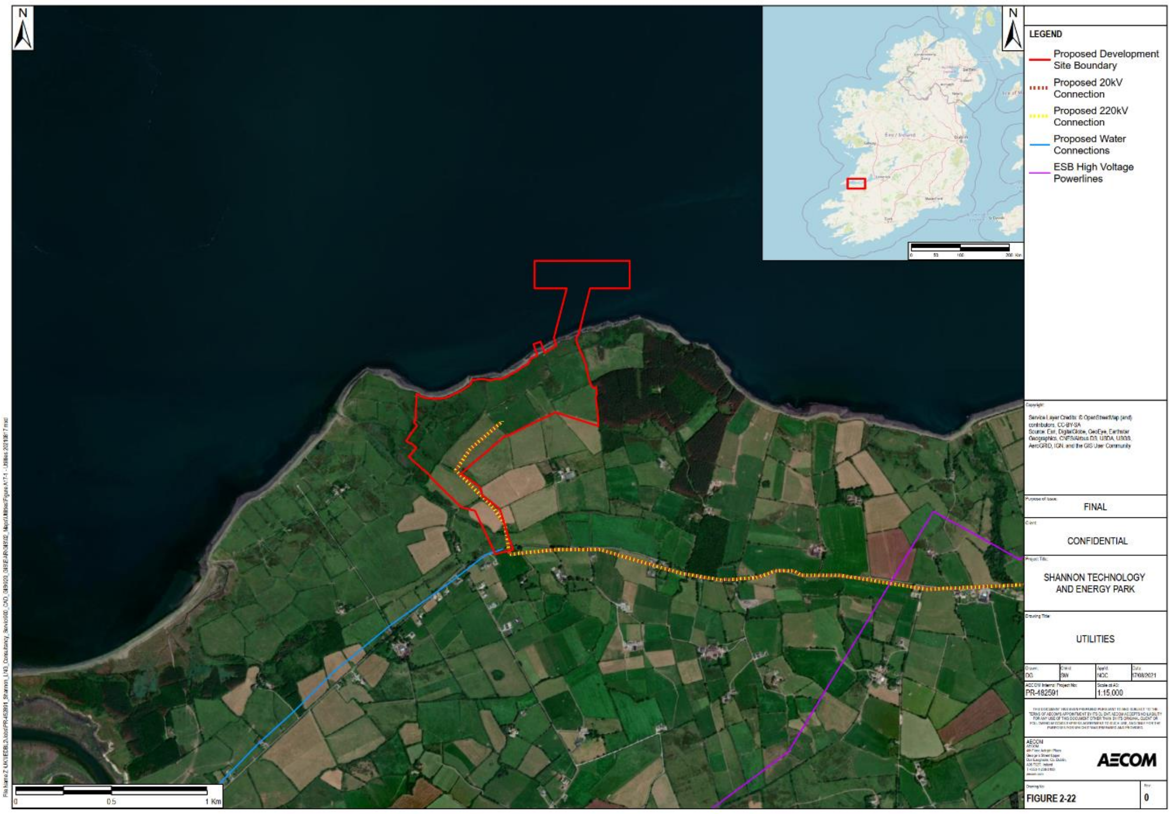


Figure 2-22 Proposed Electrical and Water Connections

In addition, the fire water supply will come from the potable water supply system and will be stored onsite in two separate firewater tanks.

Water will be supplied to the vessels via portside hose connections and/ or tankers and stored onboard in potable water tanks. Freshwater will be subject to further treatment onboard before is it used for human consumption.

2.4.6.3 Telecommunications

The Proposed Development will require a connection to a broadband network. It is anticipated that it will be serviced by a new fibre cable which will be supplied via a new duct under the widened L1010 road. The installation of telecommunication utilities does not form part of the scope of the EIAR.

2.4.7 Drainage

2.4.7.1 Stormwater and Surface Water Drainage

It is proposed that stormwater from all paved and impermeable areas covering approximately 14 hectares) within the Proposed Development site boundary will be collected and discharged directly to the Shannon Estuary via a discharge pipe with an outfall located 5 m beyond the low water mark at a water depth of approximately 2.4 m. See Figure F2-6, Vol. 3 for an overview of proposed drainage at the site.

Impermeable areas include the following:

- Heater Building, nitrogen compressor building, regulator building, electrical substations, heat exchangers, administration and security buildings;
- Laydown and car parking area;
- Access road, jetty road and footpaths;
- Lined outfall; and
- A percentage of the side slope and landscaping areas.

A surface water drainage network comprising piped drainage and swales/ catch basins will be constructed to collect, convey, and attenuate the surface water runoff generated.

All stormwater collected from paved and impermeable areas will pass through an attenuation system including a class 1 hydrocarbon interceptor prior to discharge to the Shannon Estuary via the outfall pipe located 5mm offshore in a water depth of approximately 2.4m. The stormwater discharge rate has been calculated at 162 L/s/ha. Stormwater collected from roof drains and permeable areas will discharge directly to the Shannon Estuary via the final discharge monitoring station. All bunded areas within the Proposed Development site will have valved discharge points as part of their connection to the drainage network.

Groundwater seepages from springs or at the toe of cut slopes will be collected via a groundwater drainage network which will then discharge directly to the Shannon Estuary via the same discharge outfall pipe as the surface water.

Silt traps will be incorporated in all groundwater drainage points prior to discharge.

During the operational phase, all drainage from the Proposed Development site will be controlled and monitored in compliance with the terms of the IE licence.

Details of discharge mitigation measures are presented in the Outline Construction Environmental Management Plan (OCEMP) prepared as part of this application (Appendix A2-4, Vol. 4).

2.4.7.2 Sewerage Drainage System

In the LNG Terminal, sewerage effluent (foul water) will be generated at four locations onsite:

- The workshop/ warehouse building;
- The nitrogen generation package control building;
- The main control building; and
- The AGI Control and Instrumentation Building.

In the Power Plant, sanitary effluent (foul water) will be generated at the following locations on the Proposed Development site:

- The administration building;
- Central control/ operations building;
- Workshop/ stores/ canteen building; and
- Each turbine hall.

All sanitary effluent from the Proposed Development will be transferred to the dedicated onsite wastewater treatment plant (WWTP) which will treat the wastewater using a biological Wastewater Treatment System prior to discharge to the Shannon Estuary via the storm water outfall pipe. The WWTP will be designed to treat wastewater for up to 67 personnel, which is the maximum number of staff anticipated to be onsite during normal working hours (excluding the FSRU and tug staff). An average flow of 0.4 L/s (34.5 m^3/day) is expected to be discharged from the WWTP.

Figure 2-23 provides an overview of the treatment process. The treated wastewater will be monitored for compliance with the IE licence limits prior to discharge and will be continuously monitored for pH before discharging to the estuary. The automatic control system associated with the WWTP will sound an alarm if pH falls outside of expected range. This will alert the operator to take corrective action to remedy the problem. If the problem continues to go outside the pre-set range, this will automatically close the discharge valve and effluent will be diverted to a holding tank.

Table 2-7 summarises the characteristics of the WWTP discharge.

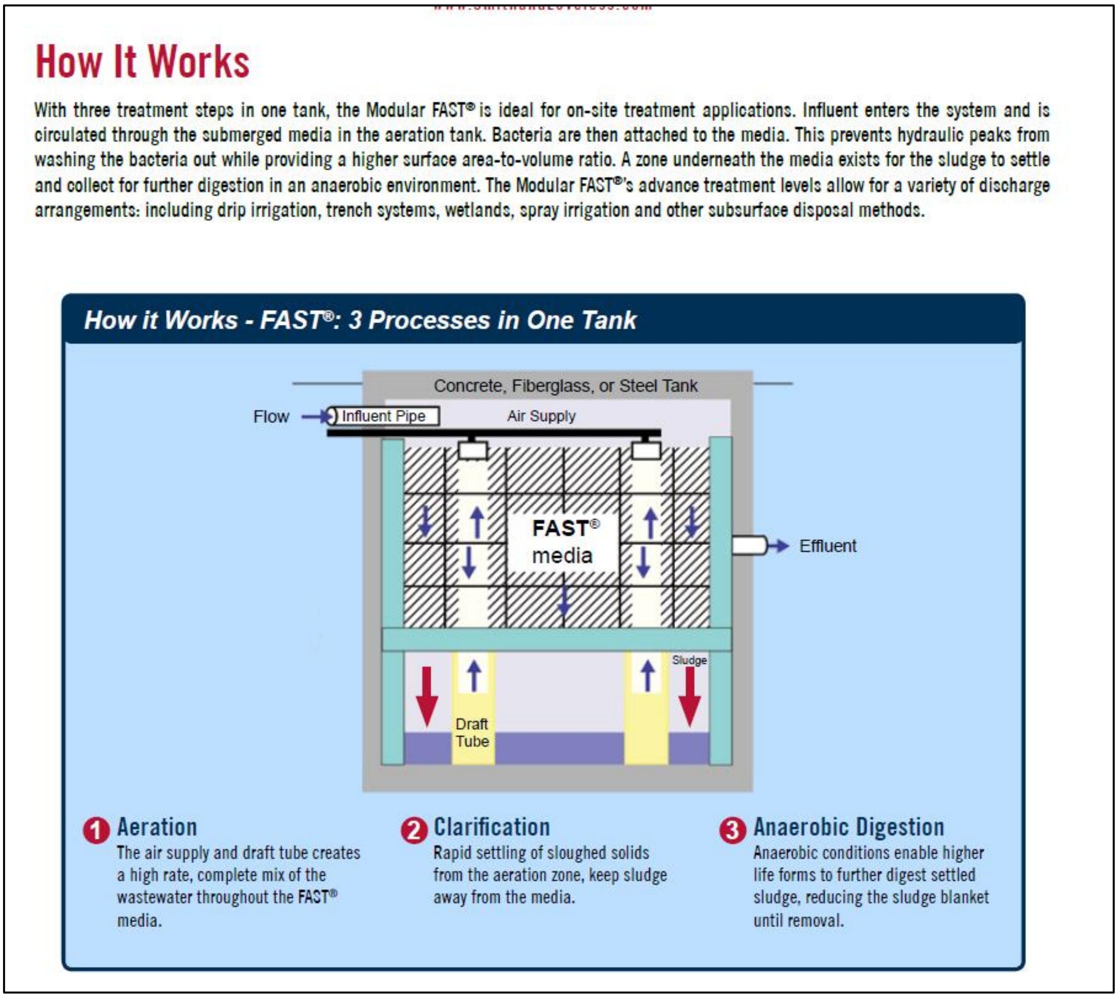


Figure 2-23 Overview of Proposed Wastewater Treatment System

Table 2-7 Characteristic of Wastewater Treatment Plant Discharge

Parameter	Discharge Limit Value
Volume	35 m^3/day
pH	6 – 10
BOD	25 mg/l
Suspended Solids	35 mg/l
Ammonia	5 mg/l as N
Total Phosphorous	2 mg/l as N

All sanitary effluent from the FSRU will be retained onboard and pumped to a vacuum lorry for transfer to a licensed waste facility. Table 2-8 provides estimated of expected operational waste quantities from onshore operations, the FSRU, tugs and potentially from visiting LNGCs.

Table 2-8 Estimated Waste Quantities

Waste Type	Waste Classification	Quantity per Year (m^3)	Potential Waste Management Route
Galley waste (garbage from FSRU, tugs and LNG carriers)	Non-hazardous	240	In accordance with MARPOL Annex V requirements, when in port waste all waste will be stored in suitable containers onboard. Periodically this will be transferred to shore and taken to a licensed waste

Waste Type	Waste Classification	Quantity per Year (m^3)	Potential Waste Management Route
			management site by a licensed waste contractor. Waste from visiting LNG carriers will be managed as International Catering Waste and securely transferred to a designated and licensed disposal site. Source segregation of recyclables (e.g. paper/ card, plastics, metal & glass) for non-ICW
General office waste from onshore activities	Non-hazardous	50	Source segregation of recyclables (e.g. paper/ card, plastics, metal & glass) Residual waste transported to licensed waste treatment facility (landfill or energy-from-waste)
Oily waste (waste from FSRU, tugs and LNG carriers, e.g. sludges from oil water separators)	Hazardous	900	In accordance with MARPOL Annex I the material will be transferred to shore to a licensed waste contractor for management or disposal at a licensed site.
Hazardous materials, e.g. chemicals from FSRU, LNG Terminal and CCGT	Hazardous	10	Export to hazardous waste management facility for recycling/ recovery or high-temperature incineration – delivery to an approved reception facility offshore
Sanitary waste from site washrooms	Not applicable (not subject to Waste Framework Directive)	Faecal wastewater ('black water'): 270 m^3 Other sanitary wastewater ('grey water'): 2430 m^3	Treated by onsite wastewater treatment plant (WWTP) and discharged.

2.4.7.3 Firewater Retention

A firewater retention pond is included in the Proposed Development and sized according to Environmental Protection Agency (EPA) Guidance on Retention Requirements for Firewater Runoff, as the most effective and suitable measure for retaining firewater. The retention pond will be rendered impermeable by use of an appropriate liner, and integrity-tested in line with the requirements of the site's licence. All drainage will pass through the retention pond. An automatic shut-off valve linked to the site's fire detection system will be installed on the drainage outlet point.

2.5 Discharges and Emissions

2.5.1 Power Plant: Process Effluent Collection System and Sump

The Power Plant will generate several process water effluent streams. Some of the effluent streams will be collected and transported offsite to a licensed facility and the remaining effluent streams will be pumped or fall by gravity to the effluent sump. Refer to the water flow diagram below (Figure 2-24).

The wastewater effluent collection will comprise:

- Water treatment process effluent;
- Steam cycle blowdown/ drains;
- Auxiliary boiler blowdown/ drains;
- Turbine hall drains; and
- Gas turbine wash water effluent.

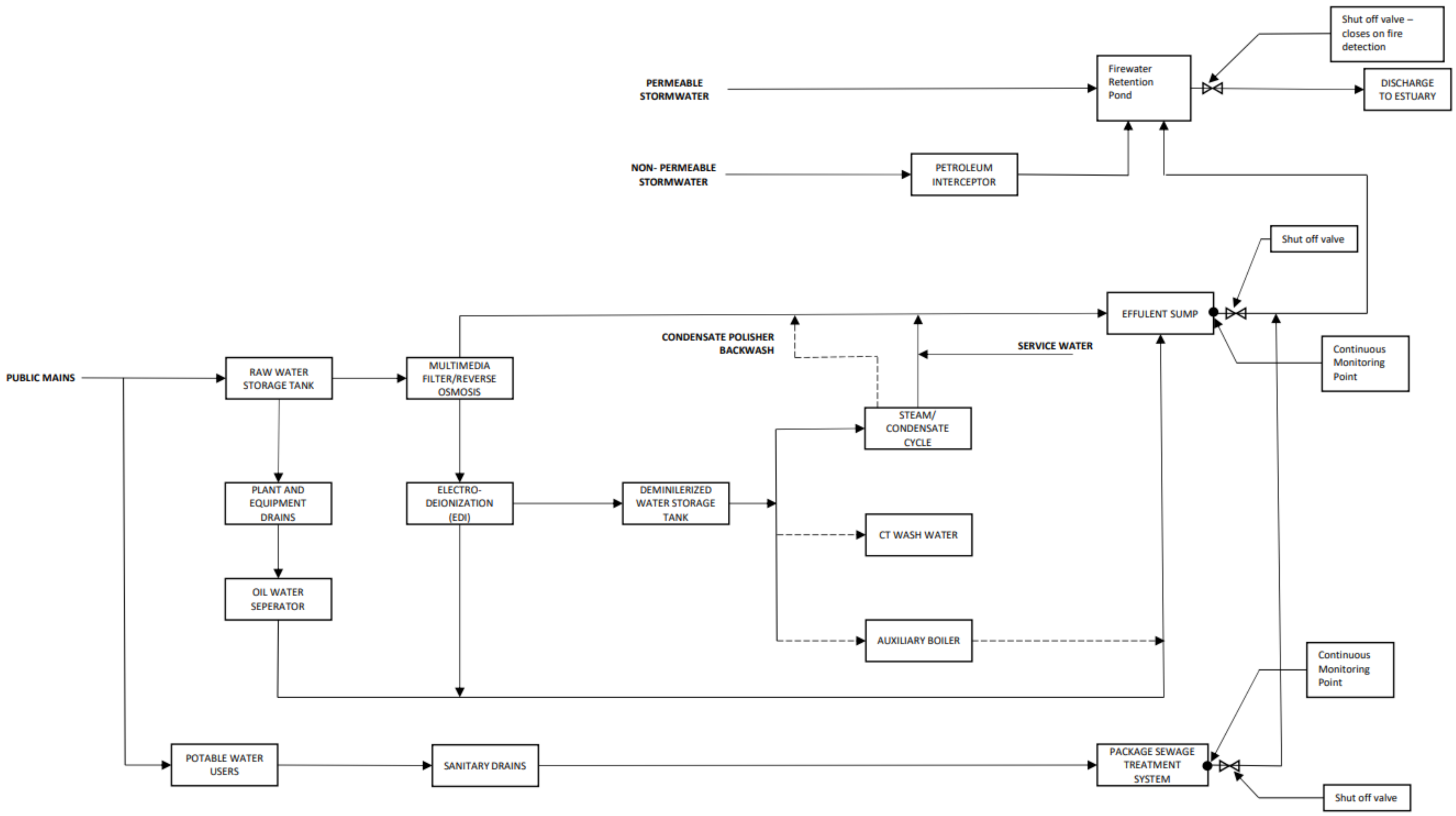


Figure 2-24 Proposed Development Water Flows

2.5.1.1.1 Water Treatment Plant Effluent

A wastewater stream will be produced by the water treatment plant. The effluent streams arising from these activities will contain inorganic dissolved solids as well as negligible traces of dilute solutions of acid, caustic, sodium bisulfite and antiscalant. The water treatment plant effluent will be directed to the effluent sump before discharge into the Shannon Estuary.

2.5.1.1.2 Steam Cycle Blowdown/ Drains

In the case of the Heat Recovery Steam Generator (HRSG), a continuous stream of water approximately 2% of the volume, called blow-down, will be removed from the otherwise closed water systems. It will be necessary to remove this water to maintain the level of dissolved solids in the steam at an acceptable level in order to minimise corrosion and deposition in the boiler water circuits, as well as maintaining steam quality. The boiler water will be dosed to ensure it will stay within the operating limits of the Power Plant. As a result, the blow-down will contain salts and will be alkaline with a pH typically up to 9. The blowdown will be collected in a blowdown tank, cooled with service water to a temperature between 25 °C and 40°C, and then pumped to the effluent sump.

Other intermittent effluent streams from the steam cycle are process steam drains and backwash of the condensate filter. During normal operation, superheated steam from the steam turbine will be sent to the HRSG; however, during start-up and shutdown when the steam piping is heating and cooling the steam will condense and be drained to the process effluent sump via the blowdown tank. There will also be intermittent backwash of the condensate polisher that will be sent to the effluent sump.

2.5.1.1.3 Auxiliary Boiler Blowdown

Similar to the heat recovery steam generator, a continuous stream of water approximately 2% of the volume, called blow-down, will be removed from the auxiliary boiler. It will be necessary to remove this water to maintain the level of dissolved solids in the steam at an acceptable level in order to minimise corrosion and deposition in the boiler water circuits, as well as maintaining steam quality. The boiler water will be dosed to ensure it will stay within the operating limits of the Power Plant. As a result, the blow-down will contain salts wthi a typical up to 9 (i.e. alkaline). The blowdown will be quenched with service water to a temperature of approximately 60° C and pumped to the effluent sump.

2.5.1.1.4 Drain Down of Feed Water and Heat Recovery Steam Generator System

During maintenance it may be necessary to drain the feed water and HRSG or auxiliary boiler systems and dispose of the water contained within these systems. This water will be sent to the effluent sump.

2.5.1.1.5 Turbine Hall Floor Drains

There will be floor drains in the turbine hall to collect water from floor washing and process equipment. The effluent from the floor drains will be collected and sent through an oily water separator. The water discharged from the separator will be sent to the effluent sump. The oily waste will be collected and removed offsite to an appropriate waste licensed facility.

2.5.1.1.6 Other Process Liquid Wastes

There will be other liquid wastes from the process equipment that will not be sent to the effluent sump but will be collected and removed offsite to an appropriate waste licensed facility. These other waste streams are as noted below:

- Gas turbine water wash – Collected in wash water tanks one per CTG (~2 m^3 each);
- Closed cycle cooling water system drain down – Collected by tanker truck or frac tank; and
- Sludges from petroleum interceptors – Collected in situ.

2.5.1.1.7 Outfall Discharge to Estuary

Process water effluent leaving the effluent sump will be continuously monitored for pH before discharging to the estuary. The automatic control system associated with the effluent sump will sound an alarm if the pH goes outside a pre-set range – typically 6 to 10. This will alert the operator to take corrective action to remedy the problem. If the pH continues to go outside the pre-set range, this will automatically close the discharge valve and open the associated re-circulation valve and will then start the re-circulation process during which period the sump will be dosed with either acid or caustic soda to return the pH to between 7 and 8. At this stage the automatic discharge valve will re-open and the re-circulation valve will close.

Regular visual checks will be undertaken for oils and greases in the sump to ensure that the discharge will be free of these contaminants before discharge.

The process effluent in the sump will be monitored for compliance with the IE licence limits and then discharged, via the storm water outfall pipe, to the Shannon Estuary. See Chapter 06 – Water for more details.

Table 2-9 below summarises the process effluents generated from the Power Plant and provides estimated quantities.

Table 2-9 Estimate of Water Discharges from Power Plant

System	Source	Characteristics	Monitoring	Rate
Boiler water treatment plant	Filter effluent. Effluent from treatment plant stages and back wash/ regeneration/ concentrate as appropriate to system installed.	High/ Low pH prior to treatment. Negligible traces of salt, dilute solution acid, caustic, sodium bisulfite and anti scalant. Effluent treated to give a pH at outlet of 6-9.	Effluent sump. Monitoring of pH and visual checks of oil and grease contamination	8.6
HRSG and Auxiliary Boiler blowdown	Outlet from blowdown vessel via a cooler. Water from drain header.	High purity water with traces of ammonia, and phosphate. pH 6 to 9. Temperature about 60°C. Trace salt in the form trisodium phosphate 5-6 ppm and silica 3-5 ppm, BOD 20 mg/l.	Effluent sump	14
Drain down of plant	Occurs during maintenance when necessary to drain feedwater and HRSG system.	High purity water with traces of ammonia, and phosphate.	Effluent sump	Maintenance activity
Turbine hall floor drains	Wash down of floor drains and equipment process drains form turbine hall.	Traces of oil.	Removed offsite for disposal at licensed facility, approximately once per year	0.03
Gas turbine washing	At intervals it is necessary to wash the gas turbine compressor blades.	Traces of oil detergent.	Removed offsite for disposal at licensed facility	N/A
Drain down of closed cooling water system	Occurs during maintenance of these systems (based upon operating hours, typically 2-3 years).	High purity water containing traces of sodium molybdate.	Removed offsite for disposal at licensed facility	N/A
Disposal of Oil	Various (bunds, site interceptors, oil/ water interceptor).	Oil and sludge.	Removed offsite for disposal at licensed facility, approximately once per year	N/A

Table 2-10 summarises the characteristics of the process effluent discharge.

Table 2-10 Characteristic of Process Effluent Discharge

Parameter	Typical Range of Emissions (min to max)
Maximum flow rate	774 m^3/day
pH	6 – 9
Temperature range	40°C
BOD	20 mg/l
Suspended Solids	30 mg/l
Total Dissolved Solids	5000 mg/l
Mineral Oil	20 mg/l
Total Ammonia (as N)	5 mg/l
Total Phosphorous (as P)	5 mg/l

2.5.2 LNG Terminal

Liquid waste from the FSRU, tugs and LNGCs is expected to total 240m^3 per year. When in port all waste will be stored in suitable containers onboard and periodically transferred to shore to be taken to a licensed waste management site by a licensed waste contractor. Waste from visiting LNG carriers will be managed as International Catering Waste and securely transferred to a designated and licensed disposal site.

All sanitary effluent from the FSRU and tugs will be retained onboard and transferred to via vacuum lorry to a licensed facility. Emissions of water from the FSRU are included in the total waste quantities above.

2.5.3 Air and Noise Emissions

During its operation, the Proposed Development will produce air and noise emissions from a number of different sources.

2.5.3.1 Noise Emissions

The operation of the Proposed Development will include a number of noise emission sources as outlined below:

- Noise generating mechanical plant associated with the Power Plant and LNG Terminal including Air Intake Filter House and Generator Cooling Outlet (air cooled);
- Three CTGs to be installed within the LNG Terminal (two operational and one back up);
- FSRU and LNGC equipment; and
- Tugs engines and generators.

In addition, there are noise sources which will operate intermittently. These intermittent sources are:

- Firewater Pumps;
- Firewater Jockey Pumps; and
- Black Start Diesel Generator.

Noise generating plant associated with the AGI will comprises the following:

- Odorant New Blend Pump Unit;
- Package Boiler Units;
- Gas Fired Generator; and
- Pressure Regulating Stream.

The noise levels from the aforementioned sources are outlined in Chapter 09 – Airborne Noise and Groundborne Vibration (both for the construction and operational phases). A list of construction vehicles and plant is provided in Appendix A2-7, Vol. 4.

2.5.3.2 Air Emissions

The operation of the Proposed Development will include a number of sources with emissions to air associated with combustion plant, to generate heat and power for onsite activity. Emissions to air associated with such plant vary with the type of plant and its purpose, the thermal capacity of the plant and the fuel used to enable combustion.

Natural gas will be the primary fuel source for all non-emergency plant at the Proposed Development site. Emissions from natural gas-fired plant predominantly include the pollutants NO_X and CO but may also include other pollutants to a lesser extent for some sources, including THC, some of which will comprise of VOC, including CH_2O.

Liquid fuel will also be utilised. Onshore, this fuel is limited to generators that will only ever be operational in the event of an emergency and for limited periods of testing and maintenance[5]. Offshore, liquid fuel is required as the pilot fuel for the main power engines on the FSRU and the operational facility's tug-boat fleet. Liquid fuel may also be likely as the engine fuel for a small proportion of the LNGCs delivering to the operational facility. Emissions from liquid fuel-fired plant include the same pollutants associated with natural gas, plus PM_{10} and SO_2 (although SO_2 emissions are generally lessened by the use of low and ultra-low sulphur content fuels). The Proposed Development will be operated under the conditions of an Industrial Emissions (IE) Licence, the terms of which will require that any fugitive emissions are controlled at source through appropriate mitigation and monitoring measures, possibly set out as part of an Operational Emissions Management Plan, or a specific Odour Management Plan.

Additional information can be found in Chapter 08 – Air Quality.

2.5.4 Lighting

Down angle lighting will be installed with the Proposed Development site to illuminate the LNG Terminal, including the vessel / onshore interface areas to ensure activities can be safely conducted during periods of darkness.The Power Plant will have area lighting installed on a down angle to cover the facility and the car parking areas while minimising impact to surrounding neighbours.

The height of the proposed light columns has been kept to a minimum throughout the Proposed Development site, and light temperatures reviewed to minimise the content of blue light. Light columns will be fitted with focused luminaires to avoid glare, sky glow and light spill to the estuary. Figure F2-7 in Volume 3 present lighting design drawings.

An uninterruptible power supply for emergency lighting shall be provided to allow for safe escape of staff from accessible areas of the plant in the event of a power and essential lighting failure or an emergency.

[5] As noted in Section 2.4.1.7 after consultations between the CRU and the Applicant, the CRU has agreed that the Power Plant does not need to combust liquid fuel to comply with CRU rules on Secondary fuel obligations.

2.6 Site Management

2.6.1 Staffing

Once operational the Proposed Development will employ approximately 101 permanent staff, some of whom will work in shifts as the plant will be operational 24 hours per day for seven days a week. This number excludes the FSRU and tug crews. The maximum number of staff onsite during normal working hours (excluding the FSRU and tug staff) is anticipated to total 67 employees. Additional contract staff and service personnel will be utilised as needed. The LNG Terminal and the Power Plant will be operated with integrated staffing. Personnel will perform the following functions:

- Management and administration;
- Operations;
- Maintenance;
- Marine operations;
- Health, Safety, Security and Environment;
- Finance and accounting; and
- Sales and marketing.

Managerial staff will be experienced personnel from the energy industry. Apart from the FSRU complement of approximately 35 crew members, who will be international marine crew employed by the Ship's operator, operations, maintenance and support personnel employed for the Proposed Development will be recruited locally to the extent possible. Staff will be given extensive training which will include in-plant training or experience in another operating LNG facility or Power Plant. All key personnel to work on the LNG Terminal will be trained in the properties of LNG and natural gas, , proper operation of all equipment, workplace safety and incident response, including leaks, spills, and fires.

The Applicant will operate and maintain the LNG Terminal and the Power Plant to meet or exceed all applicable European Union and Irish employment regulations and requirements. The Applicant will prepare, maintain and update a comprehensive set of operations, maintenance, safety, and emergency response manuals for the combined operations. All operations and maintenance personnel will be trained in accordance with the procedures in these manuals.

Maintenance staff will carry out routine inspections, maintenance, and repairs, as well as major equipment overhauls, where applicable. Certain major overhauls and maintenance will be handled by contract maintenance personnel. Security personnel, pilots, tug and mooring personnel, and catering/ cleaning personnel will be provided by third parties. Warehouse personnel are anticipated to be contract staff.

After the start of operations, operating and maintenance personnel will be involved in ongoing safety, operating, and maintenance training. Operating, maintenance, and emergency response procedures and manuals will be subject to regular review and will be updated to reflect best industry practices, or to reflect the addition of new procedures, equipment or other facilities at the Terminal and Power Plant.

2.6.1.1 Liquid Natural Gas Terminal

The LNG Terminal will be designed to operate 24 hours per day using a rotating shift schedule. The actual shift schedule has yet to be determined; however, it is anticipated that the following manpower levels will be provided.

It is anticipated the FSRU will have up to 35 crew onboard. This will include a Master, 4 deck officers, Cargo engineer, Chief Engineer and 4 engineering officers. The remainder of the crew will be working on deck, in the engine room, LNG process and in catering. The crew typically work on 3- or 6-months rotation, i.e. the officers and supervisory staff work 3 months on and 3 months off, while the remainder of the crew typically work 6 months onboard and 6 months off. When onboard, the crew normally work a 12-hour shift pattern, and they will be stay onboard for the duration for their rotation except when granted shore leave.

The majority of the crew members on the FSRU are anticipated to originate outside of Ireland, and crew changes will be managed by the Ship's Operator, who will make available suitable transport for the crew to travel to and from Shannon or Dublin Airports as required for journeys to and from their homes countries. Appropriate Covid-19 protocols will be in place and adhered to at all times.

The tugs will normally have a working crew of 4 onboard. One of the tugs will be fully mobilised at all times, and a full complement of crew will be onboard for immediate response. A second tug's crew will be on call for immediate callout and must be ready to be onboard within 30 minutes of being called. Crews for tugs 3 and 4 will be available on 2-hours' notice.

The onshore receiving facility and jetty are anticipated to have approximately 20 personnel working during the day (09:00 – 17:30). In addition, there will be 5 shifts of 3 staff working on a 24-hr shift pattern as follows: (08:00 – 16:00), (16:00 – 00:00) and (00:00 – 08:00).

2.6.1.2 Power Plant

The Power Plant is designed to operate 24 hours a day using a rotating shift schedule. It is anticipated that a total of 34 staff will be required for the operation of the Power Plant, as follows:

- 26 day staff (08:30 – 17:00); and
- 40 shift staff – 5 shifts of 8 employees.

Additional contract staff and service personnel will be engaged in the Power Plant as needed.

2.6.1.3 Above Ground Installation

The AGI is a normally unmanned facility, operated by GNI. GNI personnel will visit the AGI as and when required for inspection and maintenance purposes.

2.6.1.4 Training

The Proposed Development, through its training regime, will ensure every employee is aware of his/ her responsibility to work safely, adhere to safety rules and work procedures, use safety equipment provided, is environmentally responsible, and play an active role in the Proposed Development's drive for continual improvement in health, safety and environmental (HSE) performance.

Pre-operational training and regular refresher courses, using simulators, will be undertaken, involving all relevant parties, including SFPA, KCC's Fire Department and the Proposed Development employees.

2.6.1.4.1 LNGC and FSRU Emergency Response and Crew Training

The IMO has developed standards for the design and construction for all classes of ships. These standards, published as specific codes, govern design, materials, construction, equipment, operation and training, and include a code covering 'Ships Carrying Liquefied Gases in Bulk' with specific reference to LNG.

Safety and crew training are addressed in IMO Conventions such as Safety of Life at Sea (SOLAS) and Standards of Training, Certification & Watchkeeping for Seafarers (STCW). These are further supplemented by any additional training provided by the vessel owner/ operator over and above statutory requirements.

The FSRU and arriving LNG Ships will be self-sufficient in their fire detection and fire-fighting capability. All FSRU and LNG ship crew members will have completed extensive training in dealing with shipboard fire response as is required under SOLAS and STCW.

IMO codes covering LNG Ships require them to have fire detection and firefighting equipment in excess of that required by conventional shipping. In addition to the gas detection systems surrounding the LNG cargo containment, there will be gas detectors in compressor rooms, motor rooms, the main engine room and accommodation areas. Heat and/ or fire detectors will be located at cargo tank domes, at the cargo transfer manifolds, in the main engine room and in accommodation spaces.

Conventional firewater mains and hydrants will be supplemented by a self-contained dry chemical powder system covering all cargo areas with a combination of fixed and hand-held monitors. The LNG ships will also be fitted with a water deluge system for fire prevention, or in the rare event of fire, for cooling the LNG ship structure and for crew protection. The deluge system will cover all cargo domes, cargo transfer manifolds and all deck houses and the super structure, accommodation block facing the cargo area. The pumps and valves can be operated remotely, and the system capacity is capable of deluging the accommodation and cargo areas simultaneously.

Sufficient quantities of personal protective equipment (PPE) will be carried in the form of self-contained breathing apparatus, fireman suits and protective suits to permit personnel to enter a cold gas atmosphere. All LNG ship crew members will receive extensive training in fighting shipboard fires as is mandated under IMO codes, flag state requirements and owner's response plans. In addition to monthly drills onboard the vessel, the vessel will also participate in terminal drills covering such areas as gas release, pool fire, electrical fire, confined space extraction.

2.6.1.4.2 Tugs Emergency Response

The firefighting capabilities required of the tugs will be as a minimum that they be equipped to FiFi 1 Class standard. The class notation FiFi 1 means that the tug is equipped with a minimum of 2 fire monitors, which will be able to throw water to a minimum distance of 120 m from the vessel and to a height of minimum 45 m. The monitors will be controlled remotely from the wheelhouse of the tug.

2.7 Process Control and Monitoring

2.7.1 LNG Terminal

The process and utility systems will be automated to support centralised monitoring and operations. Local controls to start, stop, or adjust instrumentation setpoints will be provided where local operations are desired. All actions will be under the supervision of the MCR operations staff. All critical process operations will be monitored and recorded. An integrated control and safety system (ICSS) will be provided. It is anticipated that some process equipment will operate with its own distributed control system hardware and software which will be integrated into the overall ICSS and is discussed in the following section. Refer to Section 2.5 for more information on emissions from the Proposed Development.

2.7.1.1 Integrated Control and Safety System

The ICSS will be a distributed control system that will provide process control, fire and gas detection, event logging, and emergency shutdown (ESD) functions. The functions will be fully integrated and standardised hardware and software will be utilised throughout the system as far as possible. The system is intended to minimise the need for communication gateways or bridges between software systems, thus improving the system reliability and increasing operational flexibility.

The equipment chosen will be well proven but of an up-to-date design.

The primary objective in the design of the ICSS is to provide high reliability and availability. The system will provide safe, efficient and reliable equipment of proven design. The system will use current technology with modern diagnostic capability to increase failure reporting and reduce maintenance requirements.

Dual redundant architecture will be used to avoid common mode failure points and increase availability.

The ICSS should comprise the following sub-systems:

- Process Control System (PCS);
- Process Safety System (PSS);
- ESD; and
- Fire and Gas System (FGS).

The PCS will function to produce on specification product. It will automatically correct disturbances caused by changing process conditions. The safety system is mainly composed of the ESD, FGS and PSS.

Unsafe process and operational conditions in any part of Terminal can be detected and will activate the FGS, PSS and/ or ESD, systems accordingly. The FGS, PSS and/ or ESD, system will provide a controlled shutdown of the facilities. The shutdown system could be initiated manually or automatically. The ESD will provide a reliable response to the process and fire and gas detection systems and will take the necessary executive action to avoid escalation of the event.

2.7.1.2 Alarm Management Overview

The alarm system will form an essential part of the operator interface with the ICSS. Within the alarm management framework determining the roles and responsibilities of facility operations and maintenance support personnel is paramount to ensuring that the alarm system is operated, managed and improved to obtain optimum plant efficiency through the management of abnormal conditions. The alarm system will provide vital support to the operators managing complex systems by warning them of situations that need their attention. The alarm system warns the operator that the process is moving from a Normal to an Abnormal state.

To prevent alarm flooding a robust method of alarm management and rationalisation is required. Each alarm must alert, inform and guide the operator. The information presented to the operator will, where possible, present an indication of what has gone wrong and why it may have occurred. Each configured alarm will be unambiguous and not duplicated by other alarms. Sufficient time should be allowed for the operator to analyse the situation and carry out the defined response. Operator response time includes the time to diagnose the problem and perform the corrective actions (such as shutdown). Alarm documentation and rationalisation is a consistent, logical process used to identify, prioritise and document alarms. The objective of alarm rationalisation is to create an alarm system with the correct number of alarm activations (not necessarily fewer configured alarms) and acceptable alarm rates. All changes to the alarm system must be controlled by management of change procedures. Testing and training of operators will be carried out at the implementation stage of the alarm lifecycle and continue to be performed throughout the life of the asset.

2.7.1.3 Jetty

Active and passive fire protection will be installed on the jetty including a firewater ring main to provide firefighting capability at the jetty. The firewater will have the function of providing protection from incident thermal radiation and for cooling equipment purposes. This will include the following:

- Firewater curtain to enable personnel to escape via gangway tower and/ or trestle;
- Jetty firewater curtain to reduce incident thermal radiation on the FSRU hull;
- Elevated firewater monitor(s) to provide sufficient cooling water coverage to the GLAs and/ or FSRU manifolds;
- Firewater coverage of piping for cooling purposes; and
- Onshore fire pumps with remote and local start/ stop functionality, each capable of delivering full cooling of the pierhead area and the hull of the FSRU.

The firewater system will have a capacity of approximately 800 m^3/hr. Additional information on fire safety policies and procedures can be found in Section 2.8.1.

2.7.2 Power Plant

The Power Plant will be monitored and controlled from the central control/ operations building. This building will include a control room, meeting room and offices for the operations personnel stationed at the Power Plant.

2.7.3 Above Ground Installation

The AGI, which is normally unmanned, is operated and controlled from GNI's central control system. Personnel at the LNG Terminal will be in frequent contact with GNI, who through nomination determine the offtake rate of gas from the LNG Terminal. Refer to Figure 2-16 for the proposed AGI layout and Section 2.4.2.6 for a description of components that will be included in the AGI.

2.8 Health, Safety and Environmental Aspects

The Applicant recognises and accepts its moral and legal responsibilities for ensuring the health, safety and welfare of its employees, contractors, visitors and members of the public who could be affected by its activities; it is committed to compliance with all applicable Irish health, safety and environmental laws and regulations.

The Directors and Senior Management of the Proposed Development have overall responsibility for the implementation of its HSE policies. These policies will be reviewed periodically to ensure that they remain relevant and appropriate to the Proposed Development's operations and business.

The Applicant will implement a HSE Management System, which will include setting of objectives and targets, measuring progress, reporting results as a commitment for continual improvement, and fostering a culture where incidents are reported and investigated and lessons learned are shared through the organisation. It will use regular audits to ensure its controls are effective. It will provide appropriate health, safety and environment training and guidelines to employees and contractors to enable them to meet the required standards of performance.

The Applicant aims to minimise the health, safety and environmental impacts of its activities and prevent pollution by utilising a structured risk management approach, which includes emergency preparedness and contingency planning. All new activities will be assessed for environmental impact and appropriate health and safety provision, and ongoing activities will be subject to periodic review. Health, safety and environmental protection will be given equal priority to the business objectives of the company.

The Applicant is committed to effective communication and consultation on health, safety and environmental matters with all interested parties and will make its policies available to them subject to appropriate privacy and business confidentiality protections. The Applicant will routinely monitor, assess and report on its health, safety and environmental performance with data on the rate of lost time injuries and occupational injuries. Fire and gas detection systems and associated alarm processes are summarised in Sections 2.7.1.1 and 2.7.1.2 above.

The Applicant will ensure that operating, maintenance, and emergency response procedures and manuals will be subject to regular review and will be updated to reflect best industry practice, or to reflect the addition of new procedures, equipment or other facilities.

2.8.1 Internal Fire and Rescue Plan

Safety is the main consideration in the Proposed Development design. The main fire hazards on the Proposed Development are identified from the quantitative risk assessment (QRA), which was undertaken by Vysus (previously Lloyds Register) for the Proposed Development on behalf of the Applicant (Appendix A2-5, Vol. 4). The QRA includes hydrocarbon flash fires, jet fires and pool fires. To limit the consequences of fire scenarios and to cope with any potential domino effects, the Proposed Development will be partitioned into fire zones, which are areas within the installation where equipment is grouped by nature and/ or homogeneous level of risk attached to them. The partition of an installation into fire zones will result in a significant reduction of the level of risk. The consequences of a fire, flammable gas leak or an explosion corresponding to the credible event likely to occur in the concerned fire zone shall not impact other fire zones.

In order to mitigate or control these hazards, the proposed ESD coupled with the PCS and the FGS, are crucial to ensure the safety of the plant. Should there be a loss of containment and/ or subsequent fire, the FGS will activate. The potential hydrocarbon release to be detected is a clean non-toxic single-phase gas in a well-ventilated area. On confirmed FGS detection, the active fire protection system will operate. A voting logic will be implemented to avoid spurious trips.

The fire hazards associated with the Proposed Development will be mitigated by the use of passive and active fire protection. Passive fire protection (PFP) is aimed to protect personnel and ensure that escape, evacuation and rescue (EER) systems can enable safe evacuation in all scenarios linked to hydrocarbon fire hazards at the Proposed Development site. PFP is mandatory on equipment and structures that could be exposed to a fire that could lead to loss of integrity.

Active fire protection (AFP) aims to control fires and limit escalation, reduce the effects of a fire to enable personnel to undertake emergency response actions or to evacuate, extinguish the fire where it is considered safe to do so, and limit damage to structures and equipment. The AFP equipment at the Proposed Development site will include a combination of:

- Fire water mains network, with hydrants and monitors;
- Water spray systems;
- Water curtains/ hydro shields;

- Portable dry chemical powder systems;
- Firefighting vehicle(s); and
- Portable/ mobile fire extinguishers.

An appropriate firefighting and rescue trained crew will be available/ provided onsite and ready at all times. Employees will be trained in all emergency response actions including natural gas leak and fire situations. Fire safety certificates will be required from the Chief Fire Officer of KCC prior to construction of the facility for each building on the site. The plant shall be operated in a safe and efficient manner compliant with national health and safety legislation.

The activation of firefighting equipment could be manual by push buttons located locally or control room to initiate extinguishing agent, or automatically through the FGS.

The jetty with the FSRU moored will contain primary and secondary escape routes. The primary escape route connects the jetty area via the trestle to the jetty landfall area where a muster point will be located. The jetty primary escape route also interfaces with the FSRU which has its own muster area, temporary refuge (TR), embarkation area or means of escape to the sea.

The primary route will have sufficient lighting along the jetty, floor painted markings (yellow/ black zebra lines), an anti-slip coating, illuminated signs (white with a green background) to identify the muster point which will be located at the jetty landfall, illuminated signs (white with a green background) to identify the escape route(s), a plan of the escape route(s) on the jetty, and life buoys along the escape route(s), etc.

For the onshore installation, the onshore primary escape route will lead to the muster area(s). The onshore secondary escape routes or paths from modules/ locations outside the main fire zones will lead personnel to the primary escape route. An alternative muster point will be provided for should access to the main muster point be impaired. Muster areas are safe places where all personnel normally muster while investigations, emergency response and evacuation pre-planning are undertaken. The main functions of the mustering are to protect personnel, to number and identify personnel, to provide first aid, and to provide information.

An emergency plan will be drawn up in consultation with the port authority, fire brigade, gardai, etc., and shall integrate with any other relevant plans, such as the port emergency plan. The plan will include as a minimum:

- The specific action to be taken by those at the location of the emergency to raise the alarm;
- Initial action to contain and overcome the incident;
- Procedures to be followed in mobilising the resources of the LNG Terminal, as required by the incident;
- Evacuation procedures;
- Assembly points;
- Emergency organisation, including specific roles and responsibilities;
- Communications systems;
- Emergency control centres; and
- Inventory and location of emergency equipment.

The Proposed Development will have an emergency team whose duties include planning, implementing and revising emergency procedures, as well as executing them. The emergency plan, when formulated, will be properly documented in an ‘Emergency Procedures Manual’, which will be available to all personnel whose work relates to the present facilities.

Both vessels – the FSRU and any visiting LNGC – will be advised of the LNG Terminal's emergency plan, as it relates to the ship, particularly the alarm signals, emergency escape routes, and the procedure for a ship to summon assistance, in the event of an emergency onboard.

The tugs will also be designated as firefighting craft, which enables them to supplement the LNG ships and LNG Terminal's firefighting capabilities and to act as an integral part of the overall response team and equipment at the facility.

Article 13 of the Seveso III Directive requires that: '*the objectives of preventing major accidents and limiting the consequences of such accidents for human health and the environment are taken into account in their land-use policies or other relevant policies*'. As reflected in the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. 209 of 2015), this is to be achieved through controls on the siting of new establishments, modifications to existing establishments and new developments in the vicinity of such establishments. The regulations take into account the long term need to maintain appropriate distances between establishments and residential areas, buildings and areas of public use, recreational areas, major transport routes as far as possible, and areas of particular natural sensitivity or interest. Technical advice on the risks from an establishment must be made available to the planning authority. The Planning and Development Regulations 2001 to 2021 specify when planning authorities should seek technical advice in this area and the information that must be supplied to the HSA when seeking the advice.

A quantitative risk assessment (QRA) was undertaken by Vysus (previously Lloyds Register) for the Proposed Development on behalf of the Applicant. The major accident hazards at the establishment were identified. A summary of the major accident scenarios, together with the measures in place to prevent them or mitigate their consequences, is presented in the summary of the QRA.

QRA (Qquantitative Risk Assessment) has been carried out for the purposes of Land Use Planning (LUP) in accordance with draft HSA Technical Land use planning guidance 2021 (HSA, 2021). The land use planning zone boundaries are defined as:

- Zone 1 (inner): within the 1 x 10^{-5} /y individual risk of fatality contour;
- Zone 2 (middle): between the 1 x 10^{-5} /y and 1 x 10^{-6} /y individual risk of fatality contours; and
- Zone 3 (outer): between the 1 x 10^{-6} /y and 1 x 10^{-7} /y individual risk of fatality contours.

The criteria for new establishments are:

- The individual risk of fatality at the nearest residential property should not exceed 1 x 10^{-6} /y; and
- There should be no incompatible land uses existing within any of the three zones.

Details of the QRA study for the establishment will be described in the Predictive Elements section of the Safety Report. QRA provides a quantification of the risks associated with the reasonably foreseeable major accident scenarios identified. The method involves calculating the frequency of a representative range of sizes of releases from equipment using suitable available published data.

The physical consequences of these releases are modelled (e.g. level of thermal radiation), as well as the impact on people, considering a range of weather conditions. This information is combined to give a numerical representation of the risk from the scenarios considered, in terms of 'individual risk' to site workers and members of the public offsite, and also 'societal risk' to the public population as a whole.

The QRA results are compared against tolerability criteria to demonstrate that the risk levels associated with the operations of the LNG Terminal are tolerable. Risk is traditionally defined as the product of a level of harm (severity) and the frequency of that level of harm occurring. Some risks (e.g. personal safety, slips, trips) have a relatively high frequency with low severity; others (e.g. major hydrocarbon fire) have a relatively low frequency with high severity.

Similarly, the level of risk ranges from relatively low to relatively high. At the lower end of the risk spectrum, the risks are comparable with those we are exposed to as part of our everyday activities and, as such, the risk is deemed 'broadly tolerable'. At the opposite end of the risk range, the risk is so high that it cannot be tolerated. Between these two extremes, there is a mid-range of risk values where the risk can be tolerated if it is demonstrated that it has been reduced to a level which is ALARP.

2.8.2 Pollution Mitigation and Response

The risk of marine pollution from the operation of the Proposed Development has been considered and reduced as far as possible. Specifically, the assessment of likelihood and consequences of release events from the Proposed Development are set out in the relevant sections of the following documents:

- Marine Navigation Risk Assessment (see Appendix A2-2, Vol. 4);
- OCEMP (see Appendix A2-4, Vol. 4);
- Quantitative Risk Assessment (QRA, summarised in Section 2.8.1) and associated Major Accidents to the Environment (MATTE) (Appendix A2-5, Vol. 4); and
- Environmental Impact Assessment Report (EIAR) for the Proposed Development (*this Report*).

Additionally, as discussed in Chapter 01 – Introduction, the operation of the Proposed Development will be controlled and regulated by the following bodies:

- Environmental Protection Agency;
- Commission for Regulation of Utilities;
- Health and Safety Authority; and
- Local Planning Authority (KCC).

The Shannon Foynes Port Company has statutory jurisdiction over marine activities, as detailed in Chapter 01 – Introduction.

In consultation with Shannon Foynes Port Company and the Shannon Estuary Anti-Pollution Team (SEAPT), Shannon LNG Limited has prepared an Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework for the Proposed Development. This document describes the framework in which Shannon LNG Limited will develop plans to provide a graduated, tiered and coordinated response to release incidents in the unlikely event they should occur. The developed plans will follow international best practice guidelines of the International Maritime Organization (IMO), The Society of International Gas Tanker and Terminal Operators (SIGTTO), and International Petroleum Industry Environmental Conservation Association (IPIECA) while taking into account relevant Irish legislative and regulatory approval requirements. In particular the plans will follow the requirements made within the National Maritime Contingency Plan Oil and HNS Spills 2019 (National Contingency Plan, NCP) and the National Framework for the Management of Major Emergencies. The plans will be developed to cover both In-Land (onshore) and Marine based releases and shall cover the Construction and Operational Phases of the project.

2.8.2.1 The Shannon Estuary Anti-Pollution Team (SEAPT)

The Shannon Estuary Anti-Pollution Team (SEAPT) is a Mutual Aid Group and the primary response organisations for oil and HNS spills within the Shannon Estuary. The SEAPT consists of the Shannon Foynes Port company, Kerry, Limerick and Clare Local Authorities and commercial and industrial entities operating within the Shannon Estuary. SEAPT was initiated to form a unified coordinated response to pollution incidents on the Shannon Estuary. SEAPT is a member's organisation. Members contribute annually to maintain equipment, carry out exercises and training and purchase new and replacement equipment. SEAPT holds a significant stockpile of equipment. This equipment is available to respond to any pollution incident or threat thereof. The Proposed Development will also be able to avail of spill dispersion modelling capability held by SEAPT. SEAPT are also the custodians of the Shannon Estuary Oil/ HNS Contingency Plan developed in accordance with the NCP and approved by the Irish Coast Guard. Shannon LNG Limited has consulted extensively with SEAPT and the intention is to join the SEAPT organisation on successfully receiving development consents and prior to commencement of the construction phase. The Proposed Development has (provisional to project go-ahead) been accepted as a member of the Shannon Estuary Anti-Pollution Team (SEAPT). Membership of SEAPT will enable the Proposed Development to interface directly with the approved Shannon Estuary Oil/ HNS Plan and access additional response equipment to augment that held within the LNG Terminal. Through the membership process, the Proposed Development will additionally be contributing to the ongoing development and strengthening of the SEAPT organisation.

2.8.2.2 Incident Response

In accordance with the requirements of the NCP Standard Operation Procedure 05, and the final STEP Oil and HNS Spill Plan, there will be the five operational phases of an incident response:

- Phase 1 – Discovery and Notification, Evaluation, Identification and Activation;
- Phase 2 – Development of an Action Plan;
- Phase 3 – Action Plan Implementation;

- Phase 4 – Response Termination and Demobilisation; and
- Phase 5 – Post Operations, Documentation of Costs/ Litigation.

The Proposed Development will manage the response to any Tier 1 (Local – within the capability of the operator on site) and Tier 2 (Regional – beyond the in-house capability of the operator) incident for any pollution on the water within their area of jurisdiction with the full cooperation and integration of the response with the Shannon Foynes Port, the Shannon Estuary Anti-Pollution Team (SEAPT) mutual aid group which includes the three local authorities of Kerry, Clare and Limerick and other agencies as appropriate. The developed plans will identify realistic Tier 1 and Tier 2 scenarios and the resources required to effectively response to and mitigate these. The plans will further describe any escalation to Tier 3 (requiring national resources) and as discussed above, interface with the National Marine Oil/ HNS Spill Contingency Plan. A training and exercising program forms part of the plans. The completed plans will be submitted to the Irish Coast Guard and EPA for appropriate approvals. Further detail can be found in the Oil and Hazardous and Noxious Substances (HNS) Spill Plan Development Framework for the Proposed Development (Appendix A2-6, Vol. 4). Additional technical guidance can be found in the NCP and annexes.

2.9 Construction Phase

This section describes the construction activities associated with the Proposed Development including the following phases:

- Construction schedule and working hours;
- Enabling, earthworks and site preparation;
- Construction of LNG Terminal, Power Plant and AGI;
- Construction of drainage outfall;
- Utilities;
- Environmental protection measures; and
- OCEMP.

There is no requirement for any additional temporary land take to support the construction phase; all laydown areas will be accommodated within the footprint for the Proposed Development site. The jetty construction will also be within the foreshore lease area.

2.9.1 Construction Schedule

Subject to planning consent and other approvals an arbitrary start date of Jan 2023 is taken as a construction start date (however this is subject to change). The construction programme is anticipated to take 32 months, subject to seasonal and other planning constraints. This is the basis of the impact assessment contained within this EIAR. The whole construction project is broken into 5 sections as per Table 2-11 which gives the outline of construction period for each section.

The above sections provide more detail on the proposed construction works.

Table 2-11 Indicative Construction Schedule

Area	Start On Site	Duration (months)	Completion	Duration From Start Date (Months)
Enabling, Earthworks and Site Preparation	Jan 23	10	Oct 23	10
LNG Terminal	+6 months	12	Jun 24	18

Area	Start On Site	Duration (months)	Completion	Duration From Start Date (Months)
220 kV and medium voltage (10/ 20 kV) connections[6]	+8 months	14	Sep 24	21
CCGT - 2 Blocks	+9 months	21	Jun 25	30
CCGT - 1 Block	+ 11 months	18	Aug 25	32

Note that the LNG Terminal will be constructed as part of the first phase of construction, followed by the Power Plant. An additional period of up to six months will be required for commissioning prior to operation as described in Section 2.10.

The proposed construction manpower and vehicle traffic profile projections based on the dates above are provided in Figure F2-8, Vol. 3.

2.9.2 Working Hours

Excluding the jetty construction works, it is anticipated that normal working hours during the construction phase will be as follows (Table 2-12):

Table 2-12 Working Hours

Start	Finish	Day
07:30	18:00	Monday to Friday
08:00	14:00	Saturday

It is proposed to stagger the various shift starting and ending times within the construction complex (for example civil employees 07:30 – 18:00, or 07:45 – 17:45). This small stagger in shift start and ending times could lessen the impact of traffic peaking.

Construction of the jetty will be undertaken over approximately 15.5 months, on a 24 hour basis, 6 days a week with maintenance works on Sundays. Security arrangements will also be in place full time.

Please see Chapter 07 – Biodiversity for further details.

Other areas of construction may also be required to work outside of these hours to perform certain tasks such as mechanical testing, inspection duties and commissioning. Reasons for working outside the normal hours would include considerations of safety, weather, tides and subcontractor availability. Every effort will be made during the detailed project execution planning to minimise the number and duration of night-time activities. Working outside normal hours will be agreed in advance with KCC.

2.9.3 Enabling, Earthworks and Site Preparation

2.9.3.1 Pre-Construction Environmental Surveys

A pre-construction environmental survey will be undertaken in advance of the enabling works. Following the survey, licences will be sought from the National Parks and Wildlife Service (NPWS), as appropriate. Exclusion works will be carried out in the appropriate season in line with the information presented in Chapter 07 – Biodiversity.

An extensive programme of pre-development licensed archaeological testing will be undertaken in the areas of the site which will be subject to development. Refer to Chapter 14 – Cultural Heritage for more details on archaeological, architectural and cultural heritage. This will include the demolition of a small farm complex and remains associated with a pillbox (see Figure F12-5, Vol. 3 for the location of all

[6] While the 220 kV and medium voltage (10/ 20 kV) connections are outside the Proposed Development, number and traffic from their construction is included in this EIAR. This includes the associated onsite Eirgrid 220 kV and ESBN 20 kV substations.

structures to be demolished). It is anticipated that archaeological survey and investigation works will commence in advance of the main enabling works in accordance with the relevant licenses. Enabling works will only be carried out on areas where archaeological survey and investigation works have been completed.

Prior to the start of works onsite areas to be protected (such as ecologically sensitive habitats or notable trees) will be fenced off to protect from accidental damage.

2.9.3.2 Earthworks and Site Preparation

Enabling, site preparation and earthworks activities are common to the LNG Terminal, Power Plant and ancillary facilities will comprise:

- Construction of safe access and temporary site roads;
- Erection of perimeter and environmental protection fencing;
- Installation of pre earthworks drainage;
- Establishment of the laydown construction area; and
- Earthworks to create level platform at +18 m OD for the main footprint of the development excluding AGI and jetty.

2.9.3.3 Site Access

The contractor will begin by setting out the site entrance as early as possible in the programme consistent with seasonal environmental restrictions and constraints. This operation will begin with the clearance of existing hedgerows and vegetation at the site entrance on the L1010 and progress along the route of the access road to the construction laydown area. This will be followed closely by the excavation of vegetation and topsoil for the access road which follows the existing ground levels and then the placement of crushed stone (to create a 6 m wide access road) to create an initial access and roadway to the construction laydown and jetty area. All topsoil will be retained onsite for future use. Topsoil will be placed in temporary stockpiles at various locations throughout the site for re-use on slopes, with any excess material placed in the vicinity of the contractor's compound (see Figure 2-3). Approximately 26,000 tonnes of imported aggregate will be delivered from local quarries along the L1010 from the Tarbert direction. Sources of material could include:

- Ardfert Quarries, Ardfert, Co. Kerry;
- O'Mahoney Quarries, Tralee, Co. Kerry;
- Roadstone, Foynes, Co. Limerick; and
- Liam Lynch, Adare, Co. Limerick.

It is anticipated that the creation of this initial access will take approximately 2 to 3 months. Apart from the delivery of materials, the operation will all take place within the site boundary with personnel using mobile plant.

Traffic management measures approved by KCC and An Garda Siochana will be implemented prior to the commencement of works to ensure the site access is safe for all road users.

Following the construction of the site access, a perimeter fence will be erected around the site boundary. Fencing will be installed to protect the Rallapane stream. Temporary car parking and site office and other facilities will be established to support the early works which will primarily comprise earth moving. Temporary surface water drainage and silt ponds will be constructed to control runoff from the earthworks stages. Areas within the Proposed Development site, which are not to be disturbed during the construction stage, will be fenced off. The environmentally designated areas are outside the site boundary and will therefore be fenced off by the perimeter fence.

Some hedgerows, bushes and trees, and disused buildings, will also be removed during this phase.

2.9.3.4 Fencing

Fencing will be erected along the perimeter of the site as early as possible (see Section 2.4.5 for details of the height and materials). Particular care will be taken at the boundary between the development site and the cSAC, SPA and pNHA so that construction activities do not cause damage to habitats in this area. These habitats will be securely fenced off early in the construction phase. The fencing will be clearly visible to machine operators and include relevant areas in which works are planned, such as utilities. To prevent incidental damage by machinery or by the deposition of spoil during site works, hedgerow, tree and scrub vegetation which are located in close proximity to working areas will be clearly marked and fenced off to avoid accidental damage during excavations and site preparation.

2.9.3.5 Pre Earthworks Drainage

To prevent the risk of contaminating surface water and groundwater, temporary surface water drainage (including dewatering measures) and silt ponds will be constructed to control runoff from the earthworks stages. This will flow through a filtration system (such as hay bales) to slow down flow to an acceptable level. Silt traps will be placed at crossing points to avoid siltation of watercourses. Attention will also be paid to preventing the build-up of dirt on road surfaces, caused by lorries and other plant entering and exiting the Proposed Development site, via wheel washes and road sweepers as required. The layout of the temporary surface water drainage system will incorporate the mitigation and monitoring measures outlined in this EIAR and conform to the requirements of the OCEMP, Waste Management Plan (WMP) and Outline Construction Traffic Management Plan (OCTMP) (see Section 2.9.12.1), Natura Impact Statement (NIS) and planning conditions.

Rainwater runoff will be diverted away from the construction areas into the Shannon Estuary. Rainwater runoff will passed through an attenuation system including ponds with straw bales or silt bags to prevent sediment from entering the estuary. Discharge water quality targets will be agreed with KCC and included in the OCEMP. Regular water inspection and sampling regimes will be put in place via the OCEMP on the foreshore during construction activity onsite to monitor compliance with the discharge conditions.

2.9.3.6 Laydown Construction Area

A construction compound, or laydown area, for the construction activities will be established to provide for storage of construction equipment and materials, as well as for offices, parking and welfare facilities for staff (for the duration of the construction phase. The locations and extent of the construction compounds are presented in Figure 2-3.

The laydown area will be constructed by stripping back the topsoil (which will be used later in the landscaping), and placing a layer of stone over a layer of geotextile membrane as required. The laydown areas will be suitably drained and any areas which will involve the storage of fuel and refuelling will be paved with bunding and hydrocarbon interceptors to ensure that no spillages percolate into the surface water or groundwater systems. During the removal of the topsoil and placement of the stone for the laydown areas precautions will be taken to minimise runoff into ditches, drains or the stream (this is addressed in Section 2.9.3.7 below).

Additional mitigation and monitoring measures as required will be implemented in OCEMP including the WMP and OCTMP (see Section 2.9.12).

The construction compound units will incorporate canteens, offices, medical, changing, and welfare facilities and drying rooms.

Following completion of construction, the laydown area will be cleared and re-instated, temporary buildings and containers, parking areas and material such as stone, aggregates and unused construction materials will be removed as appropriate. As much of this material as possible will be re used onsite as part of landscaping and construction works.

2.9.3.7 Earthworks

The LNG Terminal and Power Plant will be constructed to a finish grade platform with an elevation of 18 m. In order to create this platform, approximately 475,000 m^3 of overburden soils and rock will be excavated and moved within the site (Table 2-13). Some of the rock t will need to be broken up before it can be excavated. This will be done either by percussive rock breaking equipment mounted on tracked excavators or by blasting depending on the hardness and depth of the rock to be removed. The soil and rock will then be excavated using tracked excavators. Excavated material will be stockpiled for use as engineering fill, landscaping and other uses throughout the Proposed Development site. Stockpiles will be no more than 2 – 3 m high and will be seeded with an appropriate seed mix. All excavated material will be reused onsite, within the development area, and no import of soil is expected.

Table 2-13 Estimated Material Volumes

	Excavation (m^3)	Backfill (m^3)
Topsoil	35,000*	35,000
Soil excavation	356,054	437,115
Rock excavation	81,062	
Total	472,115	472,115

*Excess topsoil will be placed on the laydown area or spread onsite

The overburden will be, in places, quite thin, and to create the level platforms for the facilities. It is expected that blasting will be required to excavate some of the rock, which cannot be removed by rock breaking equipment mounted on tracked excavators. The blasting will be carried out in a controlled manner in accordance with a pre-approved plan, and in a controlled manner to minimize the noise and ground vibrations. This is done by designing a blast pattern with a small charge in many holes drilled in to the rock at close spacing; the individual charges are then set off in a sequence using an electronic relay so that the maximum charge going off at any instant (this is referred to as the 'maximum instantaneous charge') is only the small amount of charge in any one of the holes. This causes cracks in the rock which allows the rock to be broken up further using mechanical rock breakers; the rock is then excavated using tracked excavators. No more than three blasts are envisaged to occur in any given day and associated noise and vibration levels will be transient and very short lived. Refer to Chapter 09 – Airborne Noise and Groundborne Vibration for further details.

Excavated material will be stockpiled for use as engineering fill, landscaping and other uses throughout the site.

Earthworks are expected to be completed within four months, with two to three months of blasting. Piling for the construction of the jetty will also commence during this period, initially from onshore (approximately four and a half months) followed by 11 months from the water.

Monitoring of dust, noise and vibration levels will be undertaken during blasting operations at appropriate locations around the boundary in accordance with the measures outlined in the OCEMP. Piling activities will also comply with ecological constraints such as breeding mammals (June to September) and wintering birds (October to March). Refer to Chapter 07 – Biodiversity for more information.

The OCEMP will also identify mitigation and monitoring measures required to protect watercourses from pollution associated with the earthworks operations and set out the specific arrangements for the strict control of erosion and generation of sediment or any other pollutants. It will detail appropriate sediment control temporary works and plant, including silt curtains, settlement lagoons, flow control arrangements etc. to ensure no pollutants are discharged to watercourses or the sea (see Section 2.9.12.1 and Appendix A2-4, Vol. 4).

2.9.3.8 Traffic and Transport

For the purposes of the EIAR, a worst-case construction scenario of the LNG Terminal, Power Plant and medium voltage (10/ 20 kV) connection has been assumed. This scenario will result in a maximum site headcount and consequently the highest amount of traffic.

The traffic associated with the earthworks and site preparation phase will be managed such that the impact on public roads will be minimised. This is achieved by the implementation of the OCTMP which will be agreed by KCC in advance of the works. The traffic volumes on the public road will largely comprise HGV deliveries and arrival of personnel to the Proposed Development site.

Refer to Chapter 11 – Traffic and Transport for how the deliveries will be co-ordinated with the planned L1010 road upgrade works, which is anticipated to overlap with the enabling works phase. These activities will be completed at about the same time to allow the main construction works to proceed.

2.9.4 LNG Terminal Construction

The LNG Terminal construction activities will commence once the main earthworks activities have been completed. The construction of the LNG Terminal will include the following:

- Construction of jetty; and
- Construction of onshore receiving facilities
- Construction of AGI (see Section 2.9.4.3 below).

Typically, the construction equipment required will include floating plant (for the jetty), compressors, mobile cranes, tower cranes, generators, hoists, gantries, and various types of excavators, loaders, trucks, trailers, vans, etc. Other equipment required will include a rock crusher and screening plant, diesel fuel tanks, gas storage cages, electric power supply, mechanical repair shops, etc. Hard standings will be established for these by pouring concrete in the relevant locations.

Fuel will be required for the diesel generators and equipment. To minimise the numbers of fuel deliveries, one or more double skinned diesel fuel tanks (maximum 20,000 l) will be installed onsite to supply fuel for the diesel generators and construction vehicles and equipment. The diesel fuel tanks will be positioned on a temporary bunded concrete plinth (constructed at the start of the works), away from sensitive watercourses.

2.9.4.1 Jetty Construction

Construction of the jetty will include (over approximately 15.5 months):

- Installation of the jetty trestle supported on steel piles with a concrete deck and access roadway to the jetty head;
- Installation of a jetty head with unloading arms;
- Installation of mooring dolphins;
- Installation of breasting fender dolphins;
- Installation of permanent docking location for four tugs; and
- Installation of topside equipment and facilities.

Topside facilities and equipment construction will include:

- Installation of welded pipework and electric supply and instrument cables along the trestle to the jetty head and berthing facilities; and
- Installation of major equipment such as loading arms, gangway towers, firewater pumps, elevated fire monitors, lighting, safety systems, including the berthing monitoring systems.

Typically, the construction of the jetty will be undertaken from the water using floating barges and self-elevating platforms (jack-ups), manned with teams of specialist marine construction personnel, divers, operators, and labourers plus supervision. Tugs will be on hand for moving the floating equipment around. Other smaller equipment such as compressors, generators, and land-based machines will also be used.

The construction materials for the jetty consist of 203 steel tubular piles, structural steel, precast concrete elements, reinforcing steel and concrete. Up to 163 m^2 of cSAC habitat is expected to be lost as a result of the jetty piles. It is anticipated that the initial steel piles for the jetty will be delivered by road from Foynes port (within the first 3 months of enabling works) with subsequent pile deliveries supplied directly by barge once the first part of jetty is constructed. The piles will be up to 50 m long x 1067 mm in diameter and will be delivered out of hours as an abnormal load.

The majority of the piles supporting the jetty will be driven, with some piles drilled and socketed into the underlying rock to ensure stability of the jetty. This operation will require a jack-up platform supporting a large crane-mounted drill and a large barge-mounted support crane. Spoils from the drilling operation will be conveyed to the surface via reverse-circulation through the drill stem and contained within designated scows or other vessels. Approximately 1000 m^3 pile arisings are anticipated from the socketed piles (approximately 80 no.), none of which will be from onshore piling operations. The spoils will be placed on a barge, dried, then transferred to shore for drying and reused in general earthworks or in landscaped bunds. Pile installation is anticipated to advance outward from shore. It is anticipated that between 0.5 and 2 piles will be drilled per day during the construction of the jetty.

Once the pile installation is underway, one or two additional floating spreads will follow in sequence to lift and set the precast pile caps, beams, and deck planks. These spreads will comprise one or two large floating cranes and materials barges. All works will be carried out within the foreshore lease area.

The work will also involve in-situ grouting of precast members at the pile tops and other connections. The access roadway to the jetty platform will be constructed of reinforced concrete and will be 5 m wide. This work will advance outward from shore using land-based concrete transit mixers, pre cast concrete, and other paving equipment.

The jetty construction contractor will be required to liaise closely with SFPC Harbour Master and Pilotage Superintendent in relation to scheduling of activities. Support barges will be moored and anchored so as not to interfere with traffic in the navigation channel and in accordance with guidelines established by the Harbour Master and SFPC.

The use of pre-cast concrete will be maximised, while the pouring of wet concrete onsite will be minimised to reduce any potential environmental impacts on the Shannon Estuary. Any in-situ concrete work will be staged in a manner to prevent concrete from entering the water. This will be achieved by installing shuttering to contain the concrete, with all concrete pours supervised by the Environmental Manager. Refer to the OCEMP in Appendix A2-4 for further detail. Piles will be pre-fabricated as much as possible to minimize in-water construction.

2.9.4.2 Onshore Receiving Facilities Construction

Onshore, LNG Terminal facilities construction will follow the sequence below, consistent with gas industry practices, over a period of 12 months following the enabling works phase, namely:

- Placement of concrete foundations, drainage system, power and instrumentation conduits;
- Installation and erection of process and utility equipment, piping and instrumentation;
- Construction of buildings; and
- Site landscaping.

Initially, drainage systems and power and instrumentation conduits will be installed along with the placement of concrete foundations, followed by the building superstructures (including metal frames, cladding and additional finishes). Following this the fit out of the major mechanical and electrical equipment, instrumentation and process piping will be completed. The fit out and completion of the buildings, and completion of site access roads with landscaping, using stockpiled topsoil material, will then take place. The facilities will be tested and commissioned, prior to commencing operations.

Where possible, equipment will be modularised for some of the facilities, and components will be standardised and pre-fabricated in order to reduce onsite construction time and to minimise local disruption during the construction phase. Pre-fabricated materials will be delivered to the site via the road network and may require out of hours abnormal load delivery.

2.9.4.3 AGI Construction

The construction of the AGI will be undertaken following enabling works over a period of 12 months and will encompass the following activities:

- Placement of concrete foundations, drainage system, power and instrumentation conduits;
- Installation and erection of process and utility equipment, piping and instrumentation;
- Construction of buildings; and
- Site landscaping.

Buildings to house the AGI will mostly be steel framed with infill construction and cladding. Structural steel for buildings is anticipated to be delivered by road and assembled onsite.

The majority of the building materials for the AGI will be purchased as complete units, where practicable, and delivered to the site for installation. Pipe work and ducting will be assembled onsite.

Drainage system power and instrumentation conduits will be installed along with the placement of concrete foundations, followed by the building superstructures (including metal frames, cladding and additional finishes. Later stages of the initial phase will see the installation of the major mechanical and electrical equipment, instrumentation and process piping. Final stages of the initial phase will see the fit out and completion of the buildings, and completion of site access roads, with landscaping. The facilities will be tested and commissioned and the facility will commence operations.

2.9.5 Power Plant Construction

Construction of the Power Plant will begin after the platform level has been excavated to 18 m AoD and the surface prepared, as outlined in the enabling works section (2.9.3). Typically, the construction equipment required for the Power Plant includes compressors, mobile cranes, tower cranes, generators, hoists, gantries, and various types of excavators, loaders, trucks, trailers, vans, etc. Other equipment required will include diesel fuel tanks, gas storage cages, electric power supply, mechanical repair shops, etc. A number of tower cranes may be required. Hard standings will be required for these and will be located away from environmentally sensitive sites.

It is currently anticipated that the Power Plant construction will commence shortly after the commencement of the construction of the LNG Terminal.

2.9.5.1 Power Plant Construction Works

The construction works for the Power Plant will be be sub-divided into four main packages:

- Civil and structural works;
- Mechanical and electrical installation;
- Gas Infrastructure; and
- Connection to the EirGrid 220 kV substation.

Foundation construction will include excavating to a depth of approximately 2 to 3 m, installation of concrete forms, fixing of steel reinforcing, and the pouring of concrete. Pile foundations could be necessary for parts of the Power Plant, depending upon soil conditions and loading.

Buildings to house the Power Plant are expected to be steel framed with infill construction and cladding. Structural steel for buildings is anticipated to be delivered by road and assembled onsite.

The majority of the building materials for the Power Plant will be purchased as complete units, where practicable, and delivered to the site for installation. Pipe work and ducting will be assembled onsite.

The mechanical activities will include the installation of:

- Gas turbine generators;
- Steam turbine generators;
- Heat recovery steam generator;
- Air cooled condenser;
- Auxiliary cooling water system;
- Feed water/ condensate system;
- Fuel gas supply system;
- Water supply/ treatment system; and
- Fire protection system.

The main electrical activities will include the installation of the following:

- Transformers;
- Distributed control systems;
- Switchgear;
- Low and medium voltage and control and instrument systems;

- Batteries and Uninterruptible Power Supply systems;
- BESS; and
- 220 kV GIS substation.

2.9.6 Drainage Outfall Construction

A drainage outfall into the Shannon Estuary will be constructed (see Figure F2-6, Vol. 3). Within the Proposed Development site, surface water from paved and impermeable areas and groundwater will be collected by an underground drainage system and will discharge to either, the existing stream and/ or drainage ditches within the site, or to the Shannon Estuary. via the drainage outfall pipe which will extend across the foreshore to below the low water mark.

All discharges through the drainage outfall will pass through a Class 1 Hydrocarbon Interceptor. Any bunded areas within the site will have valve-controlled discharge points as part of their connection to the outfall drainage network. Drainage runoff from these areas will be tested for contamination prior to release to the outfall drainage network.

The drainage outfall pipe will be buried as it crosses the shoreline and will extend approximately 5 m beyond the low water mark. A check valve will be installed at the end of the outfall drainage pipe to prevent ingress of water from the estuary back into the drainage system.

It is anticipated that the construction of the drainage outfall pipe will be an open cut trench technique as follows:

- Excavate a trench across the foreshore to a maximum depth of approximately 2.4 m;
- Install a 900 mm diameter concrete drainage pipe in trench and backfill with concrete; and
- Reinstate the foreshore and shoreline.

The outfall trench will be excavated above the low water mark using a hydraulic rock breaker mounted on a tracked excavator. This operation will be carried out in the dry at all times working above the tide during a suitable period of spring tides.

Where the outfall extends beyond the low water mark into the estuary, excavation of rock will be undertaken using an expanding grout placed by divers into drilled holes to pre-split the rock to the required levels and facilitate its removal by long reach excavator bucket.. Trenches excavated across the shoreline will be backfilled with concrete suitable for underwater use and the surface will be embedded with cobbles and stone excavated from the trench to minimise the visual impact. The excavated material will be removed from the foreshore and incorporated as part of the earthworks and landscaping for the Proposed Development. Below the low water mark, the trench will remain open, and the sides of the trench will be battered back to avoid creating a pocket for siltation. Additionally, the cliff face will be armoured with rock to prevent erosion and maintain the integrity of the foreshore. Disturbance of the seabed below the low water mark will be small, arising primarily from the excavation of the trench and clearing and levelling of the ground to install the outfall pipe. This will result in temporary habitat loss of approximately 90m^2 of Annex I habitat above the low water mark and 10m^2 below the low water. Loss of Annex I habitat Estuaries habitat is estimated to be approximately 100m^2, while the loss of Reef habitat is approximately 65m^2. Installation of the pipe will result in the loss of 0.000041% and 0.000030% of the Annex I habitats 1130 Estuaries and 1170 Reefs respectively. This is discussed further in Chapter 07A Marine Biodiversity.

All refuelling of equipment and machinery will take place at designated refuelling areas on the site. No refuelling will take place on the foreshore. Arisings from trenching, or other works, will either be used for reinstatement. Details on this will be outlined in OCEMP.

2.9.7 Construction Utilities

2.9.7.1 Electricity

During the construction phase of the Proposed Development, electricity will be supplied via a series of portable site units prior to the medium voltage electricity connection becoming available.

2.9.7.2 Water Supply

Water will be required for consumption by the construction personnel, for general construction works, hydrotesting of tanks and pipework, for the construction of the concrete elements, and for wheel wash facilities and for dust suppression. It is anticipated that water supply for the construction phase will be obtained from a water main along the L1010. The Applicant has submitted a pre-connection agreement application to Irish Water for this supply. If this supply is not available, water will be delivered by road and stored in a temporary tank onsite.

The maximum potable water demand for construction will be 98 m^3/day. The Proposed Development will incorporate water efficiency measures such as collection of grey water to minimise water consumption as far as possible.

2.9.8 Drainage

2.9.8.1 Sewerage Drainage for Construction

Sewage effluent will arise from the site offices, canteens, toilets and showers. The effluent will be collected in tanks and self-contained toilet units for removal by tanker by a licensed haulier to a licensed facility.

2.9.8.2 Stormwater and Surface Water Drainage during Construction

Surface water and groundwater on or adjacent to the site could become contaminated with silt or debris during the construction phase. Therefore, temporary surface water drainage and silt ponds will be constructed to control runoff from the earthworks stages. Water will be reused onsite where possible, for example grey water will be used for wheel washing activities. Surface water will flow through a filtration system (such as hay bales) to slow down flow to an acceptable level. Silt traps will be placed at crossing points to avoid siltation of watercourses. Attention will also be paid to preventing the build-up of dirt on road surfaces, caused by lorries and other plant entering and exiting the Proposed Development site, via wheel washes and road sweepers as required. The layout of the temporary surface water drainage system will incorporate the mitigation and monitoring measures outlined in this EIAR and conform to the requirements outlined in the OCEMP, WMP and OCTMP (see Section 2.9.12), Natura Impact Statement (NIS) and planning conditions.

2.9.9 Construction Management

A construction management team will be onsite for the duration of the construction phases of both the LNG Terminal and the Power Plant. The team will supervise the construction of the Proposed Development, including monitoring the contractors' performance to ensure that the proposed construction phase mitigation and monitoring measures are implemented, and that construction impacts and nuisance are minimised. KCC will be notified of the identified point of contact onsite for the duration of the construction programme. Further details on the construction management structure, environmental management, site audit system, and community feedback arrangements are contained within the OCEMP (see Appendix A2-4, Vol. 4).

2.9.10 Construction Employment

It is envisaged that the initial construction phase will last approximately 32 months, with an additional 6 months commissioning prior to operation. During the initial phase, approximately 975 people will be employed onsite at peak. While some of the construction personnel will be specialists who will travel from outside the area, it is intended that many of the jobs will be filled by personnel recruited locally, with appropriate training provided as necessary. The project will therefore provide both employment opportunities as well as training during this phase. Where required, construction personnel will be accommodated locally in hotels and guesthouses.

The coordination of people and materials onsite will be one of the key activities throughout the construction phase.

2.9.11 Materials Sourcing and Transportation

Construction materials will be sourced locally from authorised quarries, where possible to minimise the environmental impact of transportation. It is intended that this will include all suitable stone recovered on during the enabling works will be reused as hardcore. For this purpose, rock crushing and screening plant will be provided. Additional rock, stone and sand materials could be procured from local quarries as required including the following:

- Ardfert Quarries, Ardfert, Co. Kerry;
- O' Mahoney Quarries, Tralee, Co. Kerry;
- Roadstone, Foynes, Co. Limerick; and
- Liam Lynch, Adare, Co. Limerick.

All the materials will be transported to the Proposed Development site by road, except those specified above in Section 2.9.11. It is anticipated that up to 26,000 t of imported aggregates will be required for the Proposed Development.

There may be periods in the early stages of construction where onsite haul roads are not surfaced. To reduce dust these routes can be dampened down (including the reuse of water from the wheel washing facilities) and maximum speed limits will be signposted and imposed.

Some of the process equipment and structural elements will arrive onsite as complete units or sub-assemblies, which may be larger than normal construction loads. It is anticipated that all the units will be delivered by ship to Foynes, and from there transported to the Proposed Development site by road. Some of the units could be 'extra-large loads' and a Garda escort may be required when they are on the road network. The timing of their transport to the Proposed Development site will be chosen to minimise disruption to other roads users. For example, the jetty piles will be up to 50 m long x 1067 mm in diameter and will be delivered out of hours as an abnormal load, subject to prior agreement with KCC. This will be managed in accordance with the OCTMP, see Appendix A11-1, Vol. 4.

2.9.12 Environmental Protection Measures

2.9.12.1 Outline Construction Environmental Management Plan (OCEMP)

An OCEMP has been produced as part of this planning submission. A detailed CEMP will be produced by the successful Contractor prior to the main construction works. The CEMP will detail the Contractor's overall management and administration of the works. The CEMP will also include any commitments included within the statutory approvals.

The CEMP will set out the necessary approach to managing the environmental aspects and impacts associated with the construction of the Proposed Development. It will also contain details of the monitoring and reporting system which will be implemented to document compliance with the following:

- Environmental commitments identified in the EIA studies; and
- The conditions of the relevant statutory consents including the planning consent and the foreshore licence associated with the Proposed Development.

The Contractor will be required to include the following information:

- Project details and the scope of works (including the locations of construction compounds and information on construction periods and phasing);
- A summary of relevant policy and project and environmental aims;
- The planning and foreshore licence conditions relevant to the construction activities and a summary of how and where they will be addressed within the CEMP;
- Information on the roles and responsibilities of key individuals, including the environmental management and reporting structure (as provided by the contractor or as available at the time of writing the CEMP);
- An outline communication strategy, making recommendations to the contractors, for example such as the implementation of toolbox talks (environmental discussion on issues encountered onsite) by the contractor relating to environmental constraints and procedures to be adhered to onsite;
- Methods to identify non-conformances, details of non-conformances and breaches of environmental limits and reporting measures;
- A summary of the potential environmental effects as identified by the EIAR, the schedule of mitigation and other existing documentation;

- The schedule of identified potential environmental impacts, risks and mitigation and monitoring measures;
- Method statements and work programmes for specific tasks such as the management of concrete washout onsite;
- Requirements for and maintenance of concrete washout areas;
- Requirements for fencing off of any protected environmental sites such as areas of ecological or archaeological importance;
- Protection of vegetation including hedgerows, trees etc.;
- An environmental monitoring programme and details of monitoring locations as required;
- An outline emergency response plan and procedure for environmental incidents including accidental spills;
- Requirements for inspection and auditing; and
- An outline reporting programme and procedure to be updated by the appointed contractor.

The CEMP will be a living document and periodically reviewed and updated as required during the course of construction.

As a minimum, the CEMP will be reviewed every six months. Notwithstanding the above requirements, the CEMP will also be reviewed at least two weeks prior to the construction stages listed below:

- Start of works;
- Start of each succeeding stage of the works;
- Start of any site activity that may potentially have an effect on sensitive habitats/ species; and
- Start of the landscaping works.

2.9.12.2 Outline Construction Traffic Management Plan (OCTMP)

An OCTMP has been prepared as part of this planning application (Appendix A11-1, Vol. 4). A detailed CTMP will then be produced by the appointed Contractor as part of the contractual agreements for the construction of the Proposed Development and will be updated as needed during the construction period. This CTMP will be agreed with KCC prior to commencement of works and shall apply to all traffic to and from the Proposed Development site including those works carried out by the Contractor and any subcontractors, as well as have regard to traffic associated with works associated with the construction of the jetty, the AGI and the gas export pipeline, the electricity substations and connections. The plan will include measures to direct construction traffic (including site access), as much as practicable, along the upgraded road from Tarbert to the Proposed Development site rather than along the road from Ballylongford to the Proposed Development site.

2.9.12.3 Waste Management Plan (WMP)

The Contractor will be responsible for developing a WMP and an OCTMP related to the construction activities. The WMP will establish a waste recording system to test and track all waste loads going offsite for appropriate disposal. This includes Waste Acceptance Testing (WAC) to determine the appropriate disposal route for the waste.

The WMP will also contain details of waste permits and hauliers who will be authorised to remove waste from the site and it will detail waste audits to be carried out.

2.10 Commissioning Phase

Following completion of construction and installation of equipment, and before the LNG Terminal commences operations, there will be a testing and commissioning phase. This phase will comprise:

- Installation compliance checks;
- Commissioning tests; and
- Performance demonstration tests.

2.10.1.1.1 Installation Compliance Checks

This will be a process of systematically checking that all systems and equipment have been constructed, assembled, aligned and installed correctly, in accordance with the design specifications and drawings, and that all interconnecting pipe work, cabling and wiring has been installed in compliance with the design specifications and drawings.

2.10.1.1.2 Commissioning Tests

The function of each item of equipment and each system will be tested and verified, in a systematic manner, as being in accordance with the design and specifications. All the alarm and control systems and instrumentation will be tested to demonstrate that they are functioning correctly. Following these tests, each system will be checked to ensure that it is ready to be commissioned under operating conditions including using real materials, temperatures, pressure, and voltages.

2.10.1.1.3 Performance Demonstration Tests

In this commissioning phase the individual items of equipment and systems will be tested under operating conditions using the materials, temperatures, pressure, and voltages to which they will be subjected when in operation. Once the operation of all equipment and systems has been tested and verified individually, they will be integrated and the operation of complete systems will be tested.

The Proposed Development's safety and fire prevention systems and the Operational Emissions Management Plan will be subject to the same rigorous testing protocols as the other systems.

2.11 Decommissioning Phase

The Proposed Development is expected to have a design life of 50 years, but this could be extended by maintenance, equipment replacement and upgrades or by the transition of the site to use hydrogen capability (which will be subject to a future planning application). It is expected that it would be a condition of the industrial emissions licence for the Proposed Development that a closure and residuals management plan, including a detailed decommissioning plan, be submitted to the EPA for their approval.

Decommissioning activities will include, as a minimum:

- All wastes at the facility at time of closure will be collected and recycled or disposed of by an authorised waste contractor, as appropriate;
- Utilities will be drained of all potential pollutants such as lubricating oils or sealed to prevent leakage if being moved offsite or reused elsewhere;
- All raw materials, oils, fuels, etc. onsite at the time of closure will be returned to the supplier, or collected and recycled or disposed of by an authorised waste contractor, as appropriate,
- All buildings and equipment will be decontaminated, decommissioned and demolished in accordance with a phased demolition plan, and either sold for reuse or recycled, or disposed of by an authorised waste contractor, as appropriate. In general, specialist equipment, pipelines and storage tanks will be sold for reuse, where possible, or disposed of offsite;
- Roadways to be broken up and removed and security fences dismantled;
- All hazardous and non-hazardous process substances to be removed;
- All roads and hardstanding areas to be removed and recycled or disposed of by an authorised waste contractor, as appropriate;
- Landscaped will be reinstated in accordance with a landscape reinstatement plan; and
- On completion of safe decommissioning of equipment, the potable water, fire water and electrical power supplies could be disconnected, and removed or abandoned in place.

When operations have ceased, and assuming confirmation from the monitoring programme that all emissions have ceased, it is expected that there would be no requirement for long-term aftercare management at the Proposed Development site.

2.12 References

European Commission. (2021). *National Energy & Climate Plan (NECP) 2021-2030*, European Commission.

EirGrid. (2020). *All-Island Generation Capacity Statement 2020-2029*.

Gas Networks Ireland (GNI). (2020). *GNI Network Development Plan 2020*.

GNI/ EirGrid. (2018). *Long Term Resilience Study.*

Government of Ireland. (2019). *Climate Action Plan 2019. To Tackle Climate Breakdown*.

International Gas Union (IGU). (2021). *World LNG Report*.

International Maritime Organization (IMO). (2017). *List of Certificates and Documents Required to be Carried On Board Ships, 2017*. Available from: https://wwwcdn.imo.org/localresources/en/publications/Documents/Certificatesonboardships.pdf

IMO. (1986). *International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).*

Kerry County Council. (2018). *Kerry County Development Plan- Strategic Environmental Assessment 2015-2021*.

Listowel Municipal District. (2020). *Listowel Municipal District Local Area Plan 2020*.

Oil Companies International Marine Forum. (2008). *Mooring Equipment Guidelines.* Third Edition. Available from: http://clbthuyentruong.com/images/upload/2014/thuyentruong/tt_20140728.pdf

Southern Regional Assembly. (2020). *Regional Spatial & Economic Strategy 2020-2032*.

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SHANNON FOYNES PORT COMPANY

SHANNON ENERGY PARK NRA UPDATE

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SHANNON FOYNES PORT COMPANY

SHANNON ENERGY PARK NRA UPDATE

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EXECUTIVE SUMMARY

In 2020, Marico Marine was commissioned by Shannon Foynes Port Company to deliver a navigation risk assessment of the proposed Liquefied Natural Gas facility near Ardmore Point in the Shannon Estuary. The 2020 update was itself an update to a previous NRA undertaken in 2008 to address advances within LNG industry over the intervening 12 years. The 2021 assessment addresses design changes introduced since completion of the 2020 NRA, primarily:

- Update of the LNG jetty design to increase the wind limitation threshold to 70 knots;
- Use of LNG supply ships of up to Q-Max in size; and
- Use of a floating storage regasification unit.

This NRA, therefore, updates and supersedes the 2020[1] and the 2008 NRAs[2].

This navigation risk assessment reviewed and assessed the risks associated with the operation of the Project. A summary of the primary work scope is provided below:

- Review of the baseline navigation profile;
- Identification of additional navigation risks (if any) arising from project design changes; and
- Review of the appropriateness of mitigation measures proposed as part of the 2020 NRA and identification of any additional mitigations.

The baseline assessment identified 56 individual hazards for assessment, of which 15 hazards were assessed to be ALARP, 39 Low and 2 Negligible. For those hazards assessed to be ALARP; the risk is 'neither acceptable or unacceptable and consideration should be given to the application of possible additional risk controls where their implementation shows a marked reduction in risk'.

A total of 27 possible additional mitigation measures, combining 22 existing and five new, informed by stakeholder consultation and data analysis, were identified and recommended by the NRA. The application of these measures reduced the score of all but two hazards; 'Contact - Project Vessel with Project Infrastructure' and 'Contact - Project Vessel with LNGC at Anchor' to a "Low" level - a level where operational safety is assumed.

[1] 18UK1448 Shannon Foynes LNG Issue 01.

[2] 08-635.

The NRA recommends that SFPC give detailed consideration to the implementation of each of the identified mitigation measures and especially those that apply to hazards that scored in the ALARP range in the baseline assessment.

The assessment of navigational risk as a result of the presence of the LNG Project at Ardmore Point, including project design changes since the original 2008 and the 2020 NRAs, has concluded that the Project is acceptable in terms of navigational risk and should have minimal impact on the existing navigational risk profile, assuming compliance with embedded and the implementation of proposed mitigation measures. This scoring reflects the comparatively large geographical size of the estuary, the substantial amount of deep navigable water available and the relatively low density of commercial shipping.

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ABBREVIATIONS

Abbreviation	Detail
AIS	Automatic Identification System
ALARP	As Low as Reasonably Practicable
CHA	Competent Harbour Authority
CIL	Commissioner of Irish Lights
DWT	Deadweight Tonnage
FSRU	Floating Storage Regasification Unit
GT	Gross Tonnage
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICW	In Collision With
IMO	International Maritime Organisation
kt	Knot (unit of speed equal to nautical mile per hour, approximately 1.15 mph)
LNG	Liquified Natural Gas
LNGC	Liquified Natural Gas Carrier
m	Metre
Marico Marine	Marine and Risk Consultants Ltd
ML	Most Likely
nm	Nautical Mile
NMCI	National Maritime College of Ireland
NRA	Navigation Risk Assessment
PEC	Pilotage Exemption Certificate
PSTQ	Port Side To Quay
SHA	Statutory Harbour Authority
SFPC	Shannon Foynes Port Company
SIGTTO	Society of International Gas Tanker and Terminal Operators
SMS	Safety Management System
STCW	Standards of Training Certification and Watchkeeping
TEN-T	Trans-European Transport Network
VHF	Very High Frequency (radio communication)
VTS	Vessel Traffic Service
WC	Worst Credible

1 INTRODUCTION

In July 2020, Marico Marine was commissioned by the Shannon Foynes Port Company (SFPC) to deliver a Navigation Risk Assessment (NRA) of the proposed Liquified Natural Gas (LNG) facility near Ardmore Point in the Shannon Estuary (the Project). The 2020 update was itself an update to a previous NRA undertaken in 2008; however, changes to the project design as well as advances within LNG industry over the intervening 12 years demanded a fundamental reworking of the original 2008 document. In 2021, further changes to the design of the terminal and evolution of the operating concept prompted the requirement for an additional update to the NRA to ensure it remained fit-for-purpose. This NRA, therefore, updates and supersedes the 2020[3] and the 2008 NRAs[4].

1.1 SCOPE

This navigation risk assessment will review the risks associated with the updated operation of the Project. The construction phase and the associated risks will need to be assessed in a separate NRA.

A summary of the primary work scope is provided below:

- Review of 2020 baseline navigation profile;
- Identification of additional navigation risks (if any) arising from project design changes, primarily: the proposal to use ships of up to “Q Max” size as LNG supply vessels and the use of a Floating Storage Regasification Unit (FSRU);
- Review the mitigation measures proposed as part of the 2020 NRA and make recommendations for any possible additional mitigations.

[3] 18UK1448 Shannon Foynes LNG Issue 01.

[4] 08 - 635

1.2 REFERENCE DOCUMENTS

The NRA has been undertaken drawing on the input data and documents outlined within **Table 1**.

Table 1: Reference Documents

Document Reference	Description
18UK1448 Shannon Foynes LNG Issue 01 (2020)	2020 Navigation Risk Assessment of marine operations at proposed LNG terminal at Ardmore Point.
08 - 635	2008 Navigation Risk Assessment of marine operations at proposed LNG terminal at Ardmore Point.
Shannon Foynes Port Company Byelaws; made pursuant to Section 42 of the Harbours Act, 1996 – 2000.	Guidance by which port and navigation is enforced, managed and administered.
Shannon Foynes Port Company - Vision 2041.	The Port and Estuary Master Plan outlining development goals for the next 20 years.
Shannon Foynes Port Company Pilotage Manual.	The Pilotage manual to which vessel masters / pilots must comply while transiting through the Shannon Estuary.
Moffatt and Nichol - New Fortress Energy – Shannon LNG Berthing and Mooring Analysis – dated 3rd April 2020.	An assessment of the proposed terminal design will be sufficient to accommodate an FSU and supply LNG ship of 130,000m^3 to 180,000m^3 cargo capacity.
National Maritime College of Ireland Shannon LNG Simulator Exercises Dec 2009.	To determine berth orientation for the proposed LNG berth at Ardmore Point under varying environmental conditions.
SIGTTO Guide for Ship-to-Ship Transfer of Petroleum, Chemicals and Liquefied Gases dated 2013.	The guide provides advice for Masters, Marine Superintendents and others, such as STS service providers and transfer organisers, involved in the planning and execution of STS operations.
LNG Operations in Port Areas, 1st Edition, 2003, SIGTTO	This publication highlights the risks and best practice for those that are connected to gas operations for those who administer ports and provide essential services in port areas.
Liquefied Gas Handling Principles on Ships and Terminals (LGHP4) 2016 - SIGTTO	Covering every aspect of the safe handling of bulk liquid gases (LNG, LPG and chemical gases) on board ships and at the ship/shore interface at terminals.

1.3 GUIDANCE

The NRA has been conducted based on the Formal Safety Assessment (FSA) approach to risk assessment utilising a combination of data analysis and stakeholder/expert judgement to determine risk levels. Applicable guidance that has informed the assessment of risk is given within **Table 2**.

Table 2: Guidance

Guidance	Description
IMO (2018) Revised Guidelines for Formal Safety Assessment (FSA) MSC-MEPC.2/Circ.12/Rev.2	Risk assessment methodology.
Irish Harbours Act 1996.	"An Act to make better provision in relation to the management, control, operation and development of certain harbours, to revise the law relating to pilotage and to enable certain harbours and property to be transferred to local authorities."
Irish National Ports Policy Statement 2005.	The policy position as set out in this document is to require the ports: to operate commercially, without Exchequer support, to provide adequate in-time capacity for the future needs of the economy and to encourage private sector investment.
SIGTTO Guide to support craft at Liquefied Gas Facilities; Principles of Emergency Response and Protection dated 2016.	This publication discusses the role of support craft in assisting with safe operations and emergency response for liquefied gas carriers and facilities.
The International Safety Guide for Oil Tankers and Terminals (ISGOTT), 6th Edition, 2016.	This Sixth Edition of ISGOTT provides essential guidance on current technology, best practice and legislation. It remains the definitive reference for the safe operation of oil tankers and the marine terminals they visit.
LNG Bunkering Guidelines 2017 – International Association of Classification Societies (IACS).	These guidelines provide recommendations for the responsibilities, procedures and equipment required for LNG bunkering operations and sets harmonised minimum baseline recommendations for bunkering risk assessment, equipment and operations.
"Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water" – Sandia Laboratory, US Dept of Energy, New Mexico. December 2004.	A framework for assessing hazards and minimising the consequences to people and property from an LNG spill over water.

2 PROJECT DESCRIPTION

New Fortress Energy Management is submitting a planning application to construct and operate a Floating Storage Regasification Unit (FSRU) nearshore terminal for the import and processing of Liquefied Natural Gas (LNG) in the Shannon Estuary. Originally conceived in 2007, the proposal envisaged the construction of an LNG terminal near Ardmore Point on the southern shore of the Estuary with the aim of providing Ireland with its own national facility for the import of LNG from markets around the world.

Since 2020, the project has evolved and anticipates the arrival of up to one LNG carrier ship per week delivering its cargo to a permanently moored FSRU with a maximum capacity of 180,000m3. The use of the FSRU means that the planned facilities for regasification ashore can be removed thus reducing the shoreside footprint in this environmentally sensitive area. The capacity of the project jetty infrastructure has been increased to allow it to accept the largest LNG Carriers (LNGC) in the world, although initially most of the LNGCs are expected to be mid-sized in LNG industry terms with a cargo capacity of 180,000m^3, 290m length overall and with an 11m draught. The LNG facility itself has been upgraded to have a 345m jetty with a central loading platform, 2 breasting and 6 substantial mooring dolphins rated to allow the FSRU to remain safely alongside in winds of up to 70 knots[5] as shown in **Figure 2-1**. The jetty, which is aligned in the direction of the prevailing wind and tidal stream and has been designed to be capable of accommodating the safe berthing of the full range of LNGC vessels up to Q-MAX size (**Figure 2-1**).

[5] See Section XX for met ocean limitations.

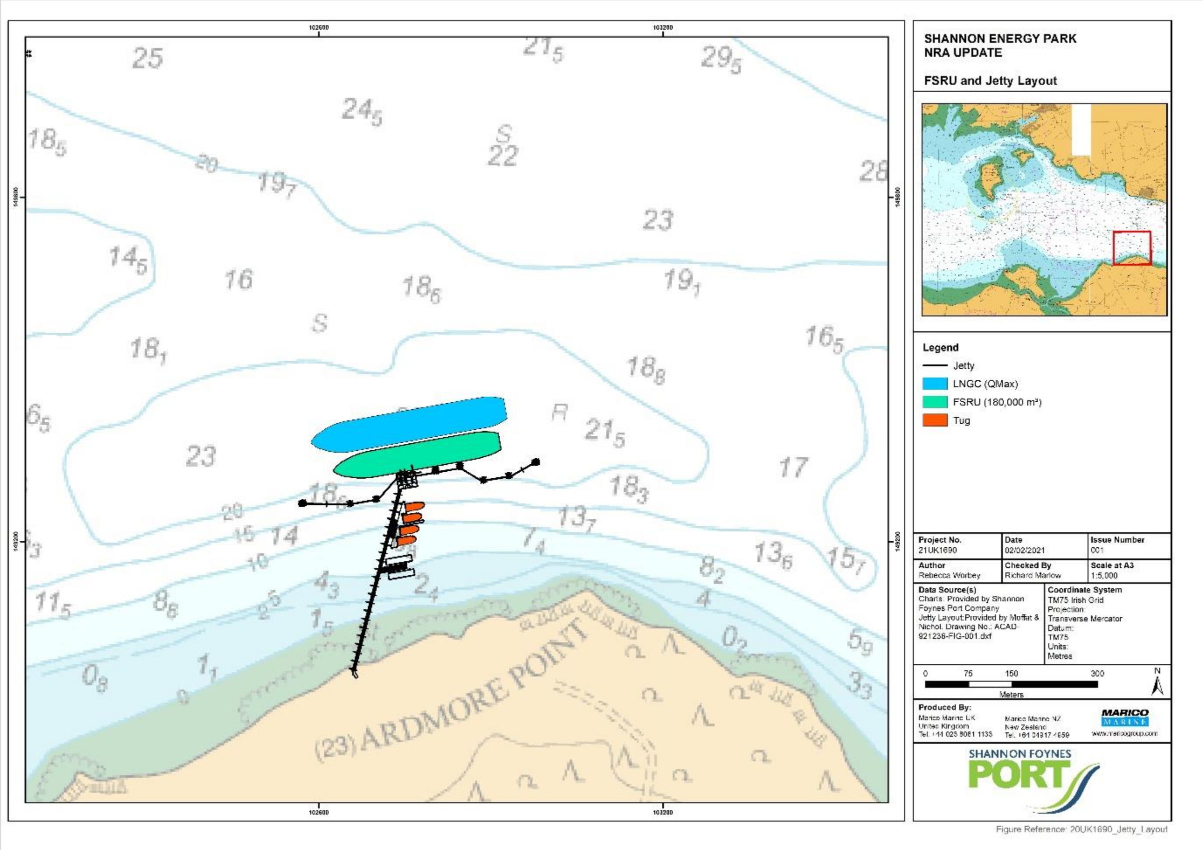


Figure 2-1: Proposed Jetty and FSRU Layout.

2.1 FSRU

An FSRU is normally a fully manned and seaworthy LNGC which is permanently moored at a marine berth. LNG is delivered by an LNGC which is moored to the seaward side of the FSRU in a ship-to-ship transfer configuration and cargo is discharged into the storage tanks of the FSRU where it is then warmed[6] and re-gasified ready to be supplied on demand direct into a national gas network. In Shannon, the developer has stipulated that the FSRU will be required to have a storage capacity of at most 180,000m3 and will be moored with its port side to the jetty[7]. Discharge operations from the arriving LNGCs are anticipated to take anything up to 48 hours depending on the size of the vessel and in order for the FSRU to maintain its sea going certification, it is possible that periodically, it may be required to proceed to sea outside Irish territorial waters.

[6] The heat for the LNG regasification will be primarily provided by seawater (“open loop” mode). When seawater temperatures are insufficient to provide sufficient heat for regasification, the FSRU would provide supplementary heat (“combined loop” mode).

[7] NMCI LNG Simulations for the Shannon LNG Terminal – Cork 2009.

Figure 2-2 Example of an LNGC mooring alongside a similar FSRU at an LNG terminal in Colombia. - Image courtesy of Höegh LNG

2.2 LNG CARRIERS

All LNG ships are of double hull construction with the LNG containment systems, equipment and insulation installed within the inner hull. LNG is carried in specially designed cargo tanks in liquid form at -163 C at atmospheric pressure. The tanks are surrounded completely by two insulation spaces which are designed to reduce 'heating of the cargo' through external ambient conditions. The insulation spaces are filled with nitrogen to provide an inert blanket around the tanks whilst also supporting the most modern gas detection systems installed to continuously monitor the cargo.

2.3 Q-MAX LNG CARRIERS

In the descriptor for a Q-Max ship, "Q" stands for Qatar and "Max" for the maximum size of ships able to berth at the LNG terminals in Qatar; ships of this type are the largest LNG carriers in the world, 345 metres long, 53.8 metres beam, an operating draft of approximately 12.5m and an LNG cargo capacity of 266,000 cubic metres. There are presently 14 Q-Max ships in service throughout the world.

2.4 PROJECTED TERMINAL CAPACITY

Up to 60 LNGC visits per year are anticipated with unloading from the LNGC to the FSRU via ship-to-ship transfer estimated to take an average of 35 hours. An additional total of 25 hours per ship is expected to be required for vessel arrival and departure. A range of vessel sizes have been considered in this NRA; it should be noted that as of February 2021, there are only 14 Q-Max vessels in service throughout the world and 31 Q-Flex vessels indicating that the majority of vessels calling at Shannon as LNGCs are likely to be in the 168,000m³ capacity range or smaller.

2.5 MOORING

At Ardmore Point, the FSRU and the LNGC are planned to be moored port side to the jetty. The mooring equipment has been designed to hold the FSRU safely in position in wind speeds of up to 70 knots[8] with a three-knot current running without exceeding 55% of the breaking load of any of the mooring lines. This comfortably exceeds the OCIMF 60 knot design specifications for the mooring of ships of at least 16,000DWT and provides sufficient spare “wind capacity” to allow the developer to plan for the FSRU to remain alongside in all but the most extreme conditions. It is expected that the FSRU will be secured to the jetty with at least 20 mooring lines and that the LNGC will secure to the FSRU and to the shore dolphins as shown in **Figure 2-3**.

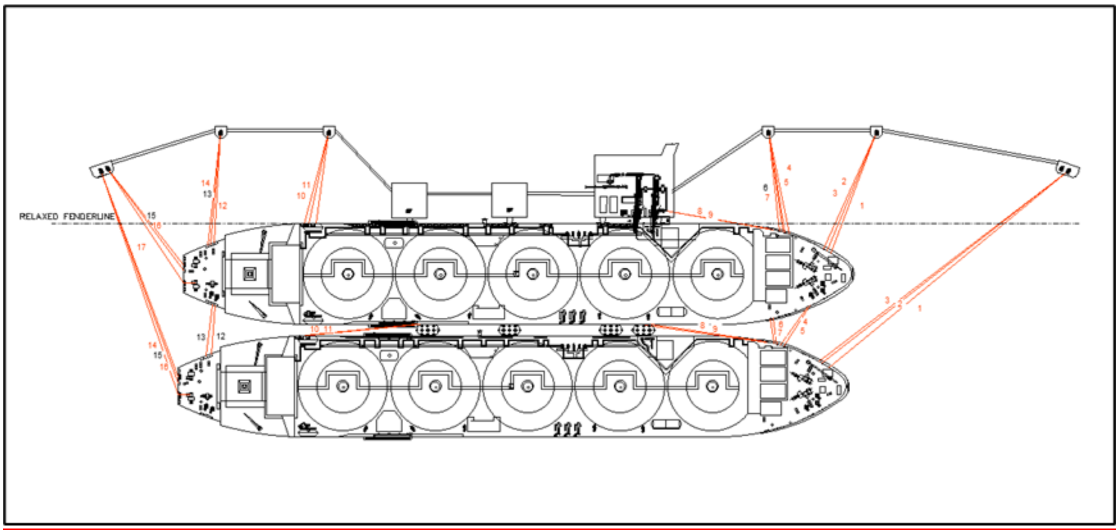


Figure 2-3 Typical LNGC Mooring Arrangement Alongside an FSRU

[8] Moffatt and Nichol Berthing Analysis Dated 3rd April 2020 – page 18.

2.6 FENDERING

It is proposed to fender the LNGC alongside the FSRU as shown in **Figure 2-4** using 4 large 'Yokohama' pneumatic type fenders (4.5m diameter and 9.0m long).

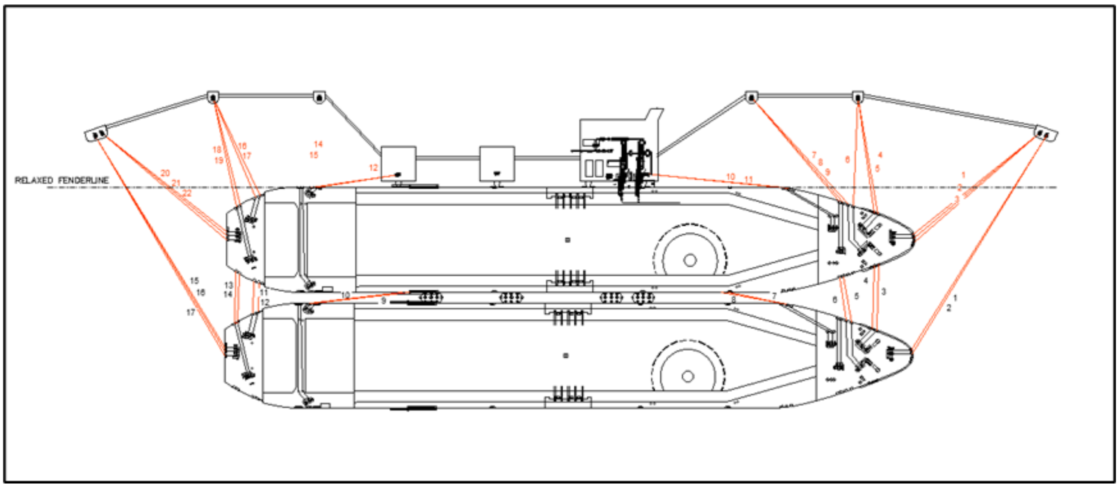


Figure 2-4 Proposed LNGC Fendering Arrangement

2.7 TOWAGE

There is already one well established towage provider which has been licensed by SFPC operate on the Shannon Estuary; however SIGTTO LNG guidance stipulates that a dedicated towage and firefighting capability is required for an LNG terminal. Accordingly, the developers have indicated that they will seek tenders from tug operators for the provision of four new tractor type tugs of about 70 tons bollard pull each.

2.8 LNG NAVIGATION TRACK

A Q-Max LNGC is 345m long, 54m wide and has a maximum operating draught of 11.5m. Although large ships, they are relatively modern, have two shafts and two rudders and can be considered to be more "manoeuvrable" than other similar sized ships. It is planned to board the Shannon pilots onto an arriving LNGC at Pilot Station Number Two which is about 1.5 nm to the east north- east of the Ballybunnion AIS / Racon Buoy.

The proposed LNGC navigation track from Pilot Station Number Two to the LNG jetty at Ardmore Point is a distance of approximately 12 nautical miles and an LNGC would normally expect to be 'all-fast' alongside approximately 2 hours after picking up the pilot. Accordingly, it is expected that the LNGC will be arriving at the pilot station 3 – 3.5 hours before HW Tarbert to be making the final approach to the berth with the flood tide still running.

From the pilot station there is a minimum depth of 16.3m over the Ballybunnion Bar. The LNG Carrier must then make a turn to port of almost 20º from 065º onto the entrance channel leading lights bearing 047°. This channel has a minimum width of 400m and is marked by buoys on both sides. Depths are in excess of 20m. At the Beal Bar Buoy, a vessel needs to turn to starboard approximately 45º and to leave the Doonaha to port. The depth of water from here to North Carrig is also in excess of 20m.

Between the Bear Bar and the North Carrig, only the port side of the deep water is marked, although there is also enough navigable water to the north of these marks almost as far as the Rineanna Buoy. The starboard side of the channel, however, is not marked, and for this reason inbound vessels tend to stay closer to the port side of the channel. Whilst this is contrary to normal practice it does not cause conflict, provided that another deep draught vessel is not outbound at the same time. The channel takes a slight deviation to the south around Asdee buoy before reaching the second pinch point at the Carrig Shoals.

Between Scattery and Carrig Islands the channel width reduces to 650m. The channel is marked by the Rineanna Port Buoy to the north and the North Carrig Buoy to the south. Minimum depth is 17.7m, although much shallower water does exist on Carrig Shoals. Again, deep draught vessels tend to keep to the port hand side of the channel.

Once past the North Carrig Buoy there are no further restrictions before the berth. There is approximately 1 mile (1,852m) between Money Point and the LNG jetty, and thus plenty of sea room in which to turn the vessel to starboard onto the berth. It should be noted, however, that shallow water does exist in Glencloosagh Bay approximately 1,000m up stream of the berth; this is sometimes used as a small ship anchorage. Tarbert Oil jetty is 2 miles away from the proposed jetty.

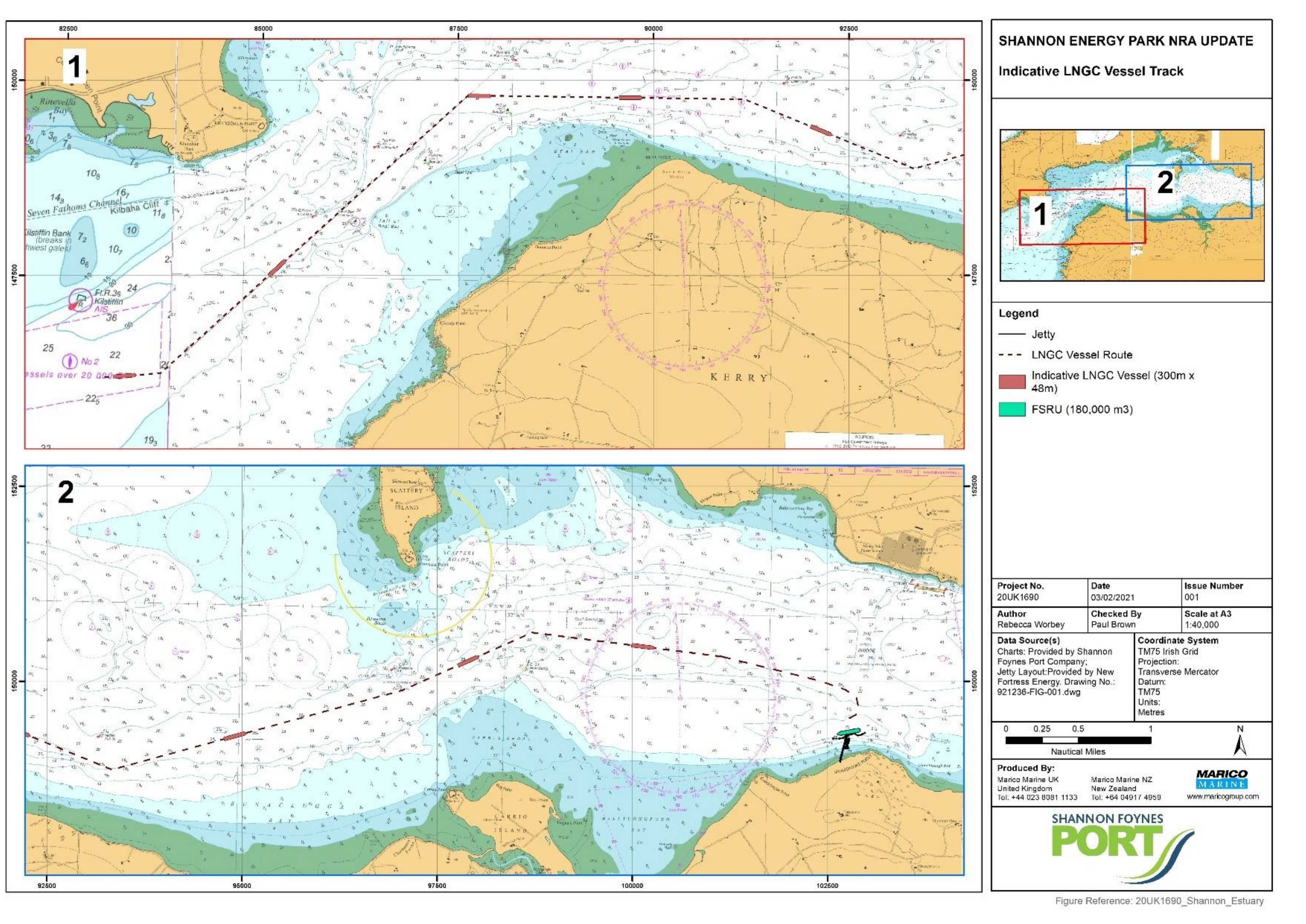


Figure 2-5: Indicative LNGC Vessel Track

2.9 LNGC BERTHING

The simulations undertaken at National Maritime College of Ireland (NMCI) in 2009 indicated that the preferred berthing approach would be to turn an LNGC in the estuary and berth it on the jetty with the bows heading west, stemming the flood current, with 4 tugs in attendance (numbered 1 to 4 from forward to aft). In consultation with Shannon Pilots, the berthing process is anticipated to consist of three distinct stages: the swing, entry to the jetty pocket and berthing as shown at **Figure 2-6**.

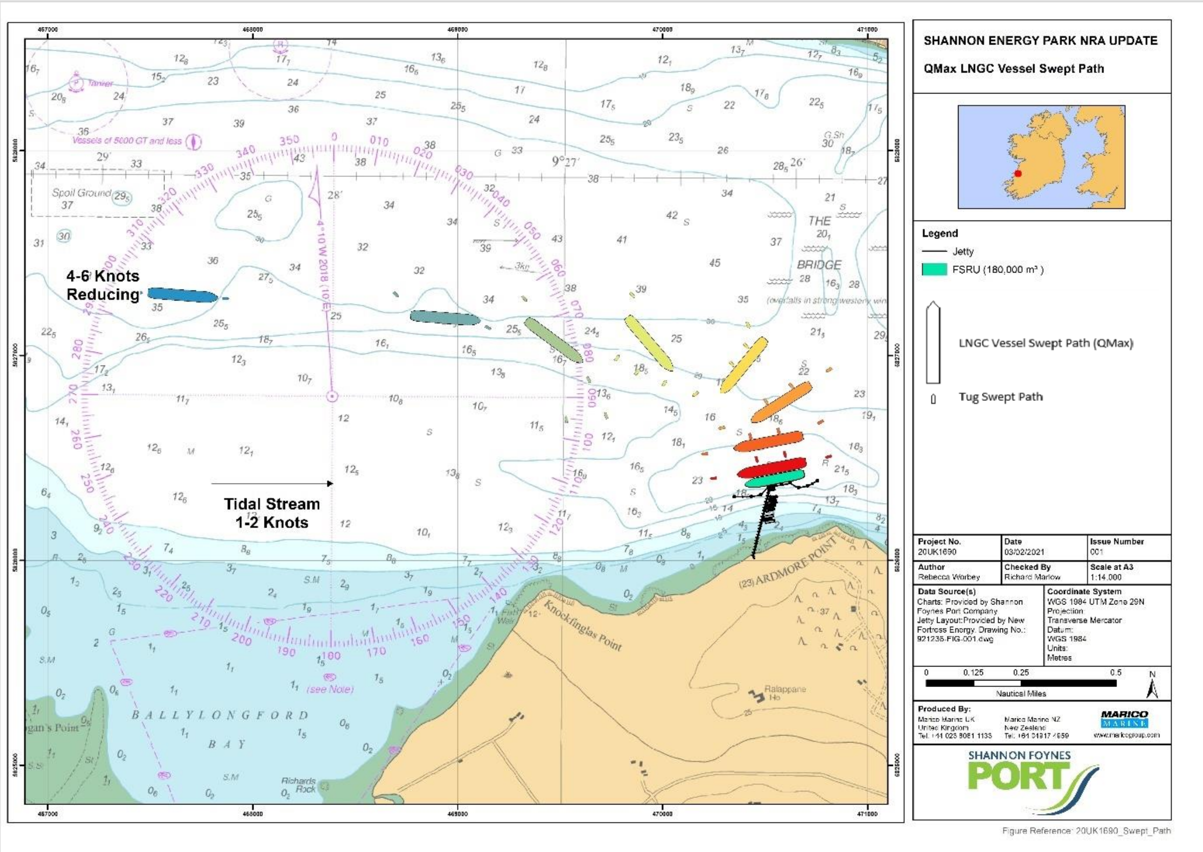


Figure 2-6: LNGC Berthing Plan

The Swing

Point 1: Heading approximately 095° past the North Carrig Buoy slowing down from passage speed of 8- 12 knots to about 4 knots. Aiming to approach the turn point about 1,200m north of the berth. Tug 4 centre lead astern and acting as a brake for the ship, Tug 1 centre lead forward on a slack line.

Point 2: Stop engines, helm hard to starboard and adjust swing with tugs such that the jetty appears right ahead on a course of about 180°. Tug 4 on port quarter, Tug 1 on starboard bow initiating. Tug 2 and 3 standing by on the starboard side.

Jetty Pocket

Point 3: Continue the swing into the jetty pocket until on an approximate heading of 230° at about 400m from the jetty.

Point 4: Maintain this heading (30° to the berthing line) crabbing slowly towards the jetty with the flood tide on the starboard bow. Tugs 2 and 3 to assist with the push into position.

Berthing

Point 5: When about 100m off the jetty, align the ship to the jetty face using tugs 2 and 3 to push alongside. Tugs 1 and 4 will control movement of the LNGC fore and aft.

Point 6: In conditions where the wind has a strong southerly component, release the tug 1 and reposition it in push/pull mode next to tugs 2 and 3 to assist in pushing the LNGC alongside.

2.10 SHIP UN-BERTHING AND DEPARTURE

For departure, once the pilot is on board and the tugs have been made fast (tug 1 centre lead forward, tug 2 and 3 midships push / pull and tug 4 centre lead aft), the mooring hooks will be released in a predetermined sequence that will have been agreed with the Pilot, Master and the Berthing Master – depending on the strength and direction of the wind. The ship will always be departing on a flooding tide so it is likely that the last lines will be the back spring (stopping the ship from being swept backwards by the current) and the intention will be for the ship to be pulled clear, remaining parallel to the berth. Once sufficient clearance is gained away from the FSRU (at least 50m) the mid ships tugs can be let go and the vessel be allowed to make headway into the estuary.

Initially it is expected that SFPC will stipulate that 4 tugs will always be required for departure until the pilots and the Harbour Master gain confidence in handling of the LNGCs. The outward passage will, in most respects, be a reversal of the inward passage with one tug in attendance ahead of the LNGC and an escort tug attached centre lead aft until the passage down the Beal Bar channel is complete. The pilot will then disembark, and the ship will head for the open Atlantic, typically having been at the berth for approximately 48 hours.

3 BASELINE NAVIGATION SCENARIO

3.1 SHANNON ESTUARY

The Shannon Estuary comprises 500 square kilometers of navigable water extending from Loop Head, in County Clare, and Kerry Head, in County Kerry, eastwards to the city of Limerick, a distance of 100 kilometers. The naturally occurring deep and sheltered waters of the estuary are accessible to large ocean-going vessels of varying types and sizes of up to 185,000 DWT.

Recognised internationally and nationally as one of the three core ports on the island of Ireland, SFPC's location provides for a highly accessible port with good road connectivity and rail access. The port facilities are of national importance and this is reflected in the fact that 37% of Ireland's bulk traffic transits the estuary every year, making SFPC the largest bulk port in the country and the second largest port based on tonnage. Within the estuary there are currently six main shipping facilities handling approximately 830 ships per year amounting to a total of 10 million DWT of shipping activity. Three of the facilities - Foynes, Limerick Docks and Shannon Airport Jetty - are owned by SFPC, whereas, the other three dedicated terminals are privately owned, including the Moneypoint coal import facility, Tarbert Island for heavy fuel oil and Aughinish for bauxite imports and alumina exports.

The Shannon Estuary has several designated anchorages on the seaward side of Scattery Island in the lower estuary with depths ranging between 6-32 metres catering for vessels ranging between 8 – 17.4m draught.

3.2 SHANNON FOYNES PORT COMPANY

Shannon Foynes Port Company (SFPC) is the Statutory Harbour Authority and has jurisdiction and responsibility for all commercial maritime activities on the Shannon Estuary between Shannon Bridge in Limerick City and an imaginary line at the mouth of the estuary joining Loop Head in County Clare to Kerry Head in County Kerry.

SFPC has the authority to issue Byelaws pursuant to Section 42 of the Irish Harbours Act, 1996 – 2000; the current Byelaws came into effect on 10 November 2004. The Harbour Master is vested with the authority to issue 'Directions' to the masters of vessels arriving, departing, or lying within the port.

3.2.1 Vessel Traffic Management

SFPC does not provide Vessel Traffic Services; it does, however, generate a Vessel Traffic Management Information System (VTMIS) employing three radar stations at Loop Head, Kilcredaun Head and

Tarbert Point, and AIS to observe, record and replay traffic movements in the estuary. Where necessary, pilots can give verbal assistance to inward and outward-bound ships as required using radar and VHF.

3.2.2 Towage

There are three tractor tugs with fire-fighting capabilities licensed to operate in the Shannon Estuary based at Foynes. Mooring boats and gangs are independently contracted to terminal owners and ship operators.

3.3 PILOTAGE

The detailed arrangements and management for the conduct of pilotage in the estuary are set out in the SFPC Pilotage manual. SFPC oversees the training and licensing of all 8 Shannon pilots, who work from Kilrush and use a 13m pilot boat capable of 20 knots. Pilotage is compulsory for all vessels over 50GT navigating eastwards of Scattery Island. There are 4 separate pilot boarding stations each catering for differing sizes and tonnages of vessel:

- Number 1 station is for vessels with a draught of over 13m and is located to the west of the Ballybunnion Bar Racon / AIS buoy;
- For vessels over 20,000 GT but less than 13m draught, pilot station number 2 lies south and west of the Kilstiffin buoy and is generally considered to be more sheltered for boarding; and
- Pilot stations 3 and 4 lie within the estuary and are for vessels under 20,000GT and 5000GT, respectively.

3.3.1 PPUs

Each of the Shannon Pilots uses a Navicom Dynamics Channel Pilot 3, a Portable Pilot Unit to provide live situational awareness during pilotage. Used with the Wärtsilä Pilot Pro software, this system provides a light, reliable and robust backup to the pilot and routinely delivers positional accuracies of 50cm or less. In addition, the system has its own AIS receiver which “handshakes” with the parent ship’s AIS, to augment the accuracy of the PPU but also to present the pilot with live estuary traffic awareness. The “route follow” and “docking” modes of the Wärtsilä software are perfectly suited to support the pilot during estuary pilotage and especially for assessing the progress of the LNGC turn towards the jetty.

3.4 MET-OCEAN CONDITIONS

Met-Ocean conditions are considered in detail in the Moffatt and Nichol mooring analysis. In summary, predominant wind directions are in the south to west sectors at the project site, with speeds expected to exceed 25.6 knots for 10% of the time and 38.5 knots for 1% of the time. Wave heights greater than 1.0m are expected to occur approximately 8% of the time with relatively low peak periods. There is a tidal range of 4.0m at the project site and peak tidal streams are approximately 3.1 knots (1.6m/s) at maximum spring tides and 2.3 knots (1.2m/s) for neaps.

Table 3: Indicative Tidal Heights – Shannon Estuary May 2020 (Admiralty Total Tide)

Date (May 2020)	High	Height (m)	Low	Height (m)
05	04:40	4.7	10:54	0.3
	17:16	5.0	23:17	0.4
06	05:29	5.0	11:40	0.1
	18:01	5.2	-	-
07	06:15	5.2	00:02	0.1
	18:44	5.3	12:25	0.0
08	07:00	5.2	00:45	0.0
	19:26	5.3	13:07	0.1
09	07:45	5.1	01:26	0.1
	20:08	5.2	13:48	0.2
10	08:30	4.9	02:07	0.2
	20:50	4.9	14:29	0.5
11	09:15	4.6	02:48	0.5
	21:32	4.7	15:11	0.9
12	09:03	4.3	02:31	0.8
	21:18	4.3	14:56	1.2
13	09:59	4.0	03:19	1.1
	22:12	4.0	15:50	1.6
14	11:10	3.7	04:17	1.4
	23:19	3.8	17:02	1.8
15	12:32	3.7	05:32	1.5
	-	-	18:27	1.8
16	00:36	3.7	06:51	1.5
	13:44	3.8	19:38	1.7
17	01:45	3.8	07:57	1.4
	14:39	3.9	20:33	1.5
18	02:41	4.0	08:48	1.2
	15:23	4.2	21:17	1.3

4 DATA GATHERING

Data gathering has been undertaken to inform the assessment of the baseline navigation profile and NRA. The following input data has been utilised for the assessment:

- Stakeholder consultation feedback;
- One year's commercially sourced AIS Data: 01 January – 31 December 2019;[9]
- Vessel count data (Shannon Foynes Port Company); and
- RNLI callout data.

4.1 COVID 19

The NRA update was given approval to proceed by SFPC in mid-December 2020 at which time the entire UK and Ireland were in the third travel lockdown owing to the COVID 19 pandemic. Marico personnel would have travelled to Shannon Foynes to conduct a site visit, face to face stakeholder consultations and liaise directly with the Harbour Authority and the developer. The restrictions imposed meant that it was again necessary to conduct the NRA remotely, relying on electronic interactions with developer and stakeholders.

4.2 STAKEHOLDER CONSULTATION

Information was gathered through remote consultation with key local stakeholders, including the Harbour Master, to establish the baseline risk profile, and inform impact and hazard identification.

Stakeholders consulted as part of the NRA and the key impacts identified from each consultation are listed in **Table 4**. The minutes of the stakeholder meetings are contained within **Annex B**.

[9] For the 2021 NRS update it would have been normal to update the traffic survey with data from 2020. In consultation with the SFPC Harbour Master and considering the impact of COVID 19 on traffic levels, it was considered that the data from 2019 would be more representative of the baseline traffic volumes.

Table 4: Stakeholder Consultation Meetings Summary

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
2021 NRA Stakeholder Feedback			
Shannon Ferries (Email 05 February)	• No further comments at this time.	-	-
Marine Survey Office (Email 02 February)	• The MSO has no further comment other than already submitted via previous correspondence at this time.	-	-
Tarbert Island Maritime Club (Email 22 January)	• There are no issues arising that would change our first input. This would not affect our immediate area for boating and for those of us who wish to go out the Estuary there is very little navigation change, extra shipping traffic wouldn't be a concern.	Noted.	-
Carrigaholt Dolphin Watch (Email 15 January)	• No further observations beyond those offered last June.	-	-
Foynes Yacht Club (Email 13 January)	• No further comments.	-	-

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
Aughinish Alumina Limited (Email 13 January)	• No further comments.	-	-
NORA (Email 12 January)	• Due to the very limited level of shipping activity in which NORA engages into and out of Tarbert, the Agency is not sufficiently familiar with the navigational profile to assess the navigational risks that might exist at present, or in the future, in the event of shipping of LNG.	-	-
	• I don't believe NORA have any navigational concerns resulting from the updates to the project.		
Irish Whale & Dolphin Group (IWDG) (Email 5 January)	• Risk associated with shipping such as collision, oil pollution etc are considered minor.	• Noted	-
	• The issues regarding increased noise associated with transiting and stationary ships both on jetties and on anchor are real and we know some of this will be addressed within the EIAR/AA of the proposed Shannon LNG application. Ocean noise is cumulative and may at some point reach a threshold which	• Noted	-

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
	impacts on dolphin communication and navigation or mask their vocalisations.	• Not navigationally significant. Impacts considered within the wider ES.	-
ESB Moneypoint	• No update received.	-	-
Shannon Ferries	• No update received.	-	-
Western Yacht Club	• No update received.	-	-
Kilrush Creek Marina	• No update received.	-	-
Angling and Fishing	• No update received.	-	-
Shannon Estuary Marine	• No update received.	-	-
2020 NRA Stakeholder Feedback			
Shannon Pilots (Email 1st May) (Teleconference 26th May)	• Submarine cables have been and will be laid 1 nm to the east of the intended position of the LNG terminal.	• Hazard 'Cable Snagging' assessed within risk assessment.	**Annex B**
		• 'Restrict Anchoring in Vicinity of Submarine Cables' added as a possible additional risk control measure.	**Section 9** **Annex B**
	• Dolphin watching, fishing and yachting takes place in	• Risks to small passenger, fishing and recreational vessels assessed within the risk assessment.	**Section 4.3** **Annex B**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
	this part of the estuary, but usually in the summer months only.	• Consultation undertaken with dolphin watch, fishing and yachting consultees to inform baseline assessment of risk.	**Table 4** **Annex B**
		• 12 months supporting AIS data obtained to assess seasonal variations.	**Section 4.3**
	• Recommend using pilot boarding area No 2 south of the Kilstiffin Buoy. Always ensuring that there is enough sea room to allow time for the pilot to get from the ladder to the bridge of the ship.	• The imposed arrival berthing limitations of no more than 25 knots of wind at the berth means that in these conditions No 2 station is likely to be tenable.	**Table 8**
		• 'Arrival Preconditions' added as a possible additional risk control measure.	**Section 9**
		• 'LNGC Passage Plan' added as a possible additional risk control measure.	**Section 9**
	• The abort entry position for the ship would likely be the Ballybunnion Racon Buoy.	• 'Arrival Preconditions' added as a possible additional risk control measure.	**Section 9**
		• 'LNGC Passage Plan' added as a possible additional risk control measure.	**Section 9**
	• What would be the limitations on when the LNGC has to stop transferring cargo and would have to sail / under what weather conditions would there be a	• 'Define Marine Operating Thresholds' added as a possible additional risk control measure.	**Section 9**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
	requirement for the FSRU to sail?	• 'Install Storm Wire' added as a possible additional risk control measure.	**Section 9**
		• Navigational risks associated with transit of the FSRU assessed within vessel category 'Project Vessels'.	**Annex A** **Annex B**
	• As these are large ships with a high freeboard, they may set heavily in windy conditions, therefore requiring the pinch points on the estuary to be clear of all traffic.	• 'Mobile Control Zone' added as a possible additional risk control measure.	**Section 9** **Annex B**
	• Simulation training for berthing alongside a FSRU would be desirable.	• 'Additional Ship Pilotage and Berthing Simulations' added as a possible additional risk control measure.	**Section 9** **Annex B**
ESB Moneypoint Email 1 May Teleconference 28 May	• The subsea transmission electrical cable from Moneypoint to southern shore lies on the turning track for LNG supply vessels approaching the new jetty.	• Assessment of the turning track for the LNGC has established that it is at least 1nm separated from the cables.	**Figure 2-6**
		• Hazard 'Cable Snagging' assessed within risk assessment.	**Annex B**
		• 'Restrict Anchoring in Vicinity of Submarine Cables' added as a possible additional risk control measure.	**Section 9** **Annex B**
	• Primary concern is the navigational risks in the vicinity of the main and small jetties at Moneypoint.	• Hazard 'Contact: Non-Project Infrastructure' assessed within risk assessment.	**Annex B**
	• Will the presence of the LNG terminal push other ships closer to Moneypoint?	• Hazard 'Contact: Non-Project Infrastructure' assessed within risk	**Annex B**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
		assessment.	
		• AIS data obtained to establish baseline distribution and frequency of passing vessel traffic.	**Section 4.3**
	• Will there be any increase in wash from passing vessels coming closer to Moneypoint?	• The navigable channel (i.e. deeper than 15m) at Ardmore Point is over 1 nm wide – LNGCs will be turning at least 0.5nm south of the Moneypoint terminal and at speeds of less than 4 knots and so it is anticipated that wash will be minimal.	**Section 2.8**
	• Tug availability – would new terminal reduce availability of present harbour tugs?	• Tug provision at the LNG terminal will be in addition to that already provided for and by SFPC. It is, therefore, likely that tug provision will be increased.	**Section 2.7**
	• Will there be impacts and delays to Moneypoint vessel scheduling?	• LNGC's will be one vessel per week.	**Section 2**
		• If two ships arrive on the same tide then normal HM prioritisation rules will apply.	**Table 8**
		• LNG ships are planned to arrive at the berth 1 hour before HW. Moneypoint vessels arrive at their berth at HW and so will deconflict.	**Section 2.8**
SSE Tarbert	• Declined to participate.	-	-

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
Email 1 May Teleconference 26 May			
NORA Email 1 May Teleconference 26 May	• The frequency of shipping into or out of the terminal is very low. This is perhaps best indicated by the fact that NORA has not had any shipping into or out of the terminal since the initial importation of oil stocks in 2012.	• AIS data obtained to establish baseline distribution and frequency of passing vessel traffic.	**Section 4.3**
Aughinish Alumina Terminal Email 1 May Teleconference 26 May	• Are there exclusion areas during manoeuvring of LNG ships?	• 'Mobile Control Zone' recommended as a possible additional risk control measure.	**Section 9** **Annex B**
	• Are there exclusion areas during ship to ship transfers of LNG?	• 'Static Control Zone' recommended as a possible additional risk control measure.	**Section 9** **Annex B**
	• Aughinish Alumina ships frequently utilize anchorages. There are concerns that the addition of the LNG ships will cause overcrowding.	• The project anticipates 1 LNGC ship arriving per week and so congestion is not anticipated.	**Section 2**
		• 'Arrival Preconditions' recommended as a possible additional risk control measure.	**Section 9**
		• 'Define Marine Operating Thresholds' recommended as a possible additional risk control measure.	**Section 9**
	• Concerns over pilot availability.	• LNGC transits will be of low frequency at 1 ship a week.	**Section 2**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
		• Consultation undertaken with Shannon Pilots.	**Table 4** **Annex B**
	• Aughinish Alumina considers the hazard breakout to carry the greatest potential risk to its operations.	• Hazard 'Mooring Incident / Breakout' assessed as part of risk assessment.	**Annex B**
		• 'Install Storm Wires' recommended as a possible additional mitigation measure.	**Section 9** **Annex B**
		• 'Jetty Security Measures' recommended as a possible additional mitigation measure.	**Section 9** **Annex B**
		• 'Arrival Preconditions' recommended as a possible additional risk control measure.	**Section 9** **Annex B**
		• 'Define Marine Operating Thresholds' recommended as a possible additional risk control measure.	**Section 9** **Annex B**
	• Will daylight only operations apply?	• 'FSU Daylight Berthing' recommended as a possible additional mitigation measure.	**Section 9** **Annex B**
Shannon Ferries Email 1 May Teleconference 26 May	• Greatest navigational risks exist adjacent to the line between Tarbert and Moneypoint as this is immediately adjacent to our plying limits.	• 'Collision: Project Vessel ICW Small Passenger Vessel' assessed as part of risk assessment.	**Annex B**
	• Hazards associated with breaking of moorings / drifting vessels considered to be of greatest risk to Shannon Ferries.	• LNG FSU and supply vessel mooring lines are rated up to 60 knots. If the forecast weather conditions exceed this, then the LNGC will sail to anchor	

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
		or lie offshore.	
		• Hazard 'Mooring Incident / Breakout' assessed as part of risk assessment.	**Section 9 Annex B**
		• 'Install Storm Wires' recommended as a possible additional mitigation measure.	**Section 9 Annex B**
		• 'Jetty Security Measures' recommended as a possible additional mitigation measure.	**Section 9 Annex B**
		• 'Arrival Preconditions' recommended as a possible additional risk control measure.	**Section 9 Annex B**
		• 'Define Marine Operating Thresholds' recommended as a possible additional risk control measure.	**Section 9 Annex B**
	• Fire or explosion could also be of high consequence to river users including Shannon Ferries.	• Hazard 'Fire / Explosion' assessed as part of risk assessment.	**Section 9 Annex B**
		• 'Update Emergency Plans' recommended as a possible additional mitigation measure.	**Section 9 Annex B**
		• 'Use of Appropriate LNG Tugs' (with fire-fighting capability) recommended as a possible additional mitigation measure.	**Section 9 Annex B**
	• Increased traffic frequency will give rise to increased navigational risk.	• LNGC transits will be of low frequency at 1 ship a week.	**Section 2**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
Commissioner of Irish Lights Email 1 May No Response	• Declined to participate.	-	-
Irish Coast Guard Email 1 May Teleconference declined on account of Statutory Planning responsibilities	• "We would not have comment or observation at this stage, again comment from the Irish Maritime Administration on the assessment lies principle within the competency of the MSO." • "However, we would like to draw your attention to the statutory requirements for robust contingency planning arrangements for such facilitates in respect to preparedness and response."	• 'Update Emergency Plans' recommended as a possible additional mitigation measure.	**Section 9** **Annex B**
Irish Marine Survey Office Email 1 May Teleconference offered but declined.	• Inclusion of additional aids to navigation in the channel.	• 2008 NRA recommendation to relocate the Doonaha buoy and the Beal Bar Buoy carried out by SFPC.	**Table 8**
		• It is considered that narrows at Kilcredaun Point are already well buoyed and with a good set of leading lights.	**Section 3**
	• Additional training for pilots / tug masters.	• 'Additional Simulations' recommended as a possible additional risk control measure.	**Section 9**
	• Emergency response training.	• Emergency Response training already	

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
		in place for SFPC staff.	**Section 9**
		• 'Update Emergency Plans' recommended as a possible additional risk control measure.	
	• Establishment of visual readouts to provide real-time information on wind speed and direction, speed of approach, current and tidal information etc.	• 'Use of Centimetric PPU for Berthing' recommended as a possible additional risk control measure.	**Section 9**
	• Consideration of under keel clearance at the pinch point shallows.	• The LNGC are anticipated to be arriving with draught of 11m and are planned to arrive at the berth 1 hour before HW.	**Section 2**
		• Hazard 'Grounding: Project Vessel' assessed within risk assessment.	**Annex B**
	• Speed restrictions of passing traffic.	• The estuary is wide enough to allow a safe passing distance. The channel at Ardmore point is over 1 mile wide and therefore, speed restrictions are not considered necessary.	-
	• Development of mooring plans.	• Hazard 'Mooring Incident / Breakout' assessed within risk assessment.	**Annex B**
		• 'FSRU Daylight Berthing' recommended as a possible additional risk control measure.	**Section 9**
		• 'Install Storm Wires' recommended as a possible additional risk control measure.	**Section 9**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
	• Fendering to comply with ISO standards.	• 'Review of FSRU Fendering Requirements' recommended as a possible additional risk control measure.	**Section 9**
	• Contingencies to ensure expeditious response to mother and daughter vessels being able to vacate the berth in response to any possible security, fire or other significant threat.	• Hazard 'Fire / Explosion' assessed within risk assessment.	**Annex B**
		• 'Update Emergency Plans' recommended as a possible additional risk control measure.	**Section 9**
	• Enhanced VTS management.	• The appropriateness of the 2008 recommendations concerning VTS were reviewed and are discussed at Annex C.	**Annex C**
Royal Western Yacht Club, Kilrush Email 10 May Teleconference 29 May	• The navigation risks are resulting from the project are thought to be minimal.	• All navigation major navigation hazard types and vessel types have been assessed within the NRA.	**Annex B**
	• Good communication will need to be maintained between the Yacht Club, SFPC and the Pilots.	• 'Corporate Communications' recommended as a possible additional risk control measure.	**Section 9**
		• 'Operational Communications' recommended as a possible additional risk control measure.	**Section 9**
	• Main risk factors are considered to be explosion and fire during offloading at the LNG terminal.	• Hazard 'Fire / Explosion' assessed as part of NRA.	**Section 9**
	• RWYC expressed concern with regard to visiting recreational vessels not knowing about the LNG ships and the potential control zones.	• Navigational risks to recreational vessels, including visiting vessels, assessed against all key accident	**Annex B**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
		categories.	
		• Update navigational chart recommended as a possible additional risk control measure.	**Section 9**
		• Corporate communications recommended as a possible additional risk control measure.	**Section 9**
Kilrush Creek Marina Email 10 May Teleconference 28 May	• Collision risk not considered high but would want to consider the effect of the introduction of more ships navigating the lower Shannon Estuary.	• Collision hazards were assessed for all vessel types within the NRA.	**Annex B**
		• 12 months supporting AIS data obtained to establish baseline transit frequencies.	**Section 4.3**
Tarbert Island Maritime Club Email 10 May Teleconference 28 May	• No major concerns expressed. • Concentrations of shipping at the narrows mentioned as a minor concern.	• Collision hazards were assessed for all vessel types within the NRA.	**Annex B**
		• ‘Shipping Schedule Deconfliction’ recommended as a possible additional risk control measure.	**Section 9**
Angling and fishing Email 10 May	• More ships with restricted ability to maneuver will add to risk.	• ‘Shipping Schedule Deconfliction’ recommended as a possible additional risk control measure.	**Section 9**

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
Teleconference 28 May	• Potting takes place primarily in the narrows. Pots are always laid outside of the channel. Concerns were raised over the ability of fishing vessels hauling gear / at anchor to respond quickly in response to an approaching LNG vessel, particularly if a control zone is enforced.	• 'Mobile Control Zone' recommended as a possible additional risk control measure. • It is expected that initially, the control zone will be enacted as a Shannon Harbour Masters 'Special Direction' for each vessel movement and supported by a widely published rolling Notice to Mariners, VHF broadcast and a website notification.	**Section 9**
		• 'Corporate Communications' recommended as a possible additional risk control measure.	**Section 9**
Foynes Yacht Club Email 10 May Teleconference 28 May	• FYC expressed concern with regard to visiting yachtsmen not knowing about the LNG ships and any potential control zones.	• 'Corporate Communications' recommended as a possible additional risk control measure.	**Section 9**
Irish Whale and Dolphin Group Email 1 May Teleconference 26 May	• No major navigational concerns expressed. • No vessels operated by the group. • Concentrations of shipping at the narrow mentioned as a minor concern.	• 'Shipping Schedule Deconfliction' recommended as a possible additional risk control measure.	**Section 9**
Shannon Estuary **Marine**	• Consider any additional navigation risk due to the introduction of LNG ships to be negligible; due to the sheer size of the Shannon Estuary and low frequency of transits.	-	-

	Key Comments / Navigation Concerns	NRA Response	NRA Reference
Email 11 May Teleconference 29 May			
Carrigaholt Dolphin Watch Teleconference 3 June	• Concerns were expressed over a potential control zone, but if this is the global norm then it was agreed a work around would be feasible.	• 'Mobile Control Zone' recommended as a possible additional risk control measure. • It is expected that initially, the control zone will be enacted as a Shannon Harbour Masters 'Special Direction' for each vessel movement and supported by a widely published rolling Notice to Mariners, VHF broadcast and a website notification.	**Section 9**
	• Dolphin watch vessel routinely works around the Kilcredaun Narrows – but Master is commercially certified and used to working such that they do not impede the passage of larger more constrained vessels.	• 'Shipping Schedule Deconfliction' recommended as a possible additional risk control measure. • 'Corporate Communications' recommended as a possible additional risk control measure.	**Section 9**

4.3 VESSEL TRAFFIC ANALYSIS

For the 2020 NRA, one year of commercially sourced Automatic Identification System (AIS) data was obtained to enable the assessment of the baseline traffic profile within the Shannon Estuary and in the vicinity of the Project to establish any potential impacts the Project may have upon the existing navigation profile.

AIS vessel traffic dataset was sourced for the 12-month period between 01 January 2019 and 31 December 2019 to ensure that seasonal trends are captured and is composed of both terrestrial and satellite AIS vessel positions.

In discussion with the Harbour Master for SFPC, it was agreed that the traffic data obtained above for 2019 would be used for the 2021 NRA update as it was felt that the 2019 data would be more representative – 2020 being an unusually quiet year with marine traffic being significantly subdued by the COVID-19 pandemic and the associated restrictions.

Vessels have been assessed by vessel type in categories befitting vessel operations within the Shannon Estuary within **Figure 4-1** to **Figure 4-3**.

4.3.1 Tankers

The tracks of tankers are shown within **Figure 4-1**. The plot demonstrates that tankers operate along a well-defined passage within the main channel, from which they diverge to utilise anchorages to the west and east of Scattery Island. The frequency of tanker transits is low. During the 12 months assessed, 212 tankers transited past the Project equating to an average of 18 per month, or approximately one every other day. The most frequent passing tanker was 115m LOA oil/chemical tanker THUN GENIUS which accounted for 23 transits or approximately two per month.

4.3.2 Dry Cargo Vessels

The tracks of dry cargo vessels are shown within **Figure 4-1**. 1,230 dry cargo vessels transited past the Project in 2019, or approximately 103 vessels per month, or 3 per day. The largest passing cargo vessels were 292m LOA AQUA CRYSTAL followed by 235m LOA bulker OLYMPIC GLORY.

Similar to the tankers, the dry cargo vessels operate along a well-defined passage within the main channel, from which they are noted diverging to utilise the anchorages to the west and east of Scattery Island. 36 transits are noted diverging to the south of the main channel in the vicinity of Ardmore Point; this is a recognised Shannon Pilots tactic to take the ship out of the strongest tidal stream and into a favourable counter eddy. Of these diverging ships, 8 transited within 150m of the proposed FSRU location, the largest of which was 223m LOA bulk carrier PANAMAX OTTER.

Example dry cargo and tanker vessel destinations within the Shannon Estuary are detailed within **Table 5.**

Table 5: Example Tanker and Dry Cargo Destinations – Shannon Estuary

Destination	Visits per Year	Vessel Type
Tankers		
Shannon Airport fuel jetty	45	Typically, 6,500 DWT.
Tarbert Power Station	3	Typically, 20,000 DWT.
Cargo		
Limerick Port	220 - 240	5,000 DWT general cargo ships.
Aughinish Alumina	250	75,000+DWT Panamax bulkers (bauxite import).
	250	40,000 DWT (caustic import, process materials and supplies import and alumina export).
Foynes Port	320 -340	40,000 DWT general cargo ships, tankers and bulkers.
Moneypoint Power Station (coal)	1	150,000 DWT bulkers and up to 185,000 DWT maximum size.

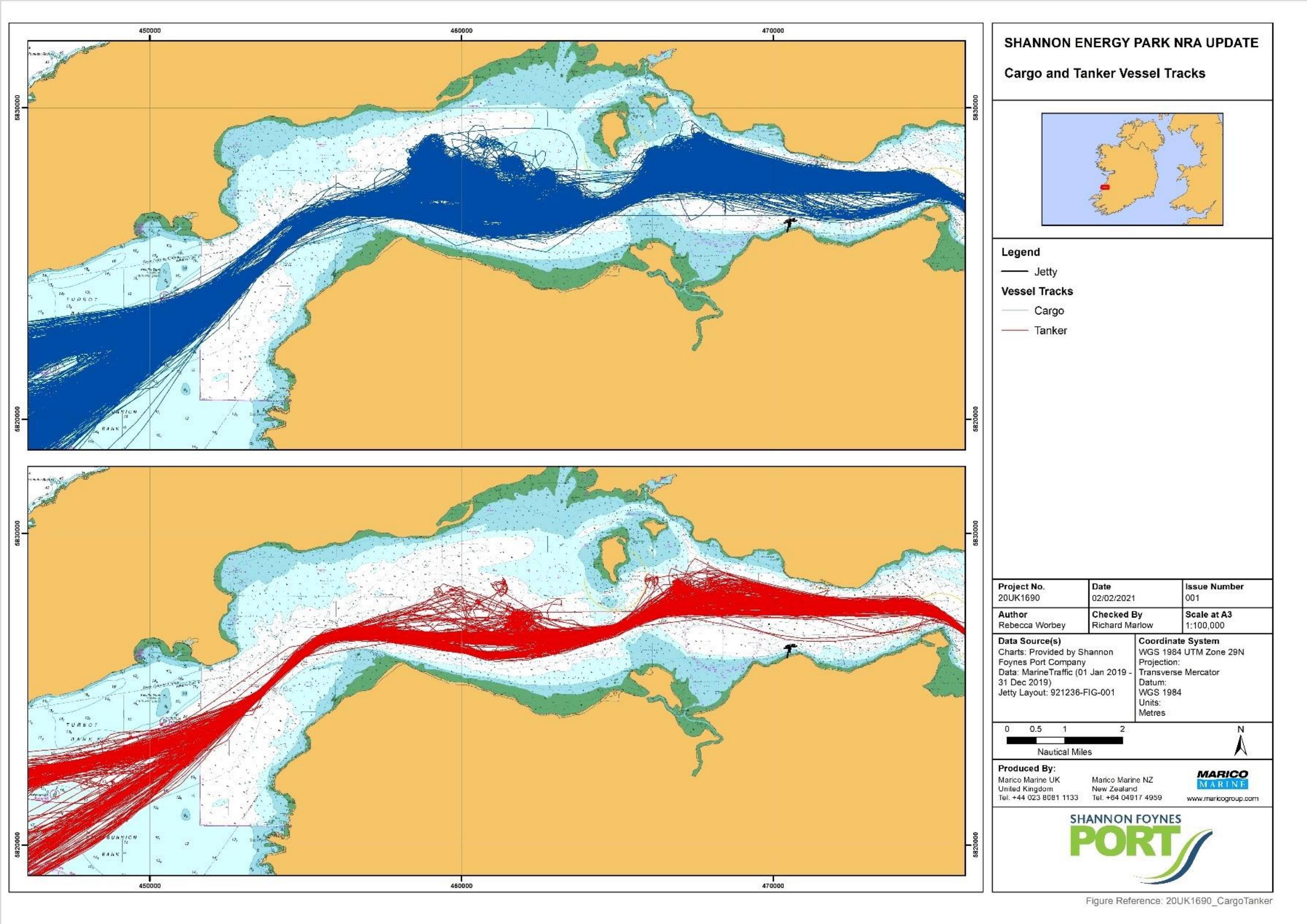


Figure 4-1: Tanker and Cargo Vessel Tracks

4.3.3 Passenger

A growing recreational marine activity is whale and dolphin watching, and trips now number over 500 per annum with the company Dolphinwatch operating their boat the "Draiocht" out of Carrigaholt. The estuary is home to more than 140 bottlenose dolphins.

Shannon Ferry Group operates a car ferry between Killimer and Tarbert. In winter, crossings are made once per hour in each direction and in summer a second ferry is brought into service, thus facilitating crossings every 30 minutes. The primary ferry is powered by four directional thrusters each of 600HP.

An area that SFPC wish to develop further, at present cruise ships of 250m or less make occasional port calls at Limerick and Foynes with a total of three cruise vessels visiting in 2019.

Table 6: Passenger Vessels that passed Ardmore Point - 2019

Vessel	Vessel Type	LOA (m)	Month of Visit
ILEN	Sailing Vessel	15	June
PRINSENDAM	Cruise	203	June
SEABOURN QUEST	Cruise	198	July

4.4 RECREATIONAL VESSELS

Seven recreational vessels passed Ardmore Point over the course of 2019; of these five were sailing vessels and two were pleasure craft, the largest of which was 18m LOA MYK. All transits occurred within May and August with the exception of one in January. One recreational vessel transited within 150m of the proposed FSRU location within the 12 months of assessed AIS data.

It should be noted that there is no requirement for recreational vessels to carry AIS, however, some may do so on a voluntary basis. The AIS data may therefore, under-represent the baseline recreational traffic level. Consultation with recreational stakeholders was undertaken to ensure the identification of any potential data gaps and determined that the data was reflective of the recreational vessel traffic profile.

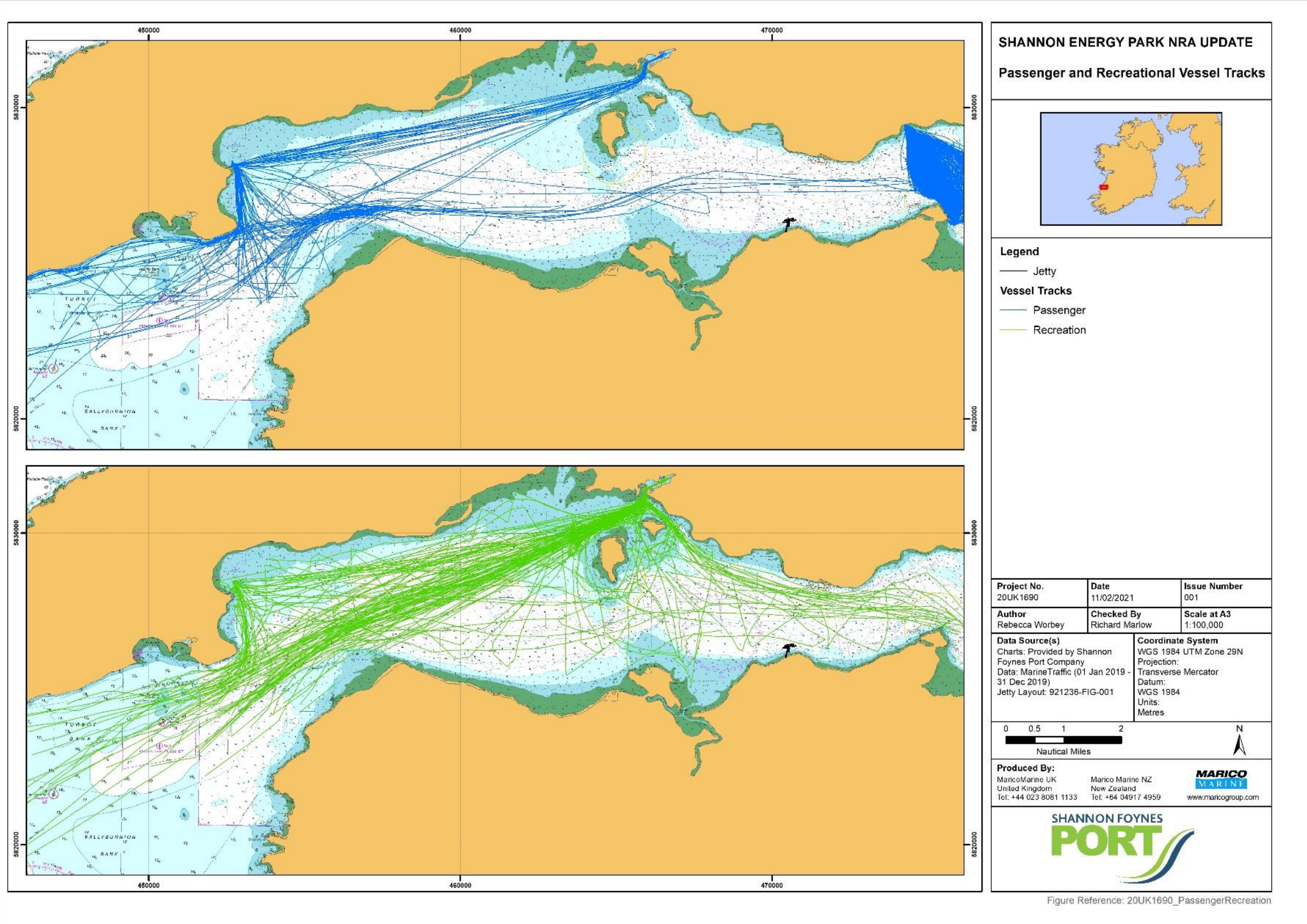


Figure 4-2: Passenger and Recreational Vessel Tracks

4.4.1 Small Commercial and Port Services

137 transits by 13 unique vessels were made by small commercial and port services vessels (including tugs, workboats and RNLI vessels) past Ardmore Point over the course of the 12-month data period, equating to approximately 11 per month, or less than one every other day. Most small commercial and port services vessel transits occurred in the vicinity of Scattery Island and through the narrows.

4.4.2 Fishing

Very few fishing vessels were identified within the assessed AIS data. One fish carrier (cargo vessel) 60m LOA fish carrier AQUA TRANSPORTER passed Ardmore Point over the course of the 12-months assessed data period. Similarly, to recreational vessels, small fishing vessels may not carry AIS and as such may be under - represented within the data analysis.

It was confirmed during stakeholder consultation that fishing activity within the estuary is minimal as the Shannon Estuary is designated a Special Conservation Area and as such, fishing on a commercial scale within the estuary is generally limited to shrimp and lobster pot fishing. Pots are normally laid in shallow water, well clear of the main shipping routes. It was reported during consultation that pots may occasionally be laid in the navigational channel for a few weeks in winter; however, the Shannon pilots have no experience of such practice causing an impediment to commercial navigation.

4.4.3 Military

81m LOA and 79m LOA military patrol vessels EITHNE and NIAMH were the only recorded military vessels to transit past Ardmore Point accounting for all nine independent military vessel transits. Although equipped with AIS, military vessels may choose not to transmit and as such, may be under-represented.

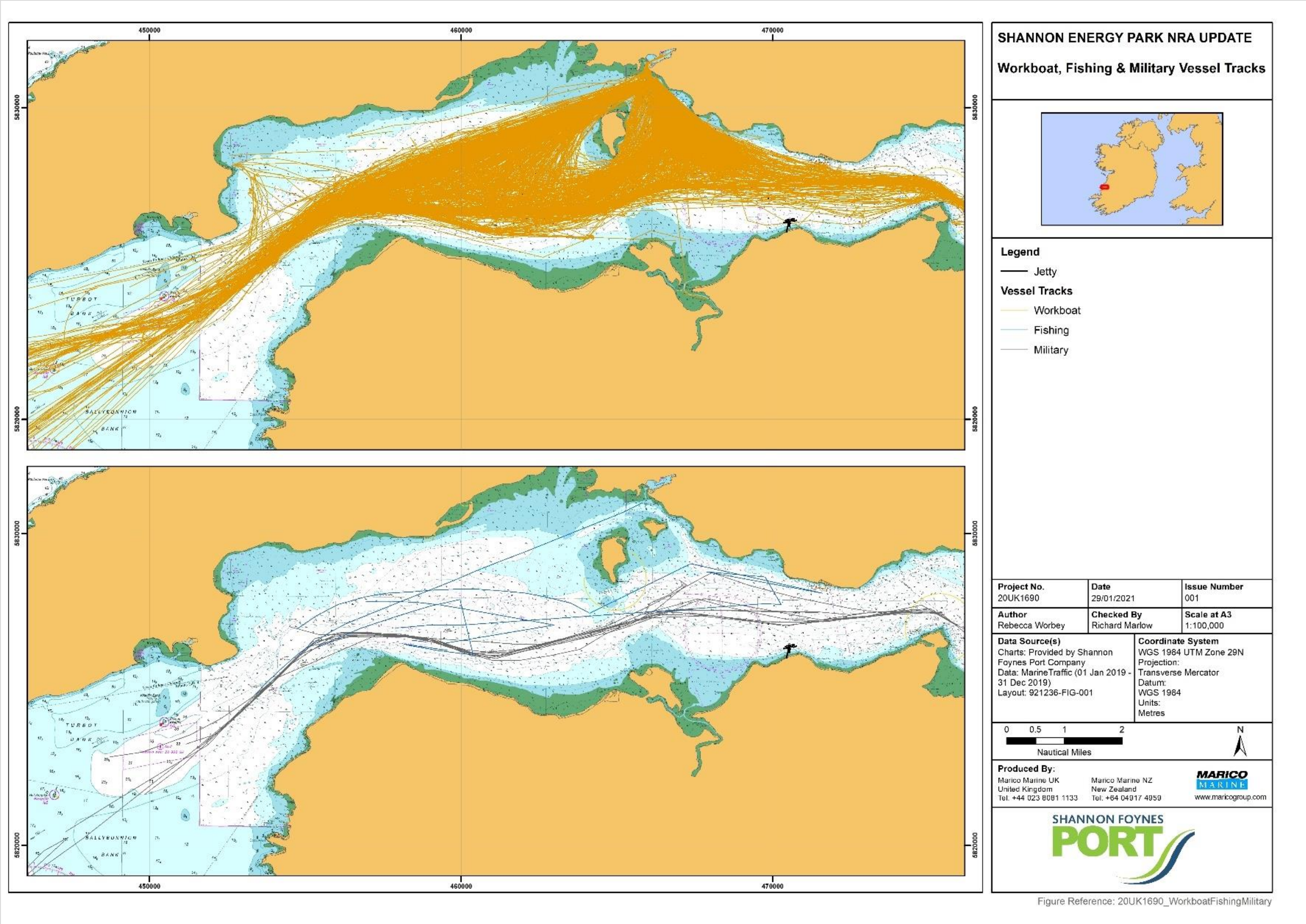


Figure 4-3: Workboat (Inc. tugs), fishing and military vessel tracks.

4.5 GATE ANALYSIS

Gate analysis was undertaken to establish the frequency and spatial distribution of shipping movements past key, potentially higher risk locations that were identified during stakeholder consultation. These were found to be in the vicinity of Ardmore Point where the LNGCs will be turning to come alongside the FSRU and the 'narrows' between Kilcredaun Point and Beal Bar.

The gate analysis at the 'narrows' between Kilcredaun Point and Beal Bar is shown in **Figure 4-4**. Two gates were assessed across the narrowest channel section and at the turn in to the estuary between the Doonaha and Beal Bar buoys. The analysis demonstrates that large commercial vessels operate in strict adherence to the leading lights through the 'narrows.' A total of 1,784 vessels transited through the gates over the assessed 12 months, or approximately 149 per month or five per day. The majority of vessel tracks outside the main channel were made by vessels <50m LOA, primarily recreational vessels and the Dolphinwatch vessel "Draiocht". Vessel tracks close to shore, particularly around Kilcredaun Point were identified to be the Dolphinwatch vessel. 44 commercial vessels transited outside of the marked channel between the 'narrows' over the course of 2019 of which 3 were >150m LOA.

At the turn between the Doonaha and Beal Bar buoys, the vessel tracks occupy a larger cross-section of the channel as commercial vessels alter course to either continue to locations upstream or to the anchorages to the west of Scattery Island.

The gate analysis in the vicinity of Ardmore Point is shown in **Figure 4-5.** The navigation channel, through which 96.4% of the total gate transits (1,612) occurred, is clearly defined. 58 vessels, including 23 dry cargo vessels and 21 tugs are noted diverging from the main channel to the south past Ardmore Point. A total of 18 transits occurred within 150m of the proposed FSRU location during the assessed 12-month period, of which 8 were made by cargo vessels, 3 by recreational vessels, two by tugs, 2 by an RNLI vessel and one by 92m LOA chemical tanker MARIA THERESA.

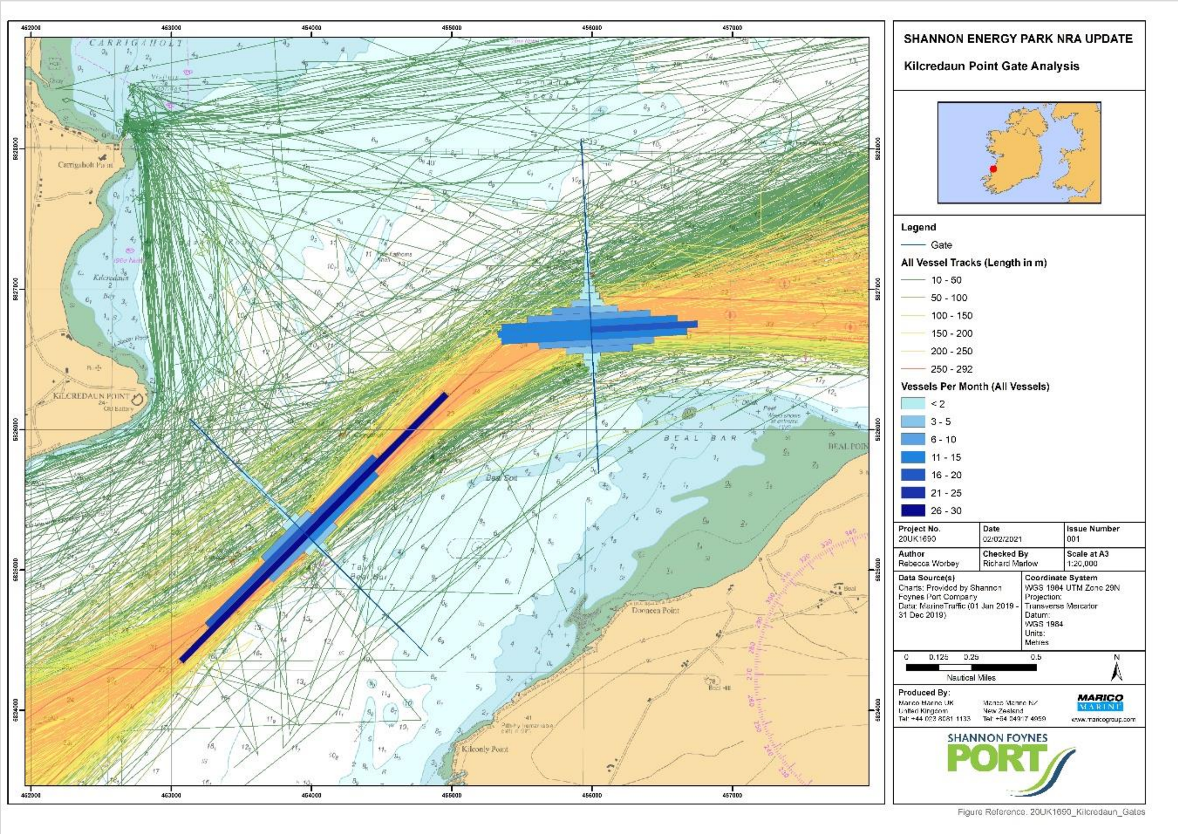


Figure 4-4: Gate Analysis – Kilcredaun Point and the estuary turn (2019)

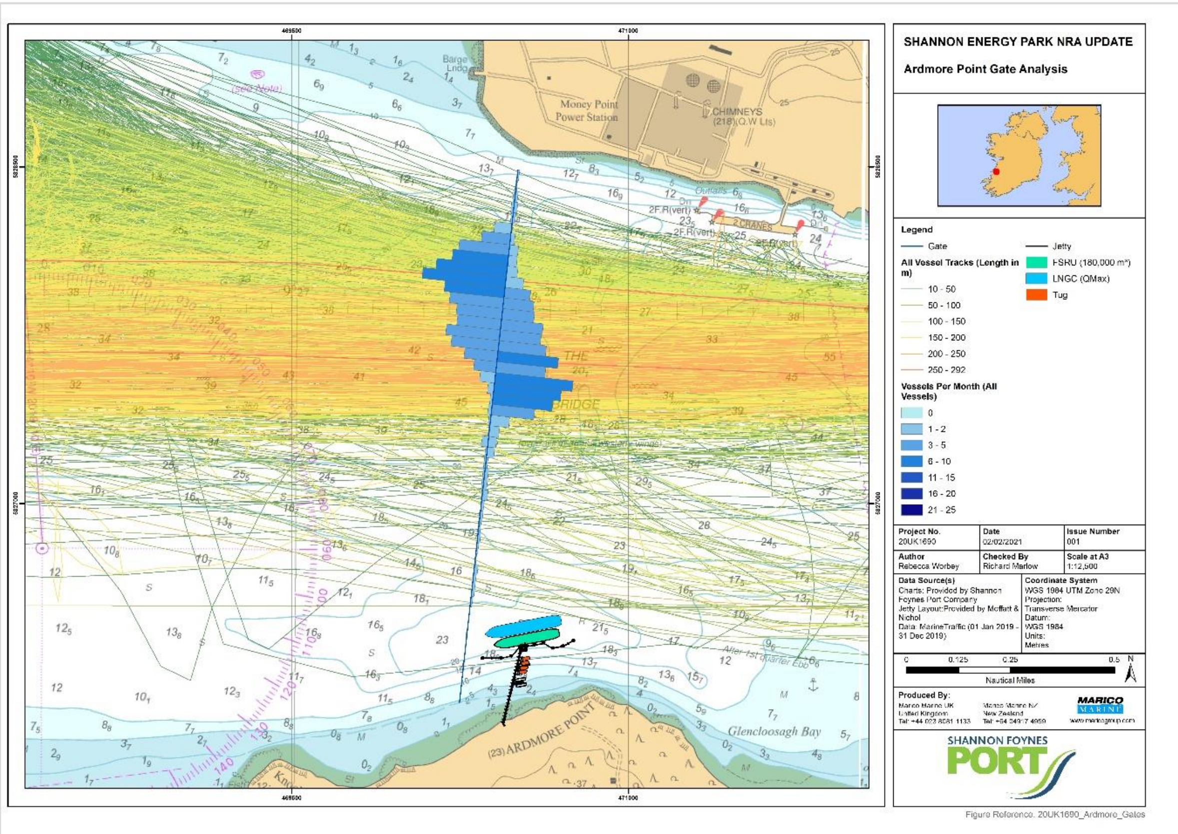


Figure 4-5: Gate Analysis – Ardmore Point (2019)

4.6 INCIDENT ANALYSIS

RNLI callout data between 2008 and 2019 was analysed to indicate the incident rate within the Shannon Estuary.[10] Over the course of the eleven years assessed 49 callouts occurred between Kilcredaun Point and Tarbert Island, excluding 2 false alarms, equating to an average of between four and five callouts per year. The most common reason for call-out was 'Mechanical Failure' at 37% followed by 'Person In Distress' and 'Stranding / Grounding' accounting for 16% each. The highest number of callouts occurred in 2015 which totalled 11, followed by 2019 which totalled 9 (five of which were classified as 'unknown'). The majority of callouts were in response to leisure vessels / activities close to shore, in particular in the vicinity of Carrigaholt Bay, Hog Island and Tarbert Island. Few callouts were in response to vessels navigating within the main channel. Few navigationally significant callouts occurred.

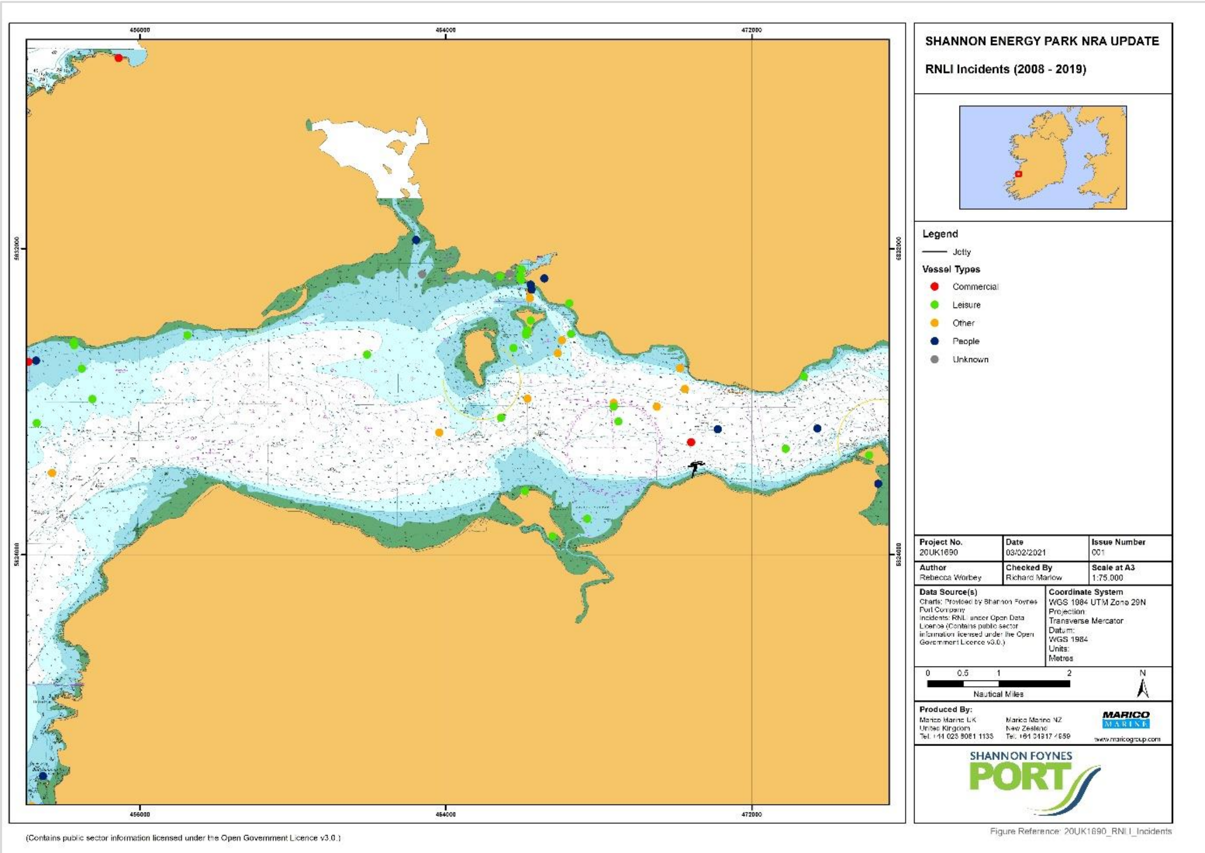


Figure 4-6: RNLI Callouts Within the Shannon Estuary (2008 – 2019)

[10] 2020 RNLI data was not available at the time of writing the 2021 NRA Update.

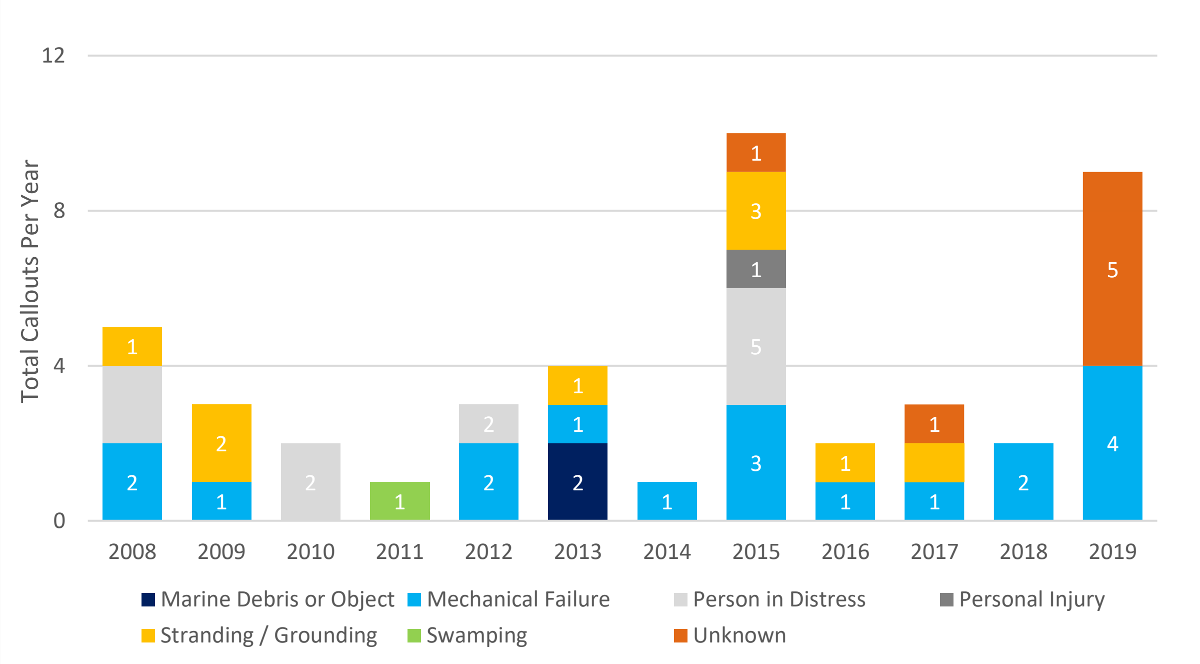


Figure 4-7: RNLI Callouts by Year (2008 – 2019)

5 HAZARD IDENTIFICATION

IMO Guidelines define a hazard as 'something with the potential to cause harm, loss or injury', the realisation of which results in an accident. Hazards relating to navigation were identified through stakeholder consultation meetings / workshops and informed by vessel traffic and incident analysis (**Section 4**).

A summary of the key impacts identified during stakeholder consultation are outlined in **Annex A.**

The hazard categories identified for assessment within the NRA are given in **Table 7**. Hazard categories were combined with the vessel categories identified in **Annex A** to establish a list of individual hazards for risk assessment. In total, 56 hazards were identified, as listed in **Table 7** and **Annex A**.

Table 7: Identified Hazard Categories.

Ref	Hazard Category	Hazard Detail	Comments	Individual Hazards
1	Collision	All Vessel Types	Two or more vessels impact each other whilst manoeuvring.	20
2	Contact	Non- Project Infrastructure	One or more vessels contacts a berth, pier or jetty.	6
		Project Infrastructure	One or more vessels contacts a stationary / berthed vessel. Also known as striking.	6
		LNGC at Anchor	One or more vessels contacts an LNGC at anchor.	6
		Navigation Buoy	One or more vessels contacts a navigation buoy. Also known as striking.	6
3	Grounding	All Vessel Types	A vessel unintentionally contacts the seabed.	6
4	Foundering /Swamping	Project Vessels	A vessel fills with water for any reason including capsize, and when overwhelmed, sinks.	1
5	Mooring/Breakout	Project Vessels	FSRU breaks away from jetty. A vessel ranges (moves excessively) whilst alongside the berth or when one or more mooring lines fail resulting in the vessel unintentionally breaking away from its moored position. An anchored LNGC breaks its anchor cable or the anchor drags.	2
6	Cable Snagging	Project Vessels	A cable is snagged by a project vessel's anchor.	1

Ref	Hazard Category	Hazard Detail	Comments	Individual Hazards
7	Fire/Explosion	Project Vessels	A fire breaks out on berthed FSRU or LNG C.	1
8	Tug Girting	Project Tugs	A tug girts while project vessel is under tow.	1

5.1 CUMULATIVE IMPACT IDENTIFICATION

SFPC is recognised by the European Commission as one of the three core ports in Ireland under the Trans-European Transport Network (TEN-T). Vision 2041, SFPC's Port Masterplan sets out the growth and development agenda for the Shannon Estuary over the next 20 years.

Following assessment as part of the Strategic Integrated Framework Plan (SIFP), the diversification and expansion of facilities on the Shannon Estuary are proposed at Moneypoint and new business opportunities are being explored at two further locations on the Estuary at Innishmurry / Cahiracon and Foynes Island (**Figure 5-1**). The provision of a new deep-water berth of 15m draft is proposed at Foynes and alongside the expansion of existing infrastructure to accommodate larger vessels.

Upstream of the primary development areas, Limerick Docks the Port Estate comprises 75.1 hectares of which existing port operations utilise circa 11 hectares. As such, four sites within Limerick Docks have been identified as 'non-core' assets and are available for alternative use.

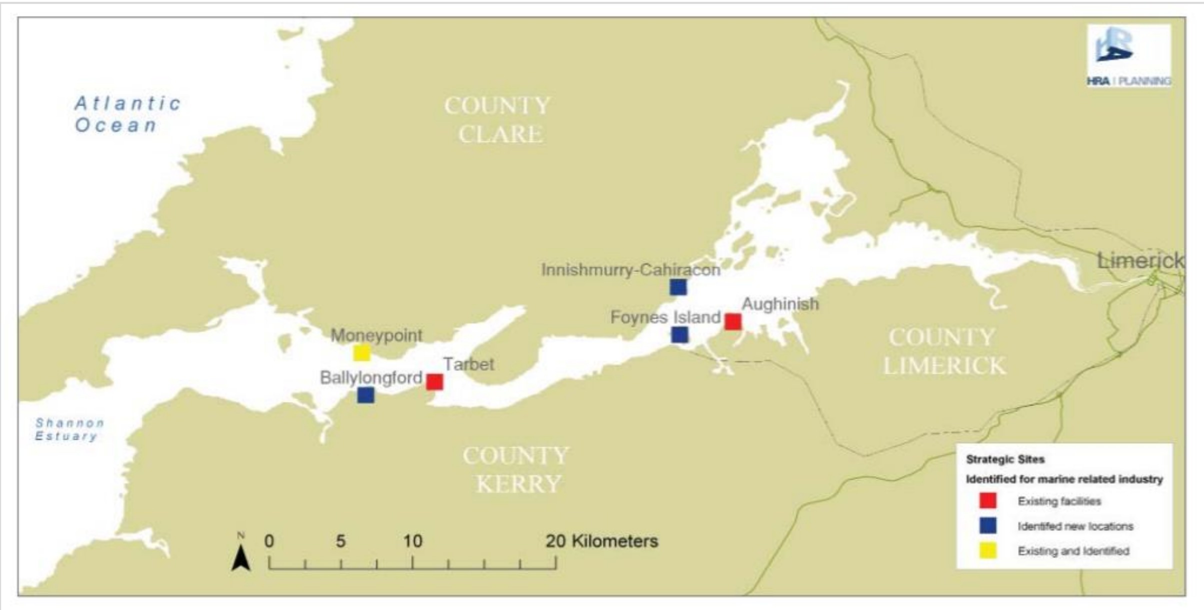


Figure 5-1: Strategic Sites Identified for Marine Related Industry (Vision 2041)

In assessing the potential cumulative impacts, it is important to bear in mind that proposed projects may or may not actually be taken forward. For the purposes of this NRA the baseline assumption is that each of the projects outlined below will be taken forward and that their possible impact on the LNG project including that of port infrastructure capacity as well as traffic levels is assumed to be contained within the risk assessment.

6 EMBEDDED MITIGATION MEASURES

Embedded mitigation measures describe those measures to which adherence is required by regulation are already enforced by Shannon Foynes Port Company which has statutory jurisdiction over the Shannon Estuary or are already accepted within the project plan. Embedded mitigation measures are therefore, assumed to be in place prior to the baseline risk assessment and, as such, cannot be applied as mitigation measures to further reduce risks assessed within the baseline risk assessment. **Table 8** lists embedded mitigation measures considered within this NRA. Following completion of the baseline risk assessment, possible additional risk control measures may be identified with a view to further reducing the residual risk (see **Section 9**).

Table 8: Embedded Mitigation Measures

ID	Risk Control Measure	Description
Existing Port Wide Procedures		
1	Notice To Mariners, Website and Corporate Communications.	The regular issue of Notice To Mariners, shipping lists and the publishing of upcoming port activity on the SFPC website as well as VHF Navigation Warnings and broadcasts to warn of specific occurrences.
2	The enabling SFPC legislation and supporting regulations.	Including Harbour Act 1996, the 2004 SFPC Byelaws and other port operational documentation such as the SFPC pilotage manual. The entire suite of Laws, regulations, guidance and manuals by which the functioning of the port is enforced, managed and administered.
3	Pilots use Portable Pilot Units for situational awareness assistance when piloting.	Reliable, robust and accurate to within 50cm, the Navicom Channel Pilots were purchased by SFPC in 2015 and are used by Shannon Pilots during each act of pilotage significantly reducing the likelihood of pilot loss of situational awareness, a leading cause of marine accidents in pilotage waters.
Adopted from the 2008 NRA and carried on to the 2020 NRA		
4	Attendance by SFPC Berthing Master or Mooring Supervisor (2008 NRA).	SFPC mandate that their marine operations staff regulate and supervise all large shipping arrivals and departures to ensure proper vessel securing arrangements and port operator compliance with SFPC regulations.
5	Designation of the Shannon Estuary as a “Narrow Channel” (2008 NRA).	The entire Shannon Estuary from the Tail of Beal and the Kilcredaun Buoys was designated as a ‘narrow channel’ in 2009. This is recorded on the relevant Admiralty Chart notes and significantly reduces the risk of vessels less than 20m impeding the navigation of large commercial vessels in transit in the Estuary.
6	Joint emergency plans have been produced and practised for the Shannon Estuary (2008 NRA).	SFPC, together with the local authorities, the emergency services and shipping operators have developed joint as well as individual Port Emergency plans which include training and exercises schedules.

ID	Risk Control Measure	Description
7	AIS integration with Port Radar (2008 NRA).	Full integration of AIS and radar tracks, including dynamic information was incorporated into the SFPC radar system in 2012. This produces an accurate and comprehensive vessel traffic image.
8	Conduct regular hydrographic estuary surveys (2008 NRA).	Surveys are now regularly conducted for the Shannon Estuary and are produced by Marine Institute on WGS84.
9	Doonaha Buoy and the Beal Bar Buoy relocated (2008 NRA).	The Doonaha and the Beal Bar buoys were moved by SFPC to reflect the recommendations made in the 2008 NRA. The Doonaha Buoy is now in line with the Corlis leading lights.
Embedded within the Existing Project Plan		
10	Berthing Limits	A berthing wind speed limit of 25 knots has been accepted by the developer and SFPC for arriving LNGCs. This limit will be reviewed after 1 year and periodically thereafter.
11	FSRU and LNGC berthed port side to into flood tide.	The NMCI simulations concluded that it was safest to berth the FSRU and the LNGC into a flooding tidal stream so as to give the best control during berthing. Accordingly, all ships will be berthed Port Side To Quay (PSTQ).
12	Display of Live Environmental Conditions	A method of transmitting or showing live environmental conditions (wind speed, direction, tidal stream, depth etc.) at the berth to the pilot (including when berthing an LNGC alongside the FSRU) will be installed at the LNG terminal.
13	Berth design upgraded to accommodate FSRU alongside in wind speeds of up to 70 Knots[11].	The 2020 NRA raised concerns with regard to the 60 knot design maxima for the proposed LNG jetty and the possibility of the FSRU having to sail from the berth partially discharged in the path of an upcoming storm event. The 2020 NRA proposed one of 3 options to be considered as a solution to this and the project designers responded by uprating the wind limit of the LNG jetty from 60 knots to 70 knots. This should allow the FSRU to remain alongside in all but the most extreme storm events.

[11] 30 second sustained gust of 70 knots.

7 METHODOLOGY

The NRA process is based on Formal Safety Assessment (FSA) methodology as adopted by the International Maritime Organisation (IMO) and follows the guidance set out in international best practice. A detailed description of the methodology is provided in **Annex A**

7.1 OVERVIEW

A standard 5x5 risk matrix was used and each hazard was assessed twice. Firstly, to determine the risk associated with the most likely outcome of the hazard and secondly to determine the risk associated with the worst credible outcome for each hazard. The results were then combined to give a total risk score for each hazard.

This approach provides a thorough assessment of risk, which reflects the reality that comparatively few accidents result in the worst credible outcome.

7.1.1 Assessment of Frequency and Consequence

The assessment of frequency was combined with assessments of typical consequences to people, property, environment and business. The frequency and consequence bands used for this NRA are shown in **Annex A.**

The frequency and consequence assessments were largely based on the data/information collected during Stage 1 of this NRA, and in particular:

- Stakeholder consultation meetings;
- Quantitative vessel traffic analysis; and
- Review of the incident database.

This information was supplemented by expert judgement and specialist knowledge provided by the assessment team, who have considerable experience in undertaking NRAs of this type in ports/harbours all around the world.

7.1.2 Risk Scores

The frequency and consequence scores were then assessed to give two distinct risk scores;

- The average risk score of the categories in the most likely set;
- The average risk score of the categories in the worst credible set;
- The maximum risk score of the four categories in the most likely set; and

- The maximum risk score of the four categories in the worst credible set.

These scores were then combined using a weighted average to produce a single numeric value representing the final risk score for each hazard, between 0 (negligible) and 10 (high) which, the final risk scores were sorted into a ranked hazard list.

Hazard risk scores were categorised as either negligible, low, As Low as Reasonably Practicable (ALARP), significant or high, as per **Table 9**, where ALARP represents a level of risk that is neither acceptable nor unacceptable and for which further investment of resources for risk reduction may or may not be justifiable – i.e. risks which fall within the ALARP band should be reduced unless there is a disproportionate cost to the benefits obtained.

Navigation hazards with a risk score of significant or high are deemed unacceptable and, as such, additional risk control measures must be implemented to reduce the risk to an acceptable level (**Table 9**).

Table 9: Risk Scoring.

Risk Score	Risk Definition	Action Taken
0 - 1.99	Negligible	The risk is acceptable and at level where operational safety is unaffected.
2 - 3.99	Low	The risk is acceptable and at level where operational safety is assumed.
4 - 6.99	ALARP	The risk is neither acceptable nor unacceptable. Risks in the ALARP band are to be managed to a level which is “As Low As Reasonably Practicable”, based on the cost-effectiveness of implementing additional risk control measures. These hazards and associated risk control measures shall be regularly reviewed as part of the Safety Management System.
7 - 8.99	Significant	The risk is unacceptable and additional risk control measures shall be identified and implemented as soon as possible (or the activity / operation temporarily suspended). These hazards and associated risk control measures shall be regularly reviewed as part of the Safety Management System.
9 - 10	High	The risk is unacceptable and additional risk control measures shall be identified and implemented immediately (or the activity / operation permanently suspended). These hazards and associated risk control measures shall be regularly reviewed as part of the Safety Management System.

The hazard log was scored twice, once for the baseline and then re-assessed applying proposed possible additional mitigation measures (**Annex D** & **Annex E**) to assess the residual risk scores and their effectiveness should they be implemented.

8 NAVIGATION RISK ASSESSMENT RESULTS

8.1 BASELINE WITH EMBEDDED MITIGATION

A summary of the ranked hazard list for the baseline assessment with embedded mitigations is at **Table 10**. The full hazard log is provided in **Annex D.** The assessment assumes the implementation of all embedded risk control measures identified within **Table 8.**

All hazards were scored as ALARP or lower, with a total of 15 hazards scored within the ALARP band. The highest scoring individual hazard assessed to be 'Contact - Project Vessel with Project Infrastructure' which scored 6.48: ALARP reflecting the risk associated with berthing an LNGC alongside followed by "Collision - Project Vessel with Port Services Vessel" to reflect the hazards associated with tugs handling the LNGCs. Another 39 risks were classed as "low" in the baseline unmitigated scoring and two final hazards was classed as "negligible."

A summary of the average baseline hazard category scores is given in **Figure 8-1**. The highest scoring overall hazard category was 'Foundering / Swamping' driven by a high consequence score and the assessment of project vessels only within this hazard category. This was followed by 'Fire / Explosion' again driven by high consequence should this event occur. The lowest scoring overall hazard category in the baseline assessment was 'Mooring Incident / Breakout' which was scored as 3.0 Low driven by a low consequence in the event of a breakout of a project tug.

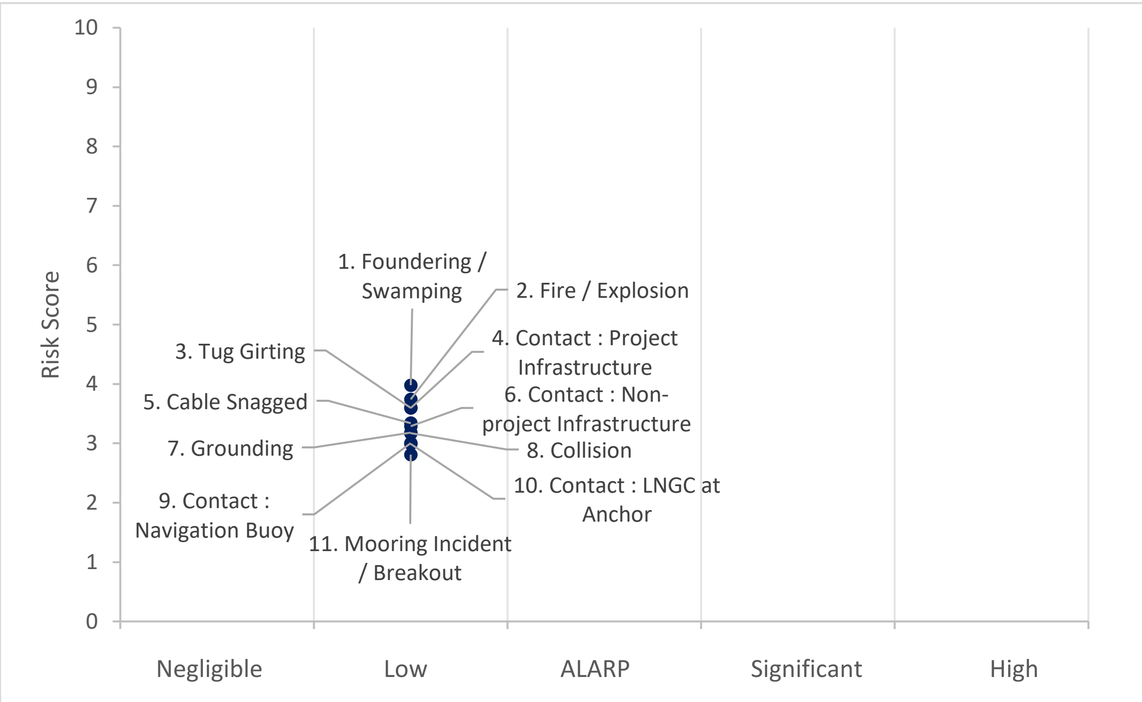


Figure 8-1: Average Risk Score by Hazard Category – Baseline Risk Assessment

Table 10 : Summary Ranked Hazard List - Baseline With Embedded Risk Controls

ID	Hazard Cat	Hazard Title	Score
22	Contact	Contact - Project Vessel with Project Infrastructure	6.48
9	Collision	Collision - Project Vessel ICW Small Commercial / Port Services Vessel	5.16
2	Collision	Collision - Tanker ICW Project Vessel (FSRU or LNGC)	4.64
8	Collision	Collision - Project Vessel ICW Small Passenger Vessel	4.50
14	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Recreational Vessel	4.46
40	Contact	Contact - Project Vessel with LNGC at anchor	4.35
28	Contact	Contact - Project Vessel with Non- Project Infrastructure	4.28
19	Collision	Collision - Small Commercial / Port Services Vessel ICW Recreational Vessel	4.18
23	Contact	Contact - Large Commercial / Dry Cargo Vessels with Project Infrastructure	4.13
41	Contact	Contact - Large Commercial / Dry Cargo Vessels with LNGC at anchor	4.13
6	Collision	Collision - Tanker ICW Recreational Vessel	4.09
10	Collision	Collision - Project Vessel ICW Recreational Vessel	4.09
52	Mooring Incident	Mooring Incident / Breakout - Project Vessel	4.1
7	Collision	Collision - Project Vessel ICW Large Commercial / Dry Cargo Vessel	4.04
5	Collision	Collision - Tanker ICW Small Commercial / Port Services Vessel	4.03
51	Foundering	Foundering / Swamping - Project Vessel	3.98
4	Collision	Collision - Tanker ICW Small Passenger Vessel	3.94
13	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Small Commercial / Port Services Vessel	3.84
16	Collision	Collision - Small Passenger Vessel ICW Small Commercial / Port Services Vessel	3.84
3	Collision	Collision - Tanker ICW Large Commercial / Dry Cargo Vessel	3.82
20	Collision	Collision - Recreational Vessel ICW Recreational Vessel	3.81
12	Collision	Collision - Large Commercial / Dry Cargo vessel ICW Small Passenger Vessel	3.81
56	Fire / Explosion	Fire /Explosion - Project Vessel	3.74
32	Contact	Contact - Recreational Vessels with Non- Project Infrastructure	3.70
17	Collision	Collision - Small Passenger Vessel ICW Recreational Vessel	3.60
54	Tug Girting	Tug Girting / Towing Incident	3.60
34	Contact	Contact - Project Vessel with Navigation Buoy	3.54
47	Grounding	Grounding - Large Commercial & Dry Cargo Vessels	3.51
18	Collision	Collision - Small Commercial / Port Services Vessel ICW Small Commercial / Port Services Vessel	3.51
1	Collision	Collision - Tanker ICW Tanker	3.43
46	Grounding	Grounding - Project Vessel	3.42
55	Cable Snagging	Cable Snagged - Project Vessel	3.34
25	Contact	Contact - Small Commercial / Port Services Vessels with Project Infrastructure	3.28
11	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Large Commercial / Dry Cargo Vessel	3.27
27	Contact	Contact - Tanker with Non- Project Infrastructure	3.24
29	Contact	Contact - Large Commercial / Dry Cargo Vessels with Non- Project Infrastructure	3.24
21	Contact	Contact - Tanker with Project Infrastructure	3.20
39	Contact	Contact - Tanker with LNGC at anchor	3.20
45	Grounding	Grounding - Tanker	3.19
15	Collision	Collision - Small Passenger Vessel ICW Small Passenger Vessel	3.18
36	Contact	Contact - Small Passenger Vessels with Navigation Buoy	3.18
35	Contact	Contact - Large Commercial / Dry Cargo Vessels with Navigation Buoy	3.12
50	Grounding	Grounding - Recreational Vessel	3.06
49	Grounding	Grounding - Small Commercial / Port Services Vessel	3.00
48	Grounding	Grounding - Small Passenger Vessels	2.98
38	Contact	Contact - Recreational Vessels with Navigation Buoy	2.94
33	Contact	Contact - Tanker with Navigation Buoy	2.91
30	Contact	Contact - Small Passenger Vessel with Non- Project Infrastructure	2.74
31	Contact	Contact - Small Commercial / Port Services Vessel with Non- Project Infrastructure	2.53
42	Contact	Contact - Small Passenger Vessels with LNGC at anchor	2.44
26	Contact	Contact - Recreational Vessels with Project Infrastructure	2.42
37	Contact	Contact - Small Commercial / Port Services Vessels with Navigation Buoy	2.34
44	Contact	Contact - Recreational Vessels with LNGC at anchor	2.08
24	Contact	Contact - Small Passenger Vessels with Project Infrastructure	2.06
43	Contact	Contact - Small Commercial / Port Services Vessels with LNGC at anchor	1.75
53	Mooring Incident	Mooring Incident / Breakout - Small Commercial / Port Services Vessels	1.53

Average risk scores by vessel and hazard categories are analysed in **Figure 8-2**. All overall vessel categories were scored as low in the baseline assessment with the exception of 'Project Vessel' with an average risk score of 4.26 ALARP, driven by the hazard 'Contact project Infrastructure: Project Vessel'. The lowest scoring overall vessel categories were 'Small Passenger Vessel' and 'Small Commercial / Port Services Vessel' with an average risk score of 3.29, driven primarily by low transit frequency in the vicinity of the project infrastructure and low hazard consequences respectively.

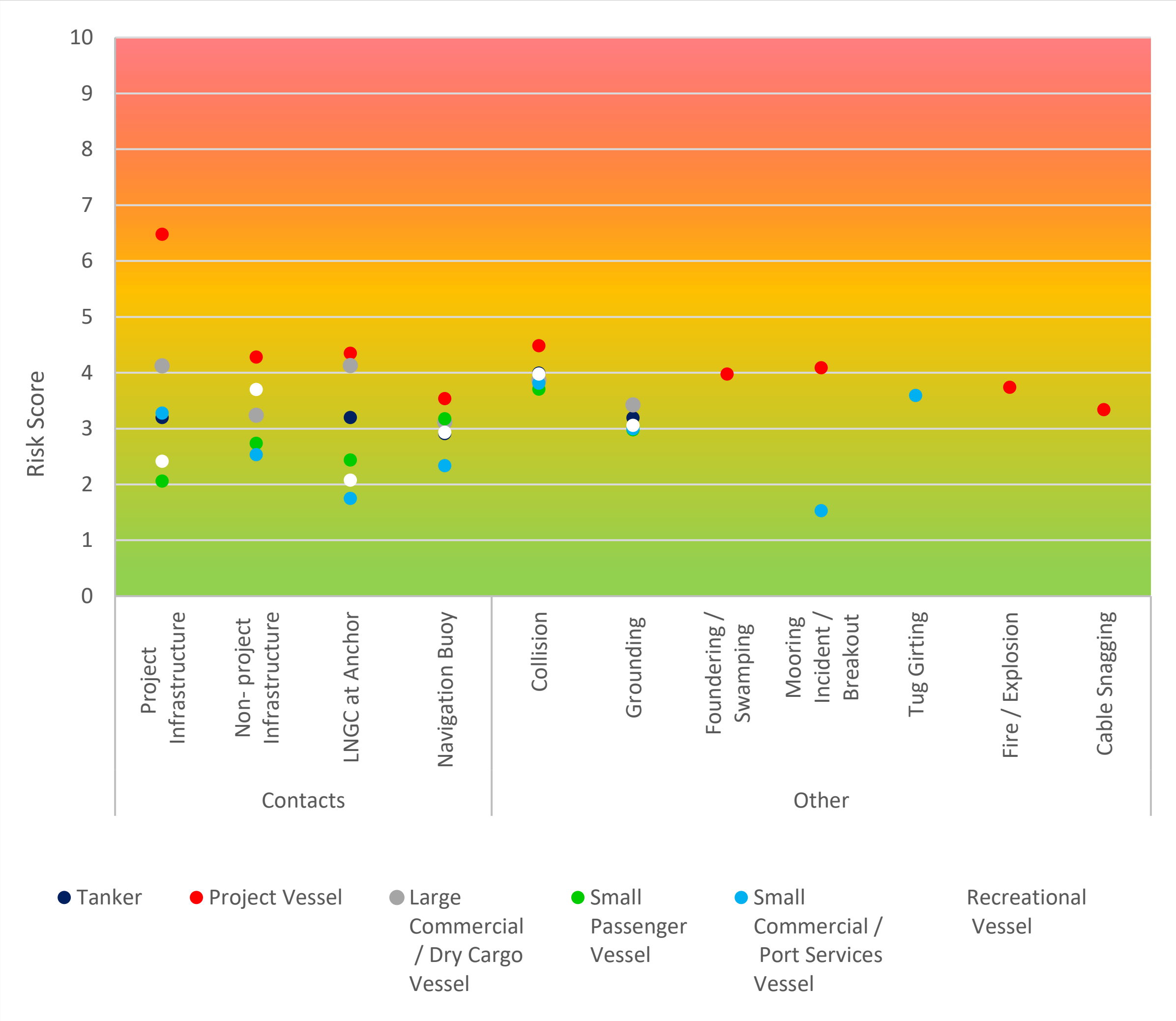


Figure 8-2: Baseline Assessment Risk Scores by Vessel and Hazard Category

9 POSSIBLE ADDITIONAL RISK CONTROL MEASURES

A number of possible additional risk control measures were identified, informed by stakeholder consultation, design analysis and the conclusions of the 2020 NRA. A review of the efficacy of the risk control measures proposed in 2020 was undertaken, in light of Project revisions and, where applicable, recommendations for their implementation have been made.

In total, 27 possible additional mitigation measures were identified as listed in **Table 11** and explained in detail in paragraphs 9.1 to 9.27 below. The hazards to which additional risk control measures apply and their effectiveness are shown in **Table 12.**

Table 11 Possible Additional Mitigation Measures

ID	Risk Control Measure	Description
1	Update SMS	SFPC Safety Management System to be updated.
2	Towage Procedures	Produce LNG Towage Operating Procedures.
3	Emergency Plans	Local / Port emergency plans updated to reflect LNG terminal.
4	Update Navigation Chart	Jetty, FSRU and Control Zone to be marked on chart.
5	Corporate Communications	Stakeholder, Corporate and Operational Communications will need to be regular and proactive.
6	Operational Communications	Communications between the pilot, the cutter, the tugs, mooring gangs/boats and the terminal staff.
7	Marine Operating Thresholds	A set of LNG operating thresholds will need to be produced.
8	Fire Fighting	Apply SIGTTO and SEVESO standards for fire-fighting provision.
9	Jetty Security	An ISPS plan will need to be produced by the operator.
10	Development of LNGC Passage Plan	Development an optimum track for LNGC transits.
11	Arrival Preconditions	An LNGC should not enter unless the preconditions are met.
12	Additional Simulations	Additional ship to ship berthing, estuary and pilot station simulator sessions.
13	Use of Appropriate Tugs	Tug design will be agreed and licensed by SFPC.
14	Mobile Control Zone	A control zone around an LNGC underway is recommended.
15	Static Control Zone	A static control zone around berthed LNG ships is recommended.
16	FSRU Fendering	It is recommended that at least five ‘Yokohama’ and two “baby” stern and bow fenders are rigged.
17	Daylight Berthing	It is recommended that berthing and unberthing initially be limited to daylight hours only.
18	Load Cells on Mooring Equipment	Consideration should be given to utilising load cells on the jetty mooring systems.

ID	Risk Control Measure	Description
19	Use of Centimetric PPU for Berthing	A Doppler docking system or PPU be fitted to allow berthing of the LNGC's outboard of the FSRU.
20	Annual Review of Operating Limits and Mitigations	It is recommended that this NRA, the mitigating measures and the operating procedures are annually reviewed.
21	Schedule Deconfliction	It is recommended that an LNGC or FSRU arrival / departure does not conflict with other large commercial estuary arrivals.
22	Restrict Anchoring in Vicinity of Cables	It is recommended that SFPC formalise the prohibition of anchoring near the Moneypoint submarine cables.
23	48 Hour Weather Forecast	A bespoke Shannon LNG 48-hour weather forecast service is implemented to allow suitable operational cargo planning and if necessary enough time for the LNGC to cease working cargo, detach and sail to anchor.
24	LNGC Operational Discharge Plan	The LNGC discharge plan is such that, if required, the vessel can be configured to a safe condition to allow it to sail to anchor within the 48 hour weather notice period.
25	LNGC Anchorage Designated and Kept Free	An LNGC anchorage is assessed and nominated by SFPC. When an LNGC is in port this anchorage will be kept free.
26	LNGC Notice for Sea at Anchor	It is recommended that further mitigations for the LNGC at anchor are considered by SFPC.
27	LNGC At Anchor Support Tug	Consideration be given to nominating a tug to standby the LNGC at anchor during a storm event.

9.1 MITIGATION 1 - UPDATE SAFETY MANAGEMENT SYSTEM

The SFPC Safety Management System (SMS) will need to be formally reviewed and updated to reflect the implemented changes to the port procedures as a result of the operation of the LNG project.

9.2 MITIGATION 2 - LNG TOWAGE AND OPERATION PROCEDURES

The procedures for LNG towage will need to be written and as a minimum, should examine the following areas:

- Define the number, capability and roles of each tug for:
    - Active escort;
    - Berthing;
    - Unberthing; and
    - Underway escort during cargo discharge.
- Communications protocols;

- The firefighting capabilities required of each vessel – as a minimum equipped to FiFi 1 Class standard[12];
- Where and when each individual tug is to be made fast;
- What connecting up procedures are to be used;
- Set the operating, seakeeping and weather limitations for tugs;
- Describe emergency procedures underway and alongside;
- The tugs role in enforcing the control zones both underway and alongside;
- Set the levels of equipment and vessel redundancy needed to achieve required the towage provision;
- Determine the notice period to activate the standby tug and the second standby tug to support the FSRU in poor weather; and
- The berth, support infrastructure and maintenance arrangements for the tugs and compliance with the requirements for the Maritime Labour Convention for the crew.

9.3 MITIGATION 3 - UPDATE EMERGENCY PLANS

The Irish national, regional, local and port emergency plans will need to be updated to reflect the existence of the LNG terminal.

9.4 MITIGATION 4 - MARK STATIC CONTROL ZONE ON NAVIGATION CHART

The existence of the new jetty, the permanent presence of the FSRU and the 150m static control zone will need to be adopted and shown on the navigational chart, initially as a Notice to Mariners but in due course as a formal update to the chart and as a Byelaw.

9.5 MITIGATION 5 - CORPORATE COMMUNICATIONS

SFPC stakeholder communications will need to continue to be regular, proactive and positive and should offer a forum for feedback and suggestions from the public. It is suggested that an estuary stakeholders' group, meeting regularly and independently chaired is the best vehicle for this. Similarly, operational communications in the form of Notices to Mariners, daily publication of shipping

[12] The class notation FiFi I means that the vessel is to be equipped with minimum 2 fire monitors, able to throw water to a minimum distance of 120 meters from the vessel and to a height of minimum 45 meters. The monitors are to be remote controlled from the wheelhouse. FiFi I Systems are normally installed on Escort tugs or Fire-fighting vessels.

movements, public availability of LNG operating parameters and other operational messages will need to be widely available, published online and updated regularly.

9.6 MITIGATION 6 - OPERATIONAL COMMUNICATIONS

The efficiency of the "tactical" level communications, estuary wide to as well as within the LNG terminal is of clear importance, in particular during ship to ship berthing and cargo transfer. The communications between the pilot, the cutter, the tugs, mooring gangs/boats and the terminal staff including the berthing master must be effective, intrinsically safe and reliable.

9.7 MITIGATION 7 - DEFINE MARINE OPERATING THRESHOLDS

Separate from the detailed technical LNG operating manuals that will be required to safely run the terminal, SFPC will also need to produce, benchmark, review and agree a set of LNG operating thresholds including wind limits and subsequent actions. The example quoted by Moffatt and Nicol[13] in **Figure 9-1** is a useful starting point and the final limits should be formally reviewed on a regular basis.

Ship Activity	Condition	Vessel Action	Authority (typical)
Berthing	Sustained wind ≥ 20-25 knots	Limiting wind speed for berthing	Pilot, Master, Terminal
Cargo Transfer	Sustained wind > 30 knots	Stop Caro Transfer	Terminal
Cargo Transfer	Sustained wind > 35 knots	Disconnect loading equipment	Terminal
Berthed	Forecasted sustained wind > 40 knots	Undock, leave berth	Pilot, Master, Terminal
Berthed	Sustained wind < 40 knots but when deemed remaining alongside would be prejudicial to safety by the Vessel Master or Person-In-Charge	Undock, leave berth	Pilot, Master, Terminal

Figure 9-1 Typical LNG Operating Wind Conditions (Moffatt and Nichol)

[13] Moffatt and Nichol NFE Berthing and Mooring Analysis Page 14.

9.8 MITIGATION 8 - FIREFIGHTING MEASURES

The rigorous standards dictated by SIGTTO and SEVESO for the levels, capability and quality of shore and afloat fire-fighting provision must be met for the LNG terminal.

9.9 MITIGATION 9 - JETTY SECURITY MEASURES

The Shannon Estuary Security Authority will need to review and approve the operators' proposed ISPS security plan for the addition of LNG operations at Ardmore Point. This will include all of the measures necessary to keep the LNG terminal secure.

9.10 MITIGATION 10 - LNGC PASSAGE PLAN

The development of an SFPC agreed optimum track for LNGC and FSRU transits through the estuary, including the expected boarding point, possible abort points and contingency plans is recommended. Once approved, this standing passage plan should be incorporated into the Master Pilot Exchange as well as into the Shannon Pilots PPUs and should be widely published on the SFPC website, by NTM and in hard copy. In real time, the progress of the LNGC against this pre-agreed track can be monitored by radar / AIS / PPU by a second pilot from ashore to provide assistance.

9.11 MITIGATION 11 - ARRIVAL PRECONDITIONS

It is recommended that the LNGC or FRSU will not be permitted to enter port[14] unless all of the following conditions are met:

- All LNG vessels shall be under the control of a licensed Shannon Estuary pilot when in transit to and from the designated pilot boarding station and the Shannon LNG facility;
- Actual wind conditions at the berth are "not exceeding 25 knots from any direction;"
- One "escort" capable tug is made fast (normally centre lead aft) to an arriving LNGC at or in the vicinity of the pilot station;
- A second "escort" capable tug is in attendance ahead of the vessel;
- The LNG berth / FSRU has reported that it is ready for the LNGC to come alongside;
- Suitable vessels and arrangements are made to make the moving "Control Zone" (see mitigation number 14) enforceable. This would normally require a vessel stationed ahead of

[14] For the purposes of this NRA, entering Port is taken to be passing the point of no return to the narrows at the Kilcredaun and Tail of Beal Bar Buoys.

the LNGC which has a sufficient reserve of speed so as to be able to intercept a potential transgressor vessel before it broke the control zone limits. The Master of this vessel would also need to have the delegated powers of the Shannon Harbour Master so as to be able to issue 'Special Directions' with sufficient legal authority to enforce the control zone; and

- There is at least a 48 hour "weather window" where wind speeds are not forecast to exceed an agreed threshold speed. Also see Mitigations 23 to 25 below.

9.12 MITIGATION 12 - ADDITIONAL BERTHING SIMULATIONS

It is 12 years since the last set of LNG simulations were conducted at the NMCI (2009). It is recognised that navigation in the estuary has not changed significantly and that the LNGCs can be considered to be largely similar in size and handling characteristics to some other ships that are regularly using the estuary. The following recommendations are made with regard to simulation:

- Simulator sessions are conducted with Shannon Pilots, tug and berthing masters to allow these personnel to gain better familiarity with ship-to-ship berthing. The 2021 project update has introduced the possibility of a mismatch in vessel sizes alongside the LNG terminal in Shannon. The FSRU, at a maximum capacity of 180,000m3 and therefore likely to be up to 300m in length overall could potentially be accommodating a Q-MAX size vessel at 345m as an LNGC outboard. At the time of writing the 2021 update to the Mooring and Berthing documentation from Moffat and Nichol was not available for reference but this mismatch, however unlikely given the scarcity of Q-Max size vessels, will need careful further and detailed scrutiny in terms of berthing stability, the lead of lines, fendering and finally, in simulation with Shannon Pilots;
- The use of Pilot station Number 2 as a boarding point for all LNGC ships, including the Q-Max sized vessels, should be examined and approved by Shannon Pilots in simulation. In particular, confirmation is required that there is sufficient sea room for a vessel of this size to safely abort its approach track to the Kilredaun Narrows should the pilot not be able to board; and
- A visit by the Shannon pilots and tug masters to a sister LNG port, and in particular one that uses an FSRU would reap significant familiarisation benefits for the berthing techniques used.

9.13 MITIGATION 13 - USE APPROPRIATE TUGS

The specification of the tug design will be agreed with the LNG Operator and licensed by SFPC. This will be guided by best practice, informed by the stipulations of Mitigation 2 and the tender for the licence written accordingly. It is suggested that:

- At least 2 of the 4 intended tugs should be “escort notated”. Escort tugs employed in the “active” role should be designed such that they are capable speeds of approximately 1.5 times the LNGC approach speed, thus allowing them to work at wide angles to the LNGC heading;
- Tugs of wide beam and low towing points will prevent excessive heel angles developing;
- Dynamic winches are also considered important so that higher bollard pulls may be safely deployed in relatively high wave heights;
- Fender systems should be designed to avoid point loadings above the maximum t/m2 specified for LNG carriers;
- Towline configuration - The use of quick connection units and LNGC dedicated towing points should be considered;
- Freewheel/quick release facilities for winches which increase safety as they allow a tug to release high load if required. Such facilities also assist when connecting up and when the tug is dropping into position;
- The berthing, maintenance and support arrangements for the tugs is anticipated that the vessels will be permanently stationed at a purpose-built facility as part of the LNG jetty as shown in **Figure 9-3** in order to meet the service notice requirements.

9.14 MITIGATION 14 - MOBILE CONTROL ZONE

While underway, best practice indicates that a moving control zone of 1 nautical mile ahead, 150m abeam and 0.5nm astern tethered to the LNGC and from which all other vessels are excluded is safe, and enforceable. It also offers the least level of impact on other estuary users while remaining in keeping with known commercial vessel bridge visibility shadow distances and expected LNGC manoeuvrability limitations. The geometry and swept path of this moving zone is shown in **Figure 9-2**. In terms of enforcement of this zone underway, it is expected that, initially, the control zone will be enacted as a Shannon Harbour Master’s ‘Special Direction’ for each vessel movement and supported by a widely published rolling Notice to Mariners, VHF broadcast and a website notification. In time and if required for longer term legal status, the control zone protocols may be formally adopted as a SFPC Byelaw.

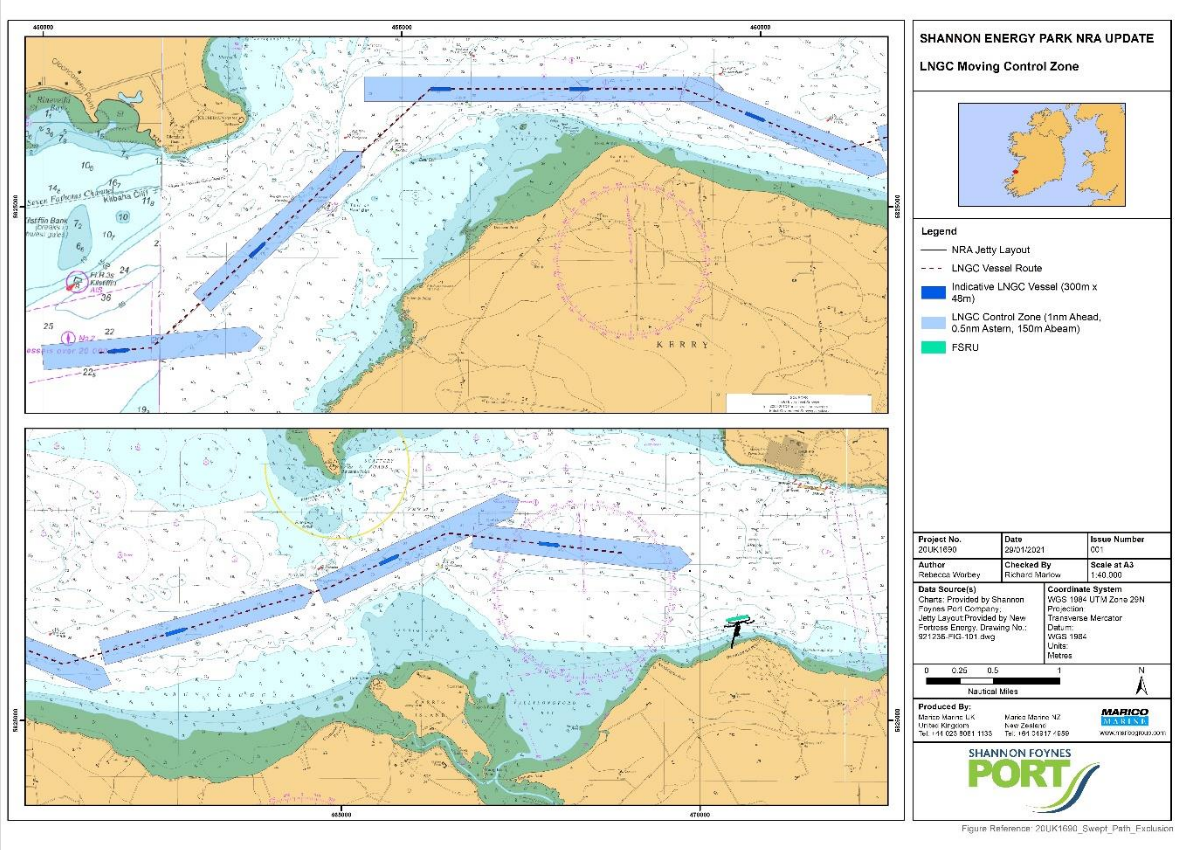


Figure 9-2: Mobile LNGC Control Zone

9.15 MITIGATION 15 - STATIC CONTROL ZONE

SIGTTO recommends that the dimensions and shape of any control zone around an LNG ship should be determined in the context of the specific conditions of a port and allow a degree of latitude for the port authority to implement a pragmatic and workable solution. Industry best practice for a control zone around a stationary LNGC normally requires a 150m distance and it is expected that this will be permanently applied around the FSRU in Shannon and when present, the LNGC as shown in **Figure 9-3.**

Whenever an LNGC is alongside the FSRU, it is intended that one tug will always be on station, underway near the jetty and ready for immediate use; its primary function will be to provide seaward element to the terminals fire-fighting capabilities during discharge but also to police the static control zone around the berthed LNGC. Enforcement using this tug would ensure that commercial and other leisure craft keep clear thereby reducing the risk of contact. This could be achieved using a Shannon Harbour Masters ‘Special Direction’ for each LNGC period alongside and supported by a widely published rolling Notice to Mariners, VHF broadcast and a website notification. In time and if required for longer term legal status, the control zone protocol may be formally adopted as a SFPC Byelaw. A second tug will be at 30 minutes' notice and the third and fourth tugs will be at 2 hours' notice.

When the FSRU is alongside on its own, it is expected that there will be one tug available at the berth, tied alongside but manned and available for immediate use with a second tug at 30 minutes' notice. The third and fourth tugs will be at 2 hours' notice.

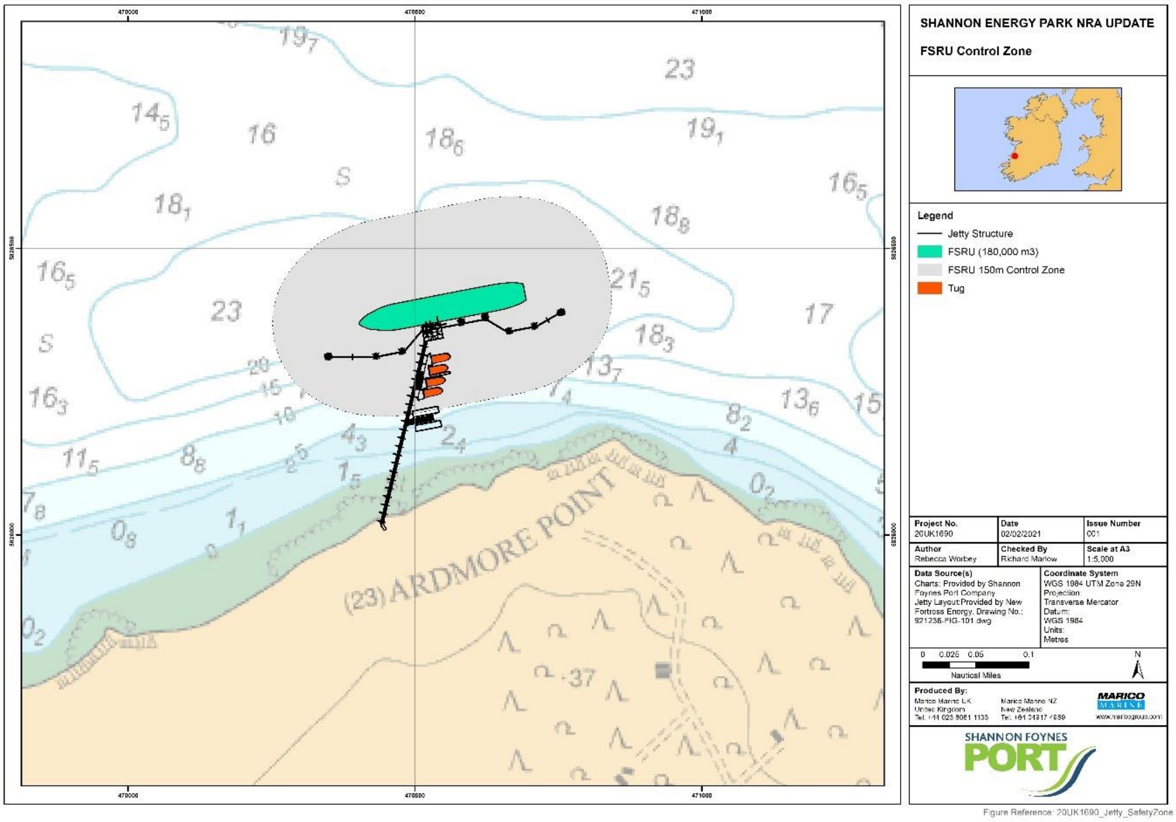


Figure 9-3: FSRU Static Control Zone

9.16 MITIGATION 16 – REVIEW OF FSRU FENDERING REQUIREMENTS

In any circumstances the arrangements for fendering two large ship alongside each other will always require careful attention and the application of sensible seamanlike precautions will always want to err on the side of caution when it comes to the provision of fendering. It is recommended that the present proposal to use 4 large Yokohama fenders for ship-to-ship berthing is enhanced to require a minimum of least five fenders are rigged in a string, three aft of the midships LNG cargo manifold and the remaining two forward as shown in **Figure 9-4**.

It is also recommended that there are also two 'baby' fenders suspended on the upper fore and aft limits of the parallel mid-body of the FSRU.

In normal circumstances it would be expected that the pilot would always make the final berthing approach such that the LNGC is perfectly parallel to the FSRU and then the fendering will comfortably absorb any berthing pressures between the vessels. As shown in **Figure 9-5**, however, very occasionally this does not happen, despite best endeavours, and on these occasions, it is the function of the fenders to absorb the closing momentum between the ships without the hulls coming into contact.

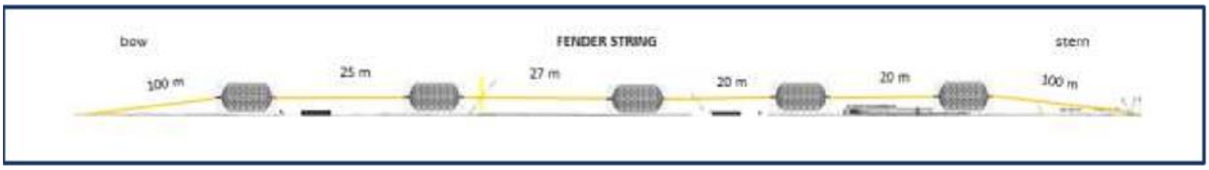


Figure 9-4 Typical Ship to Ship Fender String

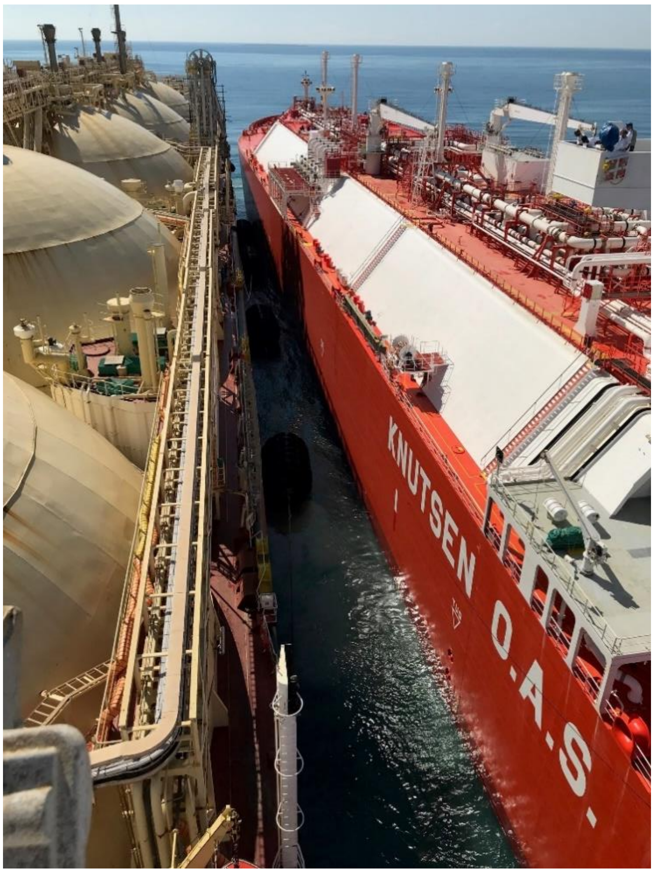


Figure 9-5: Ship to Ship Oblique Approach - Courtesy New Fortress Energy

9.17 MITIGATION 17 - FSRU DAYLIGHT BERTHING

It is recommended that, until sufficient experience of berthing the LNGC alongside the FSRU is gained by the Shannon Pilots, the tug crews and the berthing masters, that berthing and unberthing be limited to daylight hours only. Unberthing by night can take place once each class / type of vessel has unberthed in daylight and has been approved for night unberthing by the SFPC HM. These restrictions should be reviewed and risk assessed periodically.

9.18 MITIGATION 18 - LOAD CELLS ON MOORING EQUIPMENT

SIGTTO and best practice from other LNG ports recommends that load cells are fitted to the jetty mooring systems and to the FSRU. This will allow continuous and remote monitoring of the loading placed on the FSRU lines; SFPC is recommended to encourage its provision. If practical, it is recommended that a similar temporary system could be used on the lines between the FSRU and the LNGC.

9.19 MITIGATION 19 - USE OF CENTIMETRIC PPU FOR BERTHING

It was initially proposed to use a fixed docking system to assist the pilots in situational awareness in the critical final stages of berthing a ship alongside the LNG jetty. The addition of the FSRU to the project has rendered the fixed docking system redundant when berthing an LNGC alongside the FSRU (as it will not be able to “see” through the FSRU). Therefore, it is recommended that the provision of a mobile docking system be investigated or alternatively, the acquisition of a highly accurate centimetric level PPU which would provide the level of accuracy required to assist the pilot in the final stages of berthing alongside the FSRU.

9.20 MITIGATION 20 - ANNUAL REVIEW OF OPERATING LIMITS AND MITIGATIONS

SFPC corporate experience with operating vessels to and from the LNG terminal will rapidly grow and it is recommended that this NRA, the mitigating measures, and the operating procedures are formally reviewed at least annually to ensure their relevance.

9.21 MITIGATION 21 - SCHEDULE DECONFLICTION

Traffic analysis has shown that in shipping number terms, the Shannon Estuary is relatively quiet. This allows SFPC the latitude to stipulate that LNGC or FSRU arrivals / departures do not coincide geographically or temporally with other large commercial shipping movements. If implemented, this mitigation measure significantly reduces the overall collision, contact and grounding risk profile of LNG activity. Accordingly, it recommended that SFPC enact a regime whereby the LNGC /FSRU movements are separated to ensure that these vessels are the only large commercial vessel underway within a defined geographical area at any given time.

9.22 MITIGATION 22 - RESTRICT ANCHORING IN VICINITY OF CABLES

It is recommended that SFPC formalise the prohibition of anchoring near the subsea cables that are laid east of the Moneypoint terminal and that this restriction be shown on the navigational chart. While all Shannon Pilots already recognise the restriction, it is felt that the formalisation of this measure might reduce the possibility of an inadvertent snagging and / or damaging of one the cables by an LNGC vessels anchor.

9.23 MITIGATION 23 - 48 HOUR SHANNON LNG SPECIFIC WEATHER FORECAST

Notwithstanding the increased 70 knot limitation of the LNG jetty to allow the FSRU to remain alongside for longer periods and in stronger winds, the LNGC will be required to stop transferring cargo and to sail at a relatively lower threshold wind speed (as discussed in Mitigation 7) and this will require a formalised planning and execution process. The key ingredient will be an accurate, detailed rolling 48 hour weather forecast service specifically focused on the Shannon LNG jetty which the operator can use to plan cargo operations and if necessary, times of sailing for the LNGC to proceed to the safety of an anchorage.

9.24 MITIGATION 24 - LNGC OPERATIONAL DISCHARGE PLAN

The detailed weather forecast will allow the operator to produce a cargo discharge plan for the LNGC such that, in the event of a forecast storm event, the vessel can be configured into a safe condition in time to allow her to sail to anchor and safely remain there until the storm has passed.

9.25 MITIGATION 25 - LNGC ANCHORAGE DESIGNATED AND KEPT FREE

SFPC will need to identify, risk assess and formally designate an anchorage that is suitable for use by an LNGC as a storm refuge. Then, as a part of the pre-arrival conditions, the LNGC anchorage will need to be kept free or be made available as a priority to the LNGC within the sailing notice limitations.

9.26 MITIGATION 27 - LNGC TUG STANDBY

It is recommended that, in the event that an LNGC is required to go to anchor as a storm refuge, consideration is given to providing a tug to standby to provide assistance to the LNGC. It is recognised that this measure might conflict with the support role to the FSRU alongside envisaged for the LNG tugs and that this decision will inevitably be guided by the immediate operational circumstances – for e.g. the differing sizes of each vessel.

9.27 MITIGATION 26 - LNGC AT ANCHOR - NOTICE FOR SEA

In the event an LNGC is required to go to anchor to ride out a storm event, it is recommended that SFPC consider mandating further notice for sea conditions such as:

1. The vessels bridge and engine rooms are manned or are at immediate notice.
2. Ships engines are ready for immediate start.
3. A second anchor is ready to let go.

10 MITIGATION MEASURE EFFECTIVENESS

An assessment of the effectiveness of the proposed mitigation measures against the 15 top ranked hazards is at **Table 12**. This clearly demonstrates that correctly applied, the proposed mitigation measures are assessed to reduce the baseline risk by nearly 20% or over, for 12 of the 15 top hazards. As expected, even with the project design update the most significant risk reduction is for "Contact - Project Vessel with Project Infrastructure," "Collision - Tanker ICW Project Vessel (FSRU or LNGC)" and "Collision - Small Commercial / Port Services Vessel ICW Recreational Vessel" with a reduction of over 30% for each hazard. In terms of individual mitigation measures and their effectiveness the most commonly applied and the most effective measures can be grouped into 4 separate categories: communication, harbour authority good practice, operational procedures and schedule deconfliction.

- Communication – "Corporate Communications" and "Operational Communications" are applied to every one of the top 12 hazards except one;
- Harbour Authority Good Practice – "Update SMS" and "Annual Review of NRA and Mitigation Measures" are applied to every one of the top 12 hazards;
- Operational Procedures – Mitigation measures number 10 to 14 which all apply to the handling of an LNGC while underway are the next most commonly applied. Similarly,

mitigation measures 23 to 27 which address operational procedures for managing the LNGC during severe weather; and

- Schedule Deconfliction – the ability and space allowed to SFPC to physically separate the LNGC from other large commercial vessels by way of schedule deconfliction is the single most effective mitigation measure; self-evidently reducing the chance of primary collision or second order, event-chain grounding or collisions caused by other vessel avoiding the LNG ships.

It is worth restating that the baseline risk score for all hazards was already "ALARP" but the application of the proposed mitigation measures reduces all but one of the those hazards to a "Low" level indicating that the proposed LNG project in the Shannon Estuary, with the mitigation measures recommended in this NRA applied, is safe to operate from a navigational sense.

Table 12: Additional Risk Control Effectiveness – Top 15 Hazards Scoring ALARP in Baseline Assessment

ID	Hazard Title	Baseline Risk	Risk Controls Applied (Blue = Yes)																											Residual Score	Reduction	Effectiveness
			Update SMS	Towage Procedures	Update Emergency Plans	Mark on Navigation Chart	Corporate Communications	Operational Communications	Define Operating Thresholds	Firefighting Measures	Jetty Security Measures	LNGC Passage Plan	Arrival Preconditions	Additional Simulations	Use Appropriate LNG Tugs	Mobile Control Zone	Static Control Zone	Review of FSU Fendering	FSU Daylight Berthing	Load Cells on Mooring Equipment	Use of Centimetric PPU	Annual Review	Shipping Schedule Deconfliction	Restrict Anchoring Near Cables	48-hour weather Forecast	Discharge Plan	Anchorage Designated	LNGC Notice for Sea	LNGC at Anchor Tug			
22	Contact - Project Vessel with Project Infrastructure	6.48	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	4.35	2.13	33%
9	Collision - Project Vessel ICW Small Commercial / Port Services Vessel	5.16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.65	1.51	29%
2	Collision - Tanker ICW Project Vessel (FSRU or LNGC)	4.64	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.1	1.54	33%
8	Collision - Project Vessel ICW Small Passenger Vessel	4.50	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.5	1	22%
14	Collision - Large Commercial / Dry Cargo Vessel ICW Recreational Vessel	4.46	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.53	0.93	21%
40	Contact - Project Vessel with LNGC at Anchor	4.35	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	4.00	0.35	8%
28	Contact - Project Vessel with Non- Project Infrastructure	4.28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.4	0.75	21%
19	Collision - Small Commercial / Port Services Vessel ICW Recreational Vessel	4.18	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	2.88	1.3	31%
23	Contact - Large Commercial / Dry Cargo Vessels with Project Infrastructure	4.13	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.38	0.34	8%
41	Contact - Large Commercial / Dry Cargo Vessels with LNGC at Anchor	4.13	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.78	0.35	8%
6	Collision - Tanker ICW Recreational Vessel	4.09	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.25	0.84	21%
10	Collision - Project Vessel ICW Recreational Vessel	4.09	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.10	0.98	24%
52	Mooring Incident / Breakout - Project Vessel	4.1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	2.58	1.52	37%
7	Collision - Project Vessel ICW Large Commercial / Dry Cargo Vessel	4.04	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.01	1.03	25%
5	Collision - Tanker ICW Small Commercial / Port Services Vessel	4.03	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	3.29	0.74	18%

11 CONCLUSION

The assessment of navigational risk as a result of the presence of the LNG Project at Ardmore Point, including project design changes since the original 2008 and the 2020 NRAs alongside the baseline navigation profile, has concluded that the Project is acceptable in terms of navigational risk and should have minimal impact on the existing navigational risk profile, assuming compliance with embedded and implementation of proposed mitigation measures.

The project design continues to evolve and, in an effort to reduce the footprint of the project ashore, the FSU has been changed to an FSRU since the 2020 NRA. Additionally, the developer has responded to the recommendations of the 2020 NRA by spending considerable effort to uprate the design of the LNG jetty and FRSU to increase in the wind limitation threshold 60 knots to 70 knots.

11.1 RECOMMENDATIONS

In the time since the original 2008 NRA, a number of proposed mitigations have already been adopted by SFPC and embedded into the fabric of the operating procedures or the layout of the estuary, all of which have served to reduce the overall baseline navigational risk.

The 2021 NRA update revisited the data and conclusions of the 2020 NRA including stakeholder consultation and confirmed that 22 of the 23 possible additional mitigation measures in the 2020 NRA remain relevant. The only additional mitigation from the 2020 NRA to be dropped was number 23 which strongly recommended additional measures, and specifically storm wires were used to accommodate 60-knot wind loading for the 2020 jetty design. This measure was removed from the 2021 NRA after the developer uprated the design of the jetty and the FSRU alongside to 70-knot wind speeds.

The 2021 NRA update identified 5 additional mitigation measures chiefly aimed at addressing the safety of an LNGC during a potential storm event, which would be required to stop working cargo and sail to anchorage.

In terms of the greatest risks, the 2021 NRA update continued to assess “Contact - Project Vessel with Project Infrastructure” as the top risk although the residual mitigated score still remains firmly in the lower end of the ALARP range.

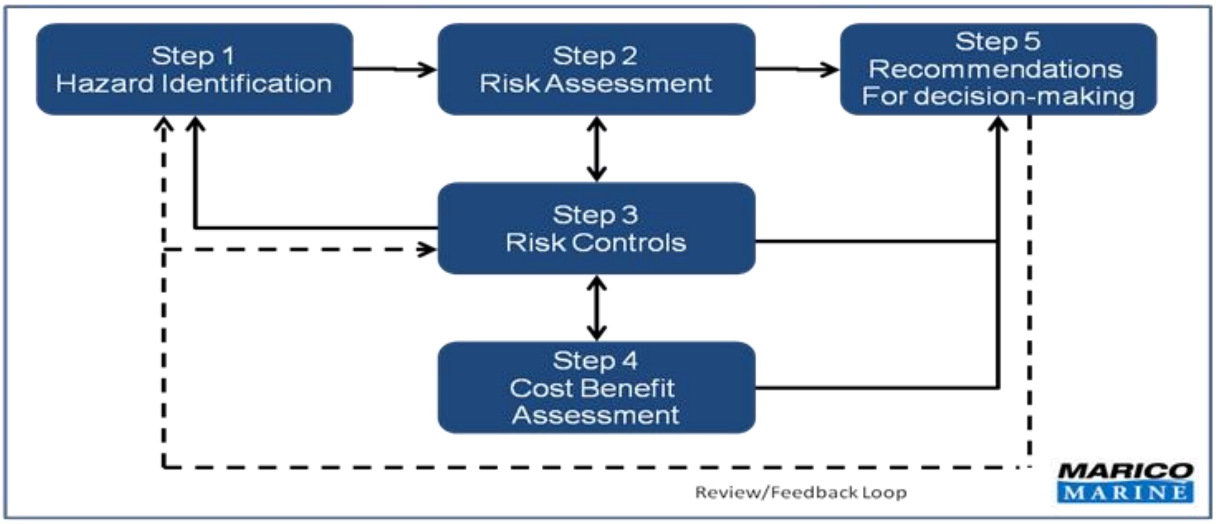
Two new risks emerged as number 2 and 3 in the list, both addressing the very unlikely but the high consequence of a contact between a vessel and the LNGC once it had proceeded to anchor in advance of a storm event. Again, both risks were in the Low range.

It is recommended that SFPC give detailed consideration to the implementation of each of the 27 additional mitigation measures and especially those that apply to 6 hazards that scored in the ALARP range in the baseline (unmitigated) assessment.

Annex A NRA Methodology

RISK ASSESSMENT METHODOLOGY

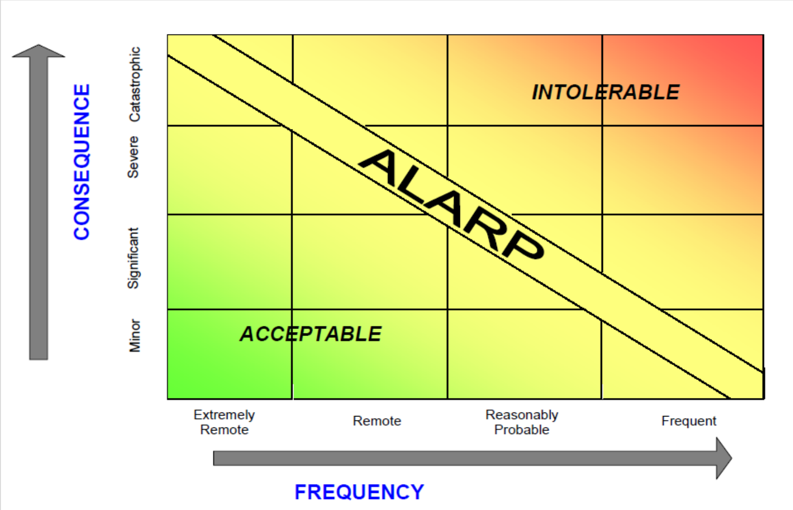
The Navigation risk assessment methodology was based on the Formal Safety Assessment methodology as adopted by IMO. Marico Marine uses a form of risk assessment that has been specifically adapted for navigational use. It is unique to Marico and is fundamentally based on concepts of "Most Likely" and "Worst Credible", which reflect the range of outcomes arising from a shipping accident.



Formal Safety Assessment Risk Assessment Process.

IMO Guidelines define a hazard as "*something with the potential to cause harm, loss or injury*", the realisation of which results in an accident. The potential for a hazard to be realised can be combined with an estimate or known consequence of outcome. This combination is termed "risk". Risk is therefore a measure of the frequency and consequence of a particular hazard. One way to compare risk levels is to use a matrix approach as illustrated below. At the lowest end of the scale, frequency is extremely remote and consequence insignificant such that a risk can be said to be negligible. At the high end, where hazards are defined as frequent and the consequence catastrophic, then risk is termed intolerable. Between the two lies an area known "As Low As Reasonably Practicable" (ALARP).

The IMO guidelines allow the selection of definitions of frequency and consequence to be made by the organisation carrying out the risk assessment. This is important, as it allows risk to be applied in a qualitative and comparative way. To identify high risk levels in a purely mathematically quantitative way would require a large volume of casualty data, which is rarely available in the maritime context. ALARP can be accepted as being "Tolerable", if the further reduction of the risk is impracticable, or if the cost of such reduction would obviously be highly disproportionate to the improvement. It can also be considered "Tolerable", if the cost of reducing the risk is greater than any improvement gained.



Frequency / Consequence Chart.

Vessel types were assessed and were subdivided into categories befitting vessel operations within the Shannon Estuary. The resultant vessel categories are identified below.

Vessel Categories

Category	Description
Commercial	
Tankers	Including product tankers, crude oil tankers, gas carriers (not associated with the project).
Large Commercial & Dry Cargo Vessels	Including general cargo, containers, non-liquid bulk carriers, cruise ships.
Project Vessels	LNGCs / FSRU
Passenger Vessels	Ferries, dolphin watch / excursion vessels up to 100 Pax.
Other	
Small Commercial / Port Services Vessels	Including tugs, pilot boats, workboats, ports vessels and fishing vessels.
Recreational Vessels	Sailing yachts, motor yachts, sailing dinghies, Rigid Inflatable Boats (RIB), Personal Watercraft (PWC) etc.

The identified vessel categories were then combined with accident categories to establish hazards for assessment. The hazard categories identified as relevant to this study, and the number of resultant individual assessed hazard categories are as follows:

Hazard Categories

Ref	Hazard Category	Hazard Detail	Comments	Individual Assessed Hazards
1	Collision	All Vessel Types	Two or more vessels impact each other whilst manoeuvring.	20
2	Contact	Non- Project Infrastructure	One or more vessels contacts a berth, pier or jetty.	6
		Project Infrastructure	One or more vessels contacts a stationary / berthed vessel. Also known as striking.	6
		LNGC at Anchor	One or more vessels contacts LNGC at anchor.	6
		Navigation Buoy	One or more vessels contacts a navigation buoy. Also known as striking.	6
3	Grounding	All Vessel Types	A vessel unintentionally contacts the seabed.	6
4	Foundering / Swamping	Project Vessels	A vessel fills with water for any reason including capsize, and when overwhelmed, sinks.	1
5	Mooring / Breakout	Project Vessels	FSRU breaks away from jetty. A vessel ranges (moves excessively) whilst alongside the berth or when one or more mooring lines fail resulting in the vessel unintentionally breaking away from its moored position.	2
6	Cable Snagging	Project Vessels	A cable is snagged by a project vessel's anchor.	1
7	Fire / Explosion	Project Vessels	A fire breaks out on berthed FSRU or LNG supply vessel.	1
8	Tug Girting	Project Tugs	A tug girts while project vessel is under tow.	1

Each hazard was reviewed with respect to cause and "Most Likely" and "Worst Credible" outcome for risk assessment in terms of frequency and consequence.

Assessment of Consequence

Using the assessed notional frequency for the "*most likely*" and "*worst credible*" scenarios for each hazard, an assessment was made for the consequences to people, property, environment and business, using the criteria outlined below.

Consequence Criteria.

Cat	People	Property	Environment	Business
1	Negligible Possible very minor injury (e.g. bruising)	Negligible Costs <10k	Negligible No effect of note. Tier1 may be declared but criteria not necessarily met Costs <10k	Negligible
2	Minor (single minor injury)	Minor Minor damage Costs 10k –100k	Minor Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity CEAS Site warning Costs 10K–100k	Minor Bad local publicity and/or short-term loss of revenue
3	Moderate Multiple minor or single major injury	Moderate Moderate damage Costs 100k - 1M	Moderate Tier 2 spill criteria reached but capable of being limited to immediate area within site COMAH site evacuation Costs 100k -1M	Moderate Bad widespread publicity Temporary suspension of operations or prolonged restrictions
4	Major Multiple major injuries or single fatality	Major Major damage Costs 1M -10M	Major Tier 3 criteria reached with pollution requiring national support. Chemical spillage or small gas release COMAH local evacuation Costs 1M - 10M	Major National publicity, Temporary closure
5	Catastrophic Multiple fatalities	Catastrophic Catastrophic damage Costs >10M	Catastrophic Tier 3 oil spill criteria reached. International support required. Widespread shoreline contamination. Serious chemical or gas release. Significant threat to environmental amenity. COMAH major area evacuation Costs >10M	Catastrophic International media publicity. Operations and revenue seriously disrupted for more than two days. Ensuing loss of revenue.

Note that the Oil Pollution Preparedness, Response Co-operation Convention[15] defines the following response levels for oil spills in Ireland:

- Tier 1 Local (within the capability of the operator on site): A Tier 1 response is the lowest response level and requires resources to be available locally. Depending on the characteristics of the oil this may or may not include the use of dispersants. By definition these resources must be at or near the incident site. It is expected that these resources will be deployed as quickly as operational circumstances allow.
- Tier 2 Regional (beyond the in-house capability of the operator): For larger pollution incidents, local resources may be insufficient to deliver a proper response. In these cases it may be that resources from a regional centre will be required. A key component of IRCG offshore Tier 2 response is that operators are expected to have this capability mobilised and applied within 2 to 6 hours of an oil pollution incident.
- Tier 3 National (requiring national resources): For very large pollution incidents, resources supplied from national and international sources may be required. A key component of IRCG offshore Tier 3 response is that operators are expected to have this capability mobilised and applied within 6 to 18 hours of an oil pollution incident.

The "Most Likely" and "Worst Credible" scenarios for each hazard, the probable consequences associated with each were assessed in terms of damage to:

- People - Personal injury, fatality etc.;
- Property – including third party;
- Environment - Oil pollution etc.; and
- Business - Reputation, financial loss, public relations etc.

Assessment of Frequency

Frequencies were derived for notional hazard events in each case, using the frequency bands defined below.

Frequency Criteria.

Scale	Description	Definition
F1	Rare	An event that could happen or has happened beyond 100 years
F2	Unlikely	An event that could happen or has happened between 10 to 99 years.
F3	Possible	An event that could happen or has happened between 1 to 9 years.
F4	Likely	An event that could happen or has happened annually.
F5	Frequent	An event that could happen or has happened in 1 month.

[15] The Merchant Shipping (Oil Pollution Preparedness, Response Co-operation Convention) Regulations 1998, Statutory Instrument 1998 No. 1056

Once the frequency and consequence have been determined for the "Most Likely" and "Worst Credible" scenarios, these scores are combined using a weighted average to produce a single numeric value representing the final risk score for each hazard, between 0 (negligible) and 10 (high) as indicated by the project risk matrix below.

Project Risk Matrix.

Consequences						
	Cat 5	5.1	5.9	7.0	8.3	10.0
	Cat 4	4.1	4.9	5.9	7.4	9.4
	Cat 3	2.9	3.5	4.4	5.9	8.3
	Cat 2	1.5	1.8	2.4	3.5	5.9
	Cat 1	0	0	0	0	0
	Frequency	>100 years	10-99 years	1-9 years	Annually	Within 1 month

These scores are then assigned a risk band that indicates their acceptability. Hazard risk scores are categorised as either negligible, low, As Low as Reasonably Practicable (ALARP), significant or high, where ALARP represents a level of risk is neither acceptable nor unacceptable and for which further investment of resources for risk reduction may or may not be justifiable – i.e. risks which fall within the ALARP band should be reduced unless there is a disproportionate cost to the benefits obtained.

Navigation hazards with a risk score of significant or high are deemed unacceptable and, as such, additional risk control measures must be implemented to reduce the risk to an acceptable level.

Risk bands

Matrix Outcome	Risk Definition	Action Taken
0 – 1.99	Negligible Risk	A level where operational safety is unaffected.
2 -3.99	Low risk	A level where operational safety is assumed.
4 – 5.99	As Low As Reasonably Practicable (ALARP)	Neither acceptable or unacceptable. Consideration should be given to the application of possible additional risk controls where their implementation shows a marked reduction in risk. Risk controls in place should be regularly reviewed in the ensuing SMS.
6 – 7.99	Significant Risk	A level where existing risk control is automatically reviewed and suggestions made where additional risk control could be applied if appropriate. New risk controls identified should be introduced within a timescale of two years.
8 - 10	High Risk	A level requiring immediate mitigation.

Annex B Stakeholder Consultation Minutes

Minutes of Meeting held on 26th May 2020 – Shannon Pilots

Client:	Shannon Foynes Port
Project:	Shannon LNG
Venue:	Teleconference
Date of Meeting:	Tuesday 26th May 2020, 15:00
Present:	Shannon Pilots (SP)
	Marico Marine (MM) Paul Brown (DF) Rebecca Worbey (RW)
	Shannon Foynes Port (SFP) Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide. • Approximately 1,800 movements per year. LNG vessels will add approximately 100 movements per year. • Tugs planned to be based just inside the jetty, LNG development will have its own towage facility.	
2	**Background to Stakeholder Operations**	

	• Pilot operations unchanged since the 2008 NRA. The number of tugs and pull capacity of the tugs to remain unchanged from the previous risk assessment.
	• 8 pilots in total with 6 pilots on duty at a time, 3 'inbound' and 3 'outbound' pilots. Only cover opposite direction from time to time.
	• Pilot cutter is based at Kilrush.
	• It takes approximately 1 hour to take a vessel to Tarbert from boarding point.
	• PPU's – Pilots currently use Navicom Dynamics Channel Pilots and Wartsila software which work well.
	[In reference to proposed LNG vessel track plot]
	• Points 4 and 5 just east of Ballybunnion Buoy is pilot boarding area 2. Pilots will be looking for a lee to board the vessel.
	  o Plenty of room to board as 2 – 3 miles to the entrance of the channel.
	  o Speed maintained through the narrows.
	• Points 6 – 12 – estuary pilotage at 10 knots. Course is essentially straight in fair weather, keeping Asdee Buoy on the starboard side.
	• In contact with vessels using the anchorages at all times.
	• Glencloosagh Bay anchorage is rarely used. Not used by pilots at all.	

3	**Hazard Identification**	

	• Definitely no pilot shortages as there are six pilots on at any one time so there is always someone available to board.
	• No issue with leading lights which are easily visible. Tail of Beal Bar buoy has AIS.
	• Due to the prevailing wind there are no issues with restricted visibility (it is unusual).
	• Narrow section between Beal Spit and Kilcredaun Point probably carries the highest navigational risk due to risk of grounding.
	    ○ With both 3-4 knots of tide and wind behind you coming out of the narrow section into the turn, this section needs to be carefully navigated past Beal Spit.
	    ○ Flood tide generally 2.5 knots. Spring tide can be up to 5 knots in this section of the estuary.
	• Escort Tug to be made fast after pilot boarding.
	• Next pinch point with grounding risk is at Carrig / Rineanna shoals. Shouldn't get close to Rineanna shoal as will be coming down from full speed so will still have good steering.
	• The additional tugs would be picked up at Rineanna Buoy and made fast by North Carrig Buoy. After which start dropping speed.
	• Plenty of room to swing on to berth south of the bridges. No reason to be in the middle of the channel to make the turn. Predominant wind direction is west / southwest.
	• Cables are present to the east of Ardmore Point with two further cables due to be laid.
	    ○ SP are not sure what depth they were buried to. In case of need to emergency anchor, would have to wait until the cables had been passed.
	    ○ There shouldn't be a need to use anchor with tugs attached.	

4	**Mitigation Measures**	

	• The 2008 NRA says that remote pilotage wont be permitted, however, SP feel that vessel equipment is much better now than in 2008 and that remote pilotage should be considered as an option.
	    ○ Pilots currently use remote pilotage on Panamax vessels and unloaded Cape size vessels to great effect in poor weather conditions where pilotage transfer is unsafe at the outer pilot boarding areas.
	• SP agree with 2008 NRA mitigation was that if wind exceeds 25 knots the vessel doesn't come in and vessel should wait at outside anchorage. As these are large ships with a high freeboard, we feel that LNG carriers may set heavily in windy conditions. Mooring at up to 25 knots should be achievable with four tugs.
	• The escort tug attached astern no problem as long as they can comfortably match the speed of the vessel. Additional tugs aid turning.
	• Boarding closer to Ballybunnion Buoy would give longer to board and ensure sufficient handling control before committing. Once through the narrows there isn't a turn point.
	    ○ At the time of the initial risk assessment it was deemed that we had approximately 12 days of gale force wind per year. Judging by the past few winters we have experienced, boarding/disembarking two miles west of the Ballybunnion racon buoy would not be achievable a lot of the time.	

	• SP recommend abort positions at Ballybunnion racon buoy and another east of Doonaha Buoy. • SP happy with the exclusion zone proposed in the 2008 NRA. The port is not overly busy so it should not interfere with other river users. • SP don't think any additional marks are required to mark the berth given that the pilots are using PPUs and already have good situation al awareness. • SP wonder if the four fenders suggested by the Moffat and Nichol study are enough. ○ SP not certain on tidal pattern at Ardmore Point, but tides are precarious across the estuary near Moneypoint. • SP suggest running stern lines • Doppler berthing system • Daylight limitations should be enforced to start with until pilots have reviewed handling of LNG vessels as they will not handle the same as bulkers. LNG vessels should be more modern and more easily able to get up to speed. • The pilots feel simulation training for berthing alongside a FSU would be desirable. • The pilots also feel that familiarisation with watching an LNG tanker berthing and unberthing from an FSU in another LNG port would be important. • Consideration could be given to getting a new pilot boat that has better sea keeping abilities if remote pilotage is not an option.	
5	**Historical Incidents**	
	• No buoy contacts have occurred to SP's knowledge while a pilot has been on board. • Two vessels have taken out the Doonaha Buoy, however, they were smaller vessels not under pilotage and they buoy has now been moved to a better location. • SP have experienced 1 mechanical failure in 11 years of piloting. In this scenario they would go to anchor and wait for assistance.	
6	**Other**	
	• There has been a reduction in the amount of commercial traffic with Moneypoint and Tarbert electricity • Generating stations operating at minimum output. Both Jetties only get 1-2 ships per year. • Dolphin watching and yachting still take place in this part of the estuary, but usually in the summer months only. • No PEC holders in the estuary • Operation shutdown data at RUSAL Aughinish would give an indication of the number of poor weather days > 30 knot winds.	

Minutes of Meeting held on 26th May 2020 – Aughinish Alumina

Client:	Shannon Foynes Port
Project:	Shannon LNG
Venue:	Teleconference
Date of Meeting:	Tuesday 26th May 2020, 12:00

Present:	Aughinish Alumina (AA)	
	Marico Marine (MM)	Paul Brown (PB) Rebecca Worbey (RW)
	Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide. • HC – In terms of frequency, there are approximately 1,800 movements per year. LNG vessels will add approximately 100 movements per year. AA – questioned how big the vessels will be. • PB – Planning application is based on supply vessels of between 130,000 and 180,000 cubic meters. They will therefore be approximately 260m long, 11.5m draught and 90,000 tonnes deadweight. • FSU vessel will be slightly larger and may go to sea once per month at most in order to maintain seagoing certification.	
2	**Background to Stakeholder Operations**	

	• Approximately 320 ships per year serving the Aughinish Alumina Ltd. Alumina refinery.
	  ○ 70 – 80 225m LOA vessels delivering bauxite ore.
	  ○ Discharge every 3-4 days – approximately 16,000 tonnes
	• As will be the case for the LNG supply vessels. AA's vessels berth and leave on the flood tide.
	• AA's vessels are restricted by weather and are intense users of the anchorages. AA likes to have at least one ship at anchor so that they are able to bring in the next vessel for loading immediately after the previous has been loaded.
	• PB – Have there been any major operational changes since 2008?
	  ○ Reduction in (Heavy Fuel Oil) HFO shipments
	  ○ Increase in parcel size of caustic fuel oil tankers.	

3	**Hazard Identification**	
	• AA questioned whether the feeder vessels will need to use the anchorages as any constraints on the number of ships at anchor could be a threat to AA's business. AA's vessels are restricted by weather and are intense users of the anchorages. Queueing for anchorages would be AA's main concern. Queuing is primarily an issue in winter and typically occurs once or twice per winter season.	

	○ The delivery vessels will only have to go to anchor if there is a need to wait for a suitable weather window. In this case, the deep water anchorage outside would be used. ○ HC – may have to hinder a bauxite vessel coming into anchor by 30 minutes or so, but they will get priority over any LNG vessel that is coming in for an early berthing. • AA questioned if there will be defined exclusion zones while the vessel is underway and while they are berthed? ○ PB explained that there are no official LNG exclusion zone guidelines and the NRA will inform the ports decision on exclusion zones. ○ Any exclusion zone will likely be no different to that enforced for one of AA's bulkers. ○ The jetty itself will have an 150m policed exclusion zone enforced at all times. • AA questioned whether the exclusion zones around the LNG supply vessels will limit use of the anchorages. ○ LNG supply vessels will arrive ready to berth and will be held outside until cleared for entrance. It is not envisaged that they will need to come in to anchor. • It was questioned whether berthing limits have been determined at this point? ○ The NRA will aid in the determination of berthing limits. ○ Berthing in up to 25 knot winds is anticipated in line with 2008 NRA. ○ In the event that an LNG vessel breaks off, an anchor may need to be used to bring her back in again. • AA questioned pilot availability. ○ HC - No conflict is envisaged. • AA considers that the consequences in the event of an incident are the primary concern as opposed to an increase in frequency of occurrence. ○ If an incident to occur it may impact their operations. • Of the navigational hazards discussed, breakout was of greatest concern, with the potential to disrupt and delay operations. ○ AA questioned what would happen in the event of a breakout while undertaking ship to ship transfer operations. ○ PB explained that safety features will ensure shut off if vessel breaks away. • Collision risk is thought to be unchanged /slightly increase.	
4	**Mitigation Measures**	
	AA asked if daylight restrictions will apply? • Vessels will have doppler systems and berthing aids therefore should be more than capable of operating at night. This will be considered as part of the NRA. • AA suggested that an incident response plan should be formulated. AA questioned if tug crews will be separate? • LNG vessels will have their own towage fleet. • Two separate licenses will be issued. • Four-hour callout for shipping movements • Unlikely that the same crews will be used, however, this has not yet been determined.	

	• Tugs will need to be available 24/7 if an LNG supply vessel is present.	
5	**Actions**	
	AA would like to be involved in the operational assessment going forward. AA asked if the NRA will be shared once completed. • HC explained that all stakeholders will have sight of the finished report.	

Minutes of Meeting held on 28th May 2020 – ESB Moneypoint

Client: Shannon Foynes Port
Project: Shannon LNG
Venue: Teleconference
Date of Meeting: Tuesday 28th May 2020, 15:30

Present: ESB Moneypoint (ESB)

Marico Marine (MM) Paul Brown (PB)
Rebecca Worbey (RW)

Shannon Foynes Port (SFP) Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently receiving LNG via ship-to-ship transfer. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide. • LNG vessels will add approximately 100 movements per year.	
2	**Background to Stakeholder Operations**	
	• ESB Moneypoint is based directly across the river from the proposed LNG jetty. • ESB receives one coal supply vessel per year and one heavy fuel oil vessel. • Vessels berth at the top of high water. • ESB delivery vessels do not use the anchorages	
3	**Hazard Identification**	

	Collision
	• No concerns/ comments about potential collisions through the narrows / estuary approaches.
	• LNG vessel is to berth at the end of high water, as such there should be natural separation between the Moneypoint and LNG vessels.
	• No concerns in the vicinity of Moneypoint and Ardmore Point as the estuary is wide therefore swinging should not be an issue.
	Contact
	• No concerns/ comments about the risk of contacts through the narrows / estuary approaches.
	• Only concerns in the vicinity of Moneypoint and Ardmore Point is if the presence of the LNG supply vessel alongside the FSU pushes other river traffic closer to Moneypoint.
	    ○ HC - LNG vessel moored alongside the FSU will not encroach on the navigable channel and therefore its presence should not push vessel traffic closer to Moneypoint.
	• As the estuary is wide (approximately 2 miles) swinging on to the berth should not increase the risk of contact with the Moneypoint jetty.
	Grounding
	• There have been some issues in vicinity of the 'bar' in the past.
	    ○ However, LNG vessel draught is significantly lower than that of the Moneypoint vessels.
	Wash	

	• ESB questioned if there would be any issues with wash affecting their jetty as a result of the LNG vessel turning to berth.
	  ○ It was agreed that owing to the width of the river and the location of the proposed supply vessel track the effects of wash would likely be minimal. The vessel would have to deviate somewhat from its course to cause and cause enough wash to interfere with Moneypoint operations.
	Tug Availability
	• Tug availability leading to operational delays is ESB's greatest concern.
	• ESB enquired how many tugs would be required to bring in an LNG vessel:
	  ○ 1 tug to attach to the stern at 'the narrows'.
	  ○ 1 Forward tug to attach around Letter Point Buoy.
	  ○ Another two tugs will then assist in the turn into Ardmore Point and coming alongside the jetty.
	Cables
	• There are plans by the national grid to lay further cables on the eastern side of the existing cable.
	• Consideration should be given to this if emergency anchoring is required following mechanical failure for example.	

4	**Mitigation Measures**	

	Anchorages / Waiting
	• ESB delivery vessels do not use the anchorages. ESB questioned procedure in case of vessels arriving at the same time.
	  ○ Normal port procedures will be enforced to determine who goes first in a situation where two vessels arrive at once.
	  ○ LNG vessel is to berth at the end of high water, as such there should be natural separation between the Moneypoint and LNG vessels.
	Communication
	• Active communication between port and estuary users.
	Towage
	• It is intended that the LNG vessels will have their own towage so Moneypoint will not be competing for towage.
	MetOcean
	• Can be poor weather conditions between October and March.
	• Berthing limit of up to 25 knots
	• If winds exceed berthing limits vessels to remain offshore to mitigate grounding risk / interaction with 'the bar'.	

5	**Other**	
	Future Scenario • There is a possibility that ESB may diversify operations in the future, exporting ash for example, which will require 3,000 – 4,000 ton ships to berth at Moneypoint and as such there may be more traffic transiting to the Moneypoint jetty in the future. Planning is in the early stages and as such no specifics or guarantees can be made at this time. • There is another smaller jetty used by ESB to the west referred to as 'barge landing' on the chart. There could potentially be activity here in the future but unable to forecast usage as of yet. LNG Vessel Berthing • ESB questioned if the LNG supply vessels will always berth facing out into the flood (turning on arrival).	

	○ PB – berthing port side to was a recommendation of the 2008 NRA that was also trailed at simulation by the pilots who preferred this option. ○ HC - Jetty designed has been designed at an angle of 260° to accommodate this. FSU Operations • ESB questioned whether the FSU will ever move away from the jetty. ○ HC - The FSU will move away once a month in order to maintain seagoing certifications. Application / Planning Status • ESB questioned the status of the planning application ○ MM – is unable to comment on the status of the planning application.	

Minutes of Meeting held on 26 May 2020 – National Oil Reserve Agency (NORA)

Client: Shannon Foynes Port
Project: Shannon LNG
Venue: Teleconference
Date of Meeting: Tuesday 26th May 2020, 11:00

Present: NORA

Marico Marine (MM) Paul Brown (PB)
Rebecca Worbey (RW)
Shannon Foynes Port (SFP) Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	NORA is not familiar with LNG shipping or LNG operations in general. PB introduced the project and changes that have occurred since the last NRA in 2008: o FSU vessel alongside permanently. o Feeder ships delivering LNG at a rate of 1 feeder ship per week	
2	**Background to Stakeholder Operations**	
	• Three terminals in Ireland owned and managed by Nora: o Two in Dublin o One in Shannon (Tarbert) • Four storage tanks in Tarbert of 40 million liter capacity used exclusively to store oil stocks for use in an oil supply emergency (national or international). o Three tanks contain diesel o One tank contains Kerosene • Tanks, which formally belonged to the power station, were refurbished by NORA in 2012. • Fuel is tested every 6 months to check it has not gone off spec. Fuel can stay on spec for 10 to 15 years. In the event that it has gone off spec then the fuel would require replacing. • Internal tank inspections occur every 10 to 15 years so next delivery will be roughly 2025 unless a national emergency occurs requiring fuel to be used. o In this event fuel would be taken out by ship. • Nora has the ability to take stock in and out by ship or truck. • Frequency of shipping into or out of the terminal is very low. o The only shipping activity to date being the initial importation of oil stocks to fill the terminal in 2012.	
3	**Hazard Identification**	
	• Due to the very limited level of shipping activity in which NORA engages into and out of Tarbert, the Agency is not sufficiently familiar with the navigational profile to assess the navigational risks that might exist at present, or in the future, in the event of shipping of LNG. • NORA does not consider that the increased frequency of vessel movements will be a concern given that movements are anticipated to be of low frequency. • NORA doesn't have any navigational concerns resulting from the project.	
4	**Other**	
	• NORA questioned what pressure LNG is stored at.	

	o MM explained that it is kept at low temperature and it is this low temperature that significantly reduces its volume for transport and storage.	
5	**Actions**	
	-	

Minutes of Meeting held on 26 May 2020 – MARINE SURVEY OFFICE (MSO)

Client:	Shannon Foynes Port
Project:	Shannon LNG
Venue:	Teleconference
Date of Meeting:	Written Response
Present:	MSO

Marico Marine (MM)	Paul Brown (PB) Rebecca Worbey (RW)
Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	o Written response received reproduced below.	
2	**Written Response**	
	I have been asked by Deputy Chief Surveyor, Marine Survey Office, to address your request and that of "Marico Marine" to participate in the consultation process with respect to the development of the Shannon LNG Terminal. As regulators, and consistent with the principles of maintaining impartiality, this office does not engage in consultation nor offer advice to third parties, this office does however, assess each foreshore application with respect to navigational safety issues on receipt of applications from the relevant departments under the Foreshore Act 1933 to 1998. Notwithstanding the above, I can confirm that I was first introduced to this project in October of 2006 by way of a foreshore application, my initial response at that time was among other requirements, to call for the developer to produce a Navigational Risk Assessment (NRA) to be considered by this office. A navigational risk assessment was subsequently produced in 2008, which was quite acceptable at that time. Although the dynamics have expressively changed in as much as the LNG discharge process will now be by means of ship to ship transfer as opposed to ship to terminal transfer, much of the previous risk assessment is still very relevant, the only fundamental change will require a detailed risk analysis to reflect this significant change to the discharge arrangement. This new development introduces an additional risk element with respect to ship to ship contact during manoeuvring operations in particular and will require commensurate mitigation to reduce the possibility of such contact. This office, having considered the mitigation measures outlined in the 2008 NRA and in particular to the additional measures contained in Annex "A"; is satisfied that much of our concerns have been addressed however we would like the developer and SFPC to also consider the following: o The developer and Shannon Foynes Port Company (SFPC), should consider the inclusion of additional aids to navigation in the channel. o Additional training for pilots. o Additional training for tug masters.	

- Emergency response training to consider collision, contact damage, grounding, equipment failure, break away, meteorological limitations, tow line parting and tug break down etc.
- Establishment of visual readouts to provide real-time information on wind speed and direction, speed of approach, current and tidal information etc.
- Consideration of under keel clearance at the pinch point shallows.
- Speed restrictions of passing traffic.
- Development of Mooring plans.
- Development of Master / Pilot exchange of information.
- Fendering to comply with ISO standards.
- Enhanced VTS management.
- Contingencies to ensure expeditious response to mother and daughter vessels being able to vacate the berth in response to any possible security, fire or other significant treat.

It should be noted that much of the control measures have to be developed by SFPC as the local port authority, new bye-laws may have to be introduced for which there is provision under the Harbours Act.

I trust you will find this of some assistance.

Kind regards.
Marine Survey Office.

An Roinn Iompair, Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport

An Tsráid Mhór Uachtarach, Béal Átha Seanaidh, Co. Dhún Na Ngall, F94 C44W
Upper Main Street, Ballyshannon, Co Donegal, F94 C44W

Minutes of Meeting held on 29 May 2020 – Shannon Estuary Marine

Client:	Shannon Foynes Port	
Project:	Shannon LNG	
Venue:	Teleconference	
Date of Meeting:	Tuesday 29th May 2020, 11:00	
Present:	Shannon Estuary Marine (SEM)	
	Marico Marine (MM)	Paul Brown (PB) Rebecca Worbey (RW)
	Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide.	
2	**Background to Stakeholder Operations**	
	• Shannon Estuary Marine is a small business based at Kilrush that has been running in the Shannon Estuary for the last three years. • SEM operates a number of different work boats, barges and tugs and is the official work boat provider at the nearby terminal at Moneypoint.	
3	**Hazard Identification**	
	• SEM would consider any additional navigation risk due to the introduction of LNG ships to be negligible due to the sheer size of the Shannon Estuary and low frequency of transits. • No additional navigational risk due to the LNG terminal location. ○ Moneypoint is used rarely these days so turning here shouldn't be an issue.	
4	**Mitigation Measures**	
	• Based on the recommendations which were recommended after the 2008 report we don't consider any further measures are necessary. • Consideration should be given to also having a smaller more maneuverable security type vessel on site when a ship is present.	
5	**Other**	
	• Since 2008 SFPC has had a sizable increase in its tonnage throughput. • The only observation we would make would be relating to site and ship security/protection. ○ HC – A discussion can be had around this at a later stage. It is not a navigation hazard and therefore doesn't need to be considered within the NRA. • SEM is very supportive of the project as this area of the estuary is underused.	

Minutes of Meeting held on 28 May 2020 – IRISH COAST GUARD (ICG)

Client: Shannon Foynes Port
Project: Shannon LNG
Venue: Written Response
Date of Meeting: Written Response

Present: ICG

Marico Marine (MM) Paul Brown (PB)
Rebecca Worbey (RW)
Shannon Foynes Port (SFP) Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	○ Written response received reproduced below.	
2	**Written Response**	
	The IRCG whilst happy to support the consultation process, would again highlight our principle remit as residing in maritime SAR and Ship causality, pollution preparedness and response. In terms of the specifics of the navigational risk assessment we would not have comment or observation at this stage, again comment from the Irish Maritime Administration on the assessment lie's principle within the competency of the MSO. However, we would like to draw your attention to the statutory requirements for robust contingency planning arrangements for such facilitates in respect to preparedness and response. Further and as you may be aware, activities such as Ship to Ship Transfers (STS) are prescribed activities within our EEZ. Such activities when conducted outside of Port/Harbour limit and require a permit on each occasion from the IRCG (DTTAS). I would be happy to provide any additional relevant detail you may require and would like to also take this opportunity and highlight the pending publication of our National Maritime Oil and HNS Spill Contingency Plan. Mr Hugh Conlon has an awareness of the Plans content and arrangements. Finally, we are happy to support future consultation as required and reserve the right to make comments or observations in the areas within which the Coast Guard has a competence. Regards Head of Section Preparedness, Response & Planning Irish Coast Guard Irish Maritime Administration An Roinn Iompair, Turasóireachta agus Spóirt Department of Transport, Tourism and Sport Lána Líosain, Baile Átha Cliath, D02 TR60	

	Leeson Lane, Dublin, D02 TR60	

Minutes of Meeting held on 03rd June 2020 – Carrigaholt Dolphin Watch

Client:	Shannon Foynes Port	
Project:	Shannon LNG	
Venue:	Teleconference	
Date of Meeting:	Tuesday 03rd June 2020, 12:00	
Present:	Carrigaholt Dolphin Watch (CDW)	
	Marico Marine (MM)	Paul Brown (PB) Rebecca Worbey (RW)
	Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide. • Approximately 1,800 movements annually through Shannon Foynes Port. LNG vessels will add approximately 100 movements per year.	
2	**Background to Stakeholder Operations**	

	• Capacity for 48 passengers and 2 crew on board CDW vessel.
	• Operate out of base in Carrigaholt
	• Operate primarily around the edges of the channel / outside of the channel
	• Trips vary depending on state of tide and behaviour of dolphins.
	  ○ April - July: On the incoming tide to the north of Beal Point and the south east of Kilcredaun Point (close to the narrow section of the estuary) are dolphin hotspots.
	  ○ Additionally, on the flood tide, the south / south east of Beal Bar Buoy is a dolphin hotspot particularly in the last two hours of flood.
	  ○ From August on it is very unlikely that CDW will be in the above-mentioned areas as the dolphins head west closer to Ballybunnion Buoy perhaps due to the end of the salmon season	

3	**Hazard Identification**	
	Collision • CDW operate in accordance with COLREGS and are used to navigating in the estuary with big ships without incident. • CDW operate in and around the navigation channel most of the time and on occasions that they are in the channel move well in advance of an approaching vessel in line with regulations. • The estuary is very wide, which cannot be easily appreciated from the navigation charts / photos. <u>Contact</u> • CDW only very rarely (maybe 3-4 times per year when swell is too bad to go west) operate to the east out of Carrigaholt. • Area 1 mile east of the North Carrig Buoy is a very popular place for dolphins and if weather does not permit other options then CDW will go here but rarely.	

	• CDW is rarely in the vicinity of Ardmore Point and as such contact with the jetty structure is not of concern. Grounding • There is a very strong current through the narrow section between the Beal Bar and Kilcredaun Point where ships commence turn at Doonaha Buoy. • One ship came into grief here 15-20 years ago. No major concerns in terms of navigation risks. CDW operations shouldn't need to be altered in any way owing to the additional ship movements.	
4	**Mitigation Measures**	
	Exclusion Zone • While CDW was happy with the proposed 150m side supply vessel exclusion zones, CDW questioned whether a the proposed 1 mile ahead was necessary given the experience of the local operators such as CDW utilizing the channel and the potential impact to their business should they lose the dolphins as a result of moving out of the way of a ship. • However, CDW was happy that, while a shorter forward exclusion zone would be preferable, if a mile was required in line with similar global operations and LNG operating procedures that CDW would be able to work around this measure.	
5	**Historic Incidents**	
	• There have been a couple of historic incidents of vessels getting wrapped up in buoys. One vessel hit a buoy at Aughinish.	

Minutes of Meeting held on 26th May 2020 – Shannon Ferries

Client:	Shannon Foynes Port	
Project:	Shannon LNG	
Venue:	Teleconference	
Date of Meeting:	Tuesday 26th May 2020, 12:00	
Present:	Shannon Ferries (SF)	
	Marico Marine (MM)	Paul Brown (PB)
		Rebecca Worbey (RW)
	Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide. • Approximately 1,800 movements per year. LNG vessels will add approximately 100 movements per year. Tugs planned to be based just inside the jetty, LNG development will have its own towage facility.	
2	**Background to Stakeholder Operations**	
	• Operate the Killimer-Tarbert Car Ferry adjacent to the proposed terminal. • Ferry has been in operation for 50 years. • Ferries are highly maneuverable quadruple screw. • EW traffic has the right of way therefore highly maneuverable ferries operating at 90° to the main direction of traffic give way and wait. • Two shuttles hold ferries against the tide. Two at each end which are used for steering.	
3	**Hazard Identification**	

	• No major concerns about the proposed LNG operations. SF suspects operations such as these will be highly regulated and monitored therefore reducing the likelihood of an incident.
	• Collision – No increased concern.
	• Contact – No increased concern.
	• Grounding – No increased concern.
	• From our perspective, the greatest navigational risks exist adjacent to the line between Tarbert and Moneypoint power stations as this is immediately adjacent to our plying limits.
	• SF considers breaking of moorings causing drifting vessels into their area of operation or loss of control to be the greatest hazards to be introduced by the project
	  ○ SF - in the flood tide 2 miles of separation if something goes wrong isn't that far.
	  ○ PB - Four tugs are planned to be attached at the time of berthing maximising control.
	• Fire or explosions would also be a concern (in terms of consequence). SF questioned what the impact to the area would be in this event.	

4	Mitigation Measures?	
	• Adequate berthage and transfer facilities with strict safety protocols in place. o Appropriate safeguards should be in place to prevent breakaway from moorings. • Obviously strict navigational limits and protocols will need to be in place. • Measures / procedures should be put in place to respond in the event of a fire / explosion.	
5	Other	
	SF - Obviously a facility of this nature comes with operational and navigational risks, but there are plenty similar facilities worldwide on which to draw on their best practise. The area has an abundance of natural landscape but again best practise can be drawn upon to ensure minimal impact. The general area has been devoid of any commercial development for many years and notwithstanding the economic benefits of such development. The estuary is prime for such development, in a tasteful way that has the local landscape and environment to the forefront at all times.	

Minutes of Meeting held on 28th May 2020 – Fishing Community

Client: Shannon Foynes Port
Project: Shannon LNG
Venue: Teleconference
Date of Meeting: Tuesday 26th May 2020, 11:30
Present: N/A

Marico Marine (MM)	Paul Brown (PB)
	Rebecca Worbey (RW)
Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide. • Approximately 1,800 movements per year. LNG vessels will add approximately 100 movements per year. • Tugs planned to be based just inside the jetty, LNG development will have its own towage facility.	
2	**Background to Stakeholder Operations**	

	Charter angling skipper and previously a commercial fisherman.
	• I would anchor to the east of Carrig island just to the NW of the proposed site to fish in shelter a few times a year.
	• Commercial fishing would take place all along the proposed track and boats would be crossing the channel and hauling pots at the edge of the channel.
	• Area between Kilcloher Head and Rinevella Bay on the north side of the estuary there is some commercial fishing. This is almost exclusively potting outside of the exclusion zone.
	• Most fishing vessels are small at < 20m, with the majority likely <12m.
	• Very few pots in the narrowest section due to the strength of the tide.
	• Lobster and crab season is after March.
	• Angling boats work north of the Beal Spit.
	  o Dolphin Watch Boat works here too in the summer.
	• East of Beal Point, there will just be the occasional angler and the Dolphin Watch Vessels which are operated by experienced crew.
	  o Almost no fishing activity in vicinity of the turn on to the berth.
	  o May be occasional use of the sheltered buoy east of Ardmore Point.
	  o Occasionally use the area east of Carrig Island as a bad weather fishing point but an 150m exclusion zone off of the jetty shouldn't impact this.
	  o Occasionally there are regattas up and down to Foynes.	

3	**Hazard Identification**	
	• As an angling boat I would be most affected at the narrows between Carrigaholt and Kilconly Point / Beal Bar as it is more confined and we would	

	often fish at anchor in this area, however, always outside of the marked shipping channel.
	  ○ This area also has higher traffic than other parts of the estuary as boats operating from Carrigaholt have to pass through here to head out to sea.
	• The requirement for vessels to give extra room outside of the shipping channel (mobile exclusion zone) will cause interference both to potting boats hauling their fishing gear and to angling boats anchored on fishing marks, especially if already hauling or anchored before the LPG ship approaches.
	• I would not expect much additional risk from the presence of the terminal except when boats are being berthed.
	  ○ Large ships with restricted ability to maneuver will of course add to risk although I would not expect this to be high.
	• Exclusion Zone will affect us the most at the narrows, which is 3 miles across, as this will decrease the available sea space. Especially if the area is closed 30 minutes prior to the LNG supply vessel's arrival.
	  ○ PB – Exclusion Zone will be assessed within the NRA and should not have the effect of closing the channel.
	  ○ HC- Exclusion Zone is planned to be 150m either side so should not significantly impact fishing outside of the channel.
	Collision
	• Not heard of any or seen any collisions. Main concern is the winter / met-ocean conditions through the narrows.	

4	**Mitigation Measures**	
	• Operations to occur within good weather (within operation limits). • Communication with the fishing and angling vessels should be maintained. • LNG supply vessel transits should be visible on the ship visits register / schedule.	
5	**Other**	
	We would like to see local vessels/ operators used in the development.	

Minutes of Meeting held on 2 June 2020 – Irish Whale and Dolphin Group

Client:	Shannon Foynes Port	
Project:	Shannon LNG	
Venue:	Teleconference	
Date of Meeting:	Tuesday 02nd June 2020, 0930	
Present:	Irish Whale and Dolphin Group (IWDG)	
	Marico Marine (MM)	Paul Brown (PB) Rebecca Worbey (RW)
	Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide. • Approximately 1,800 movements annually through Shannon Foynes Port. LNG vessels will add approximately 100 movements per year.	
2	**Background to Stakeholder Operations**	
	• We carry out boat based monitoring of the dolphins using photo-id, typically mainly during summer (May to October) but some winter too. This has been ongoing since 1993 and the boat effort varies each year depending on available resources as we don't get funded. We also carry out long term acoustic monitoring at Moneypoint through deploying a CPOD off their mooring dolphins. We visit once every 3-4 months.	
3	**Hazard Identification**	
	• From a dolphin perspective? The area off Tarbert and Moneypoint are favoured foraging areas for dolphins. Consideration should be given to dolphin watching vessels, but I know you have been in touch with them. • We are concerned with noise outputs creating an "acoustic barrier" to dolphin communication but this isn't really relevant to navigation. • Extra noise in the estuary created by increased shipping has a potential cumulative effect. We are not concerned with collision risk between dolphins and large or small vessels.	
4	**Mitigation Measures**	
	• By navigation I'm thinking of a ship moving, transiting and being serviced. Apart from noise and potential risk from spillages, I'm not sure how relevant this is to dolphins ??	

Minutes of Meeting held on 28 May 2020 – Foynes Yacht Club

Client: Shannon Foynes Port
Project: Shannon LNG
Venue: Teleconference
Date of Meeting: Thursday 28th May 2020, 14:30
Present: Foynes Yacht Club (FYC)

Marico Marine (MM) Paul Brown (PB)
Rebecca Worbey (RW)
Shannon Foynes Port (SFP) Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide.	
2	**Background to Stakeholder Operations**	
	• Formed in 1962 • 120 members • 30 dinghies, 40 cruisers • Season runs from April to end of October / stat of November.	
3	**Hazard Identification**	
	[In reference to LNG planned vessel track] • Few recreational users head out of the estuary through the 'narrows' and on past the Ballybunnion Buoy. ○ Mainly those in this region would be en route to the north /south coast. Normal navigation procedures would be adhered to. ○ Some yachts occasionally head out of the estuary to events in the summer months- probably no more than 3 or 4 boats, 5 or 6 times per year. Events are held with Kilrush Marina, but these events are held near to Scattery Island and not enter the navigation channel. Collision • FYC questioned whether the turn on the to the berth at Ardmore Point would cause a pinch point in the river for the recreational users. ○ PB explained that the LNG vessel will berth into the flood tide 1 hour before HW. ○ FYC was happy that this should deconflict the FYC and LNG vessels as FYC vessels would leave Foynes at HW and reach Ardmore at HW+2 at which time the LNG vessel will have already berthed. Contact FYC does not think that the project will increase contact risk. The FSU and exclusion zone are clear of the navigation channel which FYC members utilise. FYC members do not utilise Ardmore Point. FYC is happy that the LNG project should not impact the clubs operations.	

4	Mitigation Measures	
	Exclusion Zone • The exclusion zones are considered to be the only potential concern of the club, however, the frequency of movements are so small that opportunities for interaction with the supply vessels are limited and the exclusion zone at Ardmore Point is clear of FYC areas of operation. Communication • Communication is key. FYC always check the shipping movements schedule prior to the training schools going out on to the water.	

Minutes of Meeting held on 28 May 2020 – Kilrush Marina

Client:	Shannon Foynes Port
Project:	Shannon LNG
Venue:	Teleconference
Date of Meeting:	Tuesday 28th May 2020, 12:30
Present:	Kilrush Marina (KM)
	Marico Marine (MM) Paul Brown (PB)
	Rebecca Worbey (RW)
	Shannon Foynes Port (SFP) Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide.	
2	**Background to Stakeholder Operations**	
	• Planned LNG supply-ship track was shown to KM. • Day sail area is in vicinity of Carrigaholt away from navigational channel. • In area between Carrigaholt and Beal Point (through narrows en route out of the estuary) – recreational vessels will likely be on route to Galway or Dingle. However, transits in this area will be few and far between and really only in the summer months. The majority of KM customers stay local. • Last year there were an average of around 5 visiting boats to the Marina from outside of Ireland. • Racing area/ October Series located to the west of Scattery Islands. A lot of customers do a 'round the island trip' around Scattery Island. • The eastern course passes Scattery Island but does not extend past the lighthouse. • Dolphin watch trips also run out of the Kilrush Marina. • Vessels do not operate in the vicinity of the LNG jetty.	
3	**Hazard Identification**	
	• KM does not foresee any major navigational concerns as a result of the LNG operations. • Increased frequency of vessels in the lower Shannon Estuary. • SPFC is a successful and busy port that is used to dealing with large commercial vessel movements. Commercial vessels / pilots' knowledge of the area is good which helps to mitigate risks. • KM has not heard of any negative interactions between large commercial vessels and recreational vessels. • KM wouldn't lay a course that would interfere with the proposed navigation track.	
4	**Mitigation Measures**	
	• LNG supply vessels should be included in the ships schedule published by SFPC. The majority of clients do not check these though as they do not venture close to the main channel – however, those travelling further afield would check it.	

	• Port safety measures to be adhered to at all times – particularly in the vicinity of the jetty.	

Minutes of Meeting held on 28th May 2020 – Tarbert Island Maritime Club

Client:	Shannon Foynes Port
Project:	Shannon LNG
Venue:	Teleconference
Date of Meeting:	Tuesday 28th May 2020, 13:30

Present:	Tarbert Island Maritime Club (TI)	-
	Marico Marine (MM)	Paul Brown (PB) Rebecca Worbey (RW)
	Shannon Foynes Port (SFP)	Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Notes**	
	Declined attendance as TI does not consider there to be any change in navigational risk as a result of the additional transits, which will be infrequent. The following feedback was received in writing: • TI rarely operate outside of the navigation channel in vicinity of the LNG development. • Navigational risk during transit of supply vessels will be highest between 'the narrows'.	
2	**Mitigation Measures**	
	• Terminal should be lit in accordance with normal procedures. • Correct navigation buoys (if necessary).	

Minutes of Meeting held on 29 May 2020 – Western Yacht Club

Client: Shannon Foynes Port
Project: Shannon LNG
Venue: Teleconference
Date of Meeting: Tuesday 29th May 2020, 10:00
Present: Western Yacht Club (WYC)

Marico Marine (MM) Paul Brown (PB)
Rebecca Worbey (RW)
Shannon Foynes Port (SFP) Hugh Conlon (HC)

Item	Notes for the Record	Actions
1	**Introduction**	
	PB introduced the project and changes that have occurred since the last NRA in 2008: • FSU vessel alongside permanently. • Feeder ships delivering LNG at a rate of 1 feeder ship per week which will remain alongside for approximately 24 hours arriving and departing on the flood tide.	
2	**Background to Stakeholder Operations**	
	• WYC is located at Kilrush and operates racing areas North of 6 - 10 (of proposed LNG vessel track) of the approach channel and North of 11-12 of the approach channel. • Yacht race courses are laid around racing marks which are put down and lifted on the day of events. • Larger yacht races on the estuary may have courses that include rounding of the Port hand channel marks with Yachts returning North of the shipping channel.	
3	**Hazard Identification**	
	• I would consider the navigation risk to be minimal. • The likelihood of an incident occurring between an LNG tanker would be minimal. • Cruising Yachts that are locally owned have considerable experience in navigating the Shannon Estuary. • The rules of the road allow shipping full access to the deep draught channels. • I would consider the main risk factors to be explosion and fire during offloading at the LNG terminal. • Risks of vessel collisions as the Estuary is wide and deep especially in the turning area North of Ardmore point.	

Page Break

Item	Notes for the Record	Actions
4	**Mitigation Measures**	
	• Prior to planning a Yacht racing event contact is made with the pilot station to get advice on shipping movements so that yacht races occur at times so as not to interfere with shipping. • Maintaining communication will be the most important thing. • Fire boat on site. • Ensuring the availability of tractor tugs to escort and berth a vessel • The standard of control of the Shannon pilots would mean that a collision style accident would be very minimal.	

5	Other	
	• Visiting cruising yachts use the estuary to call at Carrigaholt, Kilrush Marina and Foynes. o Visitors tend to follow instructions from the Irish Cruising Club cruising guide so that they might not be fully aware of the areas they can navigate that are clear of the shipping channels. o WYC suggested Irish Cruising Club guide editor could be contacted to issue updates on LNG plans. • RNLI lifeboat stationed at Kilrush is a class Atlantic 85. divisional base is at Swords Co Dublin. They will be able to advise on possible rescue operations with regard to LNG shipping etc. o The Kilrush station covers the Shannon estuary, most call outs are to pleasure vessels, fishermen, with minimal call outs to commercial shipping. o The lifeboat operates under control of the Irish Coastguard who will also be able to advise on their policies with regard to LNG shipping.	

Annex C 2008 NRA Mitigation Measures Not Adopted

The following recommendations were proposed within the 2008 NRA but on review and re-evaluation were not recommended for consideration within the 2020 NRA. In the 2021 NRA update these measures were again reviewed and the 2020 conclusion to exclude them was endorsed. The text and discussion from the 2020 NRA update is included below for completeness.

VTS

The 2008 NRA was very firm in its recommendation that SFPC should formally upgrade its surveillance equipment such that it could become a classified VTS authority. IALA states that the "The purpose of VTS is to improve the maritime safety and efficiency of navigation, safety of life at sea and the protection of the marine environment and/or the adjacent shore area, work sites and offshore installations from possible adverse effects of maritime traffic in a given area."[16]

VTS is often identified as a powerful mitigation measure capable of reducing risk across a wide range of accident categories, however for SFPC to install a VTS and gain accreditation as a VTS authority would require a commitment to a significant long term and sustained investment to maintain such a capability. For clarity, the IALA guidance indicates that "VTS is generally appropriate in areas that may include any, or a combination, of the following:

- High traffic density;
- Traffic carrying hazardous cargoes;
- Conflicting and complex navigation patterns;
- Difficult hydrographical, hydrological and meteorological elements;
- Shifting shoals and other local hazards and environmental considerations;
- Interference by vessel traffic with other waterborne activities;
- Number of casualties in an area during a specified period;
- Existing or planned vessel traffic services on adjacent waterways and the need for cooperation between neighbouring states, if appropriate;
- Narrow channels, port configuration, bridges, locks, bends and similar areas where the progress of vessels may be restricted; and
- Existing or foreseeable changes in the traffic pattern in the area."

The purpose of this paper is not to conduct a full VTS risk assessment which would be required to endorse the establishment of such a capability but it has examined enough elements of the list above to be able to conclude that, having analysed the comparatively low traffic flows in the estuary, risk

[16] IALA VTS Manual Ch 7 Paragraph 0703

assessed the relatively benign navigational circumstances and the low accident rates over the last 5 years, there does not appear to be a case for the arrival of the LNG project to trigger the establishment of a VTS in the Shannon Estuary. However, it is strongly recommended that this circumstance is reviewed periodically by SFPC and not less than every 2-3 years.

Marking the Glencloosagh Bay Shallows

The shallow waters in Glencloosagh Bay was considered by the 2008 NRA to be the nearest navigational hazard to LNGCs manoeuvring onto and off the berth and as such, a recommendation was made that they should be marked by a buoy. The nearest part of the Glencloosagh shallows to the proposed manoeuvring area is just over a mile and it is considered that an LNGC ship manoeuvring with 4 tugs attached and handled by experienced professional pilots is extremely unlikely to deviate this significantly from its planned track either during berthing or unberthing. Even if this unlikely event was to occur, modern navigation technology with ECDIS and PPUs has advanced sufficiently to make the marking of the shallows largely unnecessary.

Remove/reposition small ship anchorage at Glencloosagh Bay

The 2008 NRA recommended that consideration be given to moving or disestablishing the Glencloosagh anchorage citing concerns that an arriving or departing LNGCs could come close to vessels in the anchorage. Notwithstanding the fact that the LNG ships will have 4 tugs attached during berthing and will have a pilot embarked, as well as being over a mile separated geographically, the track data for shipping in the estuary shows that the Glencloosagh bay anchorage was not used at all in 2019 making interaction between LNGCs and vessels in the anchorage extremely unlikely. Additionally, the Harbour Master was keen to retain this facility for the possible occasional use by smaller vessels seeking shelter in the face of southerly gales.

Designated Channel

The 2008 NRA proposed formalisation of a charted deep-water channel that would help other port users anticipate the likely movements of LNG carriers. Aside from the fact that the preferred navigational track already follows the deep-water channel it is felt that the relatively low levels of traffic in the estuary makes this measure overly proscriptive and unnecessary.

Reposition Carrigaholt Buoy

The 2008 NRA proposed the repositioning of the Carrigaholt Buoy onto the 14.9m patch to the west of Doonaha Buoy in order to providing a useful visual turning reference on the outside of the turn and at the limit of the navigable water in the channel. In 2013, SFPC instead moved the comparatively redundant Doonaha buoy 500m westwards to a position to mark the outer limit of the channel and to be in line with the Corlis leading lights transit, leaving the Carrigaholt buoy in position to mark the deep-water transit from Kilcredaun to the Inner Estuary.

Annex D Hazard Log – Baseline Assessment

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
1	Collision	Collision - Tanker ICW Tanker	Tanker collides with another Tanker	Tanker collides with another tanker as a result of taking avoiding action with an LNGC or FSRU underway. As a result of mechanical defect / failure, master or pilot error, reduced visibility or miscommunication between two vessels underway in vicinity of anchorages or within the narrows, scheduling error.	Single minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Multiple major injuries or single fatality; Major damage to property; Tier 3 criteria reached with pollution requiring national support. Adverse national publicity. Temporary suspension of activities.	2	2	2	2	3.0	4	4	4	4	1.5	3.43	1 , 5 , 6 , 11 , 13 , 14 , 20 , 21.
2	Collision	Collision - Tanker ICW Project Vessel (FSRU or LNGC)	Tanker collides with a Project Vessel	Tanker collides with LNGC or FSRU while underway in the vicinity of anchorages or within the narrows as a result of mechanical defect / failure, master / pilot error, avoiding action with 3rd party vessel, reduced visibility, miscommunication between ships, scheduling error.	Glancing blow. Single minor injury; Moderate damage to property, Tier 1 may be declared but criteria not necessarily met; Widespread local publicity ensuing loss of revenue.	Head-on collision. Multiple major injuries or single fatality; Major damage to property; Tier 2 spill criteria reached but capable of being limited to immediate area; Adverse international publicity. Long-term suspension of LNG operations and prolonged restrictions.	2	3	2	3	3.0	4	4	3	5	2.0	4.64	1 , 2 , 5 , 6 , 10 , 11 , 12 , 13 , 14 , 17 , 20 , 21 , 23.
3	Collision	Collision - Tanker ICW Large Commercial / Dry Cargo Vessel	Collision - Tanker ICW Large Commercial / Dry Cargo Vessel	Tanker collides with a Large Commercial Vessel / Dry Cargo Vessel (including cruise ship) as a result of taking avoiding action with an LNGC or FSRU underway. As a result of mechanical defect / failure, master or pilot error, reduced visibility or miscommunication between two vessels underway in vicinity of anchorages or within the narrows, scheduling error.	Large Commercial / Dry Cargo Vessel collides with Tanker on river passage. Single minor injury; Minor damage to property. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Tanker collides with cruise ship on estuary passage. Multiple major injuries or single fatality; Catastrophic damage to property; Tier 3 criteria reached with pollution requiring national support. Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	3.0	4	5	4	5	1.5	3.82	1 , 5 , 6 , 10 , 11 , 17 , 20 , 21.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
4	Collision	Collision - Tanker ICW Small Passenger Vessel	Tanker collides with a Small Passenger Vessel	Collision with DWV as a result of Tanker taking avoiding action with LNGC or FSRU underway or Dolphin watch vessel operating in vicinity of the narrows fails to take necessary IRPCS actions. As a result of mechanical defect / failure, master / skipper or pilot error, reduced visibility or misunderstanding between master of DWV and pilots.	Glancing blow at low speed in the narrows; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is knocked down; multiple fatalities; Moderate damage; Negligible environmental impact; International media publicity, operations disrupted for more than two days.	2	2	1	3	3.0	5	3	1	5	1.5	3.94	1 , 5 , 6 , 11 , 20 , 21.
5	Collision	Collision - Tanker ICW Small Commercial / Port Services Vessel	Tanker collides with a Small Commercial / Port Services Vessel	Tanker taking avoiding action with LNGC or FSRU underway and collides with small commercial / port services vessel. Or Project tug en-route to LNGC / FSRU collides with Tanker in narrows. Result of mechanical defect / failure, master / skipper or pilots error or as a result of reduced visibility.	Glancing blow between tanker and ship assist tug or other workboat in the narrows or estuary. Single minor injury; Negligible damage to property; Tier 1 may be declared but criteria not necessarily met small operational oil spill; Very short-term disruption to services.	Port Services Vessel fails to take avoiding action and is knocked down; multiple minor injuries or a single major injury; Major damage; Moderate environmental impact; Major national publicity and temporary suspension of activities.	3	1	2	2	3.0	4	3	4	4	2.0	4.03	1 , 2 , 5 , 6 , 10 , 11 , 12 , 13 , 14 , 17 , 20 , 21 , 23.
6	Collision	Collision - Tanker ICW Recreational Vessel	Tanker collides with a Recreational Vessel	Tanker taking avoiding action from an LNGC or FSRU underway and collides with recreational vessel. Or Tanker collides with Recreational Vessel in narrows. As a result of mechanical defect / failure, master / skipper error or pilot error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple fatalities; Major damage to vessel; Tier 1 may be declared but criteria not necessarily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	3.5	5	3	1	4	3.0	4.09	1 , 5 , 6 , 10 , 11 , 20 , 21.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
7	Collision	Collision - Project Vessel ICW Large Commercial / Dry Cargo Vessel	Project Vessel collides with a Large Commercial / Dry Cargo Vessel	Large Commercial / Dry Cargo collides with LNGC or FSRU while underway in the vicinity of anchorages or within the narrows as a result of mechanical defect / failure, master / pilot error, avoiding action with 3rd party vessel, reduced visibility, miscommunication between ships, scheduling error.	General Cargo Vessel collides with LNGC / FSRU on river passage. Single minor injury; Minor damage to property. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	LNGC or FSRU collides with cruise ship on river passage. Multiple major injuries or single fatality; Catastrophic damage to property; Tier 3 criteria reached with pollution requiring national support. Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	3.0	4	5	4	5	2.0	4.04	1 , 2 , 5 , 6 , 10 , 11 , 12 , 13 , 14 , 17 , 20 , 21 , 23.
8	Collision	Collision - Project Vessel ICW Small Passenger Vessel	Project Vessel collides with a Small Passenger Vessel	Dolphin watch vessel operating in vicinity of the narrows fails to take necessary IRPCS actions when LNGC or FSRU is on approach. As a result of mechanical defect / failure, Master / Skipper error or Pilot error, avoiding action with 3rd party vessel, reduced visibility or misunderstanding between master of DWV and pilot.	Glancing blow at low speed in the narrows; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is knocked down; multiple fatalities; Moderate damage; Small operational oil spill with little environmental impact; International publicity, operations and revenue disrupted for more than two days.	2	2	1	3	3.5	5	3	2	5	2.0	4.50	1 , 2 , 5 , 6, 10 , 11 , 12 , 13 , 14 , 20 , 21 , 23.
9	Collision	Collision - Project Vessel ICW Small Commercial / Port Services Vessel	Project Vessel collides with a Small Commercial / Port Services Vessel	Collision during pilot boarding and landing or when tug on route to LNGC fails to take appropriate avoiding action or small commercial / Port Service Vessel fails to take necessary IRPCS actions when LNGC or FSRU is on approach. As a result of mechanical defect / failure, master / skipper / pilot error, avoiding action with 3rd party vessel, reduced visibility or misunderstanding between master of Port Service Vessel and pilot.	Glancing blow (in particular tug whilst towing). Single minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Head-on collision or Small Commercial / Port Services Vessel being overrun / sunk. Multiple major injuries or single fatality; Major damage to property; Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity; Adverse local publicity. Short-term loss of revenue including minor disruption to commercial activities.	3	1	2	2	4.0	4	4	3	4	3.0	5.16	1 , 2 , 5 , 6 , 10 , 11 , 12 , 13 , 14 , 17 , 20 , 21 , 23.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
10	Collision	Collision - Project Vessel ICW Recreational Vessel	Project Vessel collides with a Recreational Vessel	An LNGC or FSRU underway collides with Recreational Vessel. As a result of mechanical defect / failure, skipper or pilot error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple fatalities; Major damage to vessel; Tier 1 criteria declared but not necessarily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	3.5	5	3	1	4	3.0	4.09	1 , 2 , 5 , 6 , 10 , 11 , 12 , 13 , 14 , 20 , 21 , 23.
11	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Large Commercial / Dry Cargo Vessel	Large Commercial / Dry Cargo Vessel collides with a large Commercial / Dry Cargo Vessel	Large Commercial / Dry Cargo Vessel collides with a large Commercial / Dry Cargo Vessel as a result of taking avoiding action with an LNGC or FSRU underway. As a result of mechanical defect / failure, Master or Pilot error, reduced visibility or miscommunication between two vessels underway in vicinity of anchorages or within the narrows, scheduling error.	Large Commercial / Dry Cargo Vessel collides with Large Commercial / Dry Cargo Vessel on estuary passage or manoeuvring in the anchorages. Single minor injury; Minor damage to property. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Large Commercial / Dry Cargo Vessel collides with cruise ship at passage speed within the estuary. Multiple fatalities; Catastrophic damage to property; Tier 2 spill criteria reached. Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	2.0	4	5	3	5	1.0	3.27	1 , 5 , 6 , 10 , 11 , 17 , 20 , 21.
12	Collision	Collision - Large Commercial / Dry Cargo vessel ICW Small Passenger Vessel	Large Commercial / Dry Cargo Vessel collides with a Small Passenger Vessel	Collision with DWV as a result of Large Commercial / Dry Cargo Vessel taking avoiding action with LNGC or FSRU underway. Or Dolphin watch vessel operating in vicinity of the narrows failing to take necessary IRPCS actions. As a result of mechanical defect / failure, master / skipper or pilot error, reduced visibility or misunderstanding between master of DWV and pilots.	Glancing blow at low speed in the narrows; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is knocked down; Multiple fatalities; Moderate damage; Tier 1 or Tier 2 environmental impact; Major national publicity and temporary suspension of activities.	2	2	1	3	3.0	5	3	2	4	1.0	3.81	1 , 5 , 6 , 11 , 20 , 21.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
13	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Small Commercial / Port Services Vessel	Large Commercial / Dry Cargo Vessel collides with a Small Commercial / Port Services Vessel	Large Commercial / Dry Cargo Vessel taking avoiding action with LNGC or FSRU underway and collides with small commercial / port services vessel. Or Project tug en route to LNGC / FSRU collides with Tanker in narrows. Result of mechanical defect / failure, Master / Skipper or Pilots error, schedule error or as a result of reduced visibility.	Glancing blow (in particular tug whilst towing). Single minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Head-on collision or Small Commercial / Port Services Vessel being overrun. Multiple major injuries or single fatality; Major damage to property; Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity; Adverse local publicity. Short-term loss of revenue including minor disruption to commercial activities.	3	1	2	2	3.0	4	3	2	4	2.0	3.84	1 , 2 , 5 , 6 , 10 , 11 , 12 , 14 , 17 , 20 , 21 , 23.
14	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Recreational Vessel	Large Commercial / Dry Cargo Vessel collides with a Recreational Vessel	Large Commercial / Dry Cargo Vessel taking avoiding action from an LNGC or FSRU underway and collides with Recreational Vessel. Or Large Commercial / Dry Cargo Vessel collides with Recreational Vessel in narrows. As a result of mechanical defect / failure, Master / Skipper error or Pilot error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple fatalities; Major damage to vessel; Tier 1 may be declared but criteria not necessarily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	3.5	5	3	4	4	3.0	4.46	1 , 5 , 6 , 11 , 20 , 21.
15	Collision	Collision - Small Passenger Vessel ICW Small Passenger Vessel	Small Passenger Vessel collides with a Small Passenger Vessel	Dolphin watch vessel operating in vicinity of the narrows fail to take necessary IRPCS actions and collides with other small passenger vessel as a result of avoiding action from approaching with LNGC / FSRU. Result of Master / Skipper error, reduced visibility, mechanical failure, miscommunication between skippers.	Glancing blow at low speed; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and one vessel is holed; multiple major injuries or a single fatality; Moderate damage; Negligible environmental impact; Major national publicity and temporary suspension of activities.	2	2	1	3	2.0	4	3	1	4	1.5	3.18	1 , 5 , 10 , 11 , 20 , 21.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
16	Collision	Collision - Small Passenger Vessel ICW Small Commercial / Port Services Vessel	Small Passenger Vessel collides with a Small Commercial / Port Services Vessel	Pilot vessels or tugs transiting through the narrows to LNGC or FSRU collide with Dolphin watch vessel. As a result of mechanical defect / failure, master / skipper error, result of avoiding action with 3rd party vessel, reduced visibility, miscommunication between skippers.	Glancing blow at low speed; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is holed; multiple major injuries or a single fatality; Moderate damage; Tier 1 or Tier 2 environmental impact; Major national publicity and temporary suspension of activities.	2	2	1	3	3.0	4	3	2	4	2.0	3.84	1 , 2 , 5 , 6, 13 , 20 , 21 , 23.
17	Collision	Collision - Small Passenger Vessel ICW Recreational Vessel	Small Passenger Vessel collides with a Recreational Vessel	Dolphin Watch Vessel takes avoiding action from an LNGC or FSRU underway and collides with Recreational Vessel. As a result of mechanical defect / failure, master / skipper error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations. Recreational vessel passing too close to dolphin watch vessel within the narrows.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple major injuries or single fatality; Major damage to vessel; Tier 1 may be declared but criteria not necessarily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	3.5	4	3	4	4	2.0	3.60	1 , 5 , 6 , 10 , 11 , 20 , 21.
18	Collision	Collision - Small Commercial / Port Services Vessel ICW Small Commercial / Port Services Vessel	Small Commercial / Port Services Vessel collides with a Small Commercial / Port Services Vessel	Collision during pilot boarding and landing or when tug on route to LNGC fails to take appropriate avoiding action or small commercial / Port Service Vessel fails to take necessary IRPCS actions when LNGC or FSRU is on approach. As a result of mechanical defect / failure, master / skipper error or pilot error, avoiding action with 3rd party vessel, reduced visibility or misunderstanding between master of Port Service Vessel and pilot. Fishing activity (potting) within the narrows.	Glancing blow at low speed during towage operations; single minor injury; minor damage to property, negligible environmental impact; negligible publicity.	One vessel is holed and sinks; multiple major injuries or a single fatality; Moderate damage; Tier 1 or Tier 2 environmental impact; Local publicity and possible suspension of activities / operational delays.	2	2	1	1	3.5	4	3	2	2	3.0	3.51	1 , 2 , 5 , 6 , 7 , 10 , 11 , 12 , 13 , 14 , 17 , 20 , 21 , 23.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence: People	Most Likely Consequence: Property	Most Likely Consequence: Environment	Most Likely Consequence: Business	Most Likely Consequence: Frequency	Worst Credible Consequence: People	Worst Credible Consequence: Property	Worst Credible Consequence: Environment	Worst Credible Consequence: Business	Worst Credible Consequence: Frequency	Risk Score	Possible Additional Mitigation Measures
19	Collision	Collision - Small Commercial / Port Services Vessel ICW Recreational Vessel	Small Commercial / Port Services Vessel collides with a Recreational Vessel	Collision between vessels as a result of either taking avoiding action with arriving LNGC / FSRU. Mechanical defect / failure, master / skipper error, reduced visibility or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations. Increased likelihood of interaction in the narrows and north of Scattery Island.	Pilot vessel collides with a yacht. Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational or Small Commercial Vessel sunk. Multiple major injuries or single fatality; Major damage to either vessel; Tier 1 may be declared but criteria not necessarily met; Local publicity. Temporary suspension of operations.	2	2	1	2	4.0	4	4	2	3	3.0	4.18	1 , 2 , 5 , 6, 10 , 11 , 12 , 13 , 14 , 20 , 21 , 23.
20	Collision	Collision - Recreational Vessel ICW Recreational Vessel	Recreational Vessel collides with another Recreational Vessel	2 recreational vessels collide as a result of taking avoiding action from approaching LNGC or FSRU. Mechanical defect / failure, Skipper error, reduced visibility, Sailing vessel taking additional risks during racing, visiting vessels unfamiliar with local regulations.	Glancing blow (especially during racing). Single minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Either or both recreational vessels sink. Multiple major injuries or single fatality; Moderate damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Adverse local publicity. Short-term loss of revenue including minor disruption to commercial activities.	2	2	1	2	4.0	4	3	1	2	3.0	3.81	1 , 5 , 6 , 10 , 11 , 13 , 20 , 21.
21	Contact	Contact - Tanker with Project Infrastructure	A Tanker underway contacts project infrastructure including; Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure, Pilot or Master error, Adverse weather conditions.	Mechanical failure causes tanker to drift across the estuary towards the moored FSRU. Impact minimised by tanker using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes tanker to drift across the estuary and strikes the FSRU. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	2.0	4	3	4	5	1.0	3.20	1 , 4 , 7 , 15 , 16 , 20 , 23.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
22	Contact	Contact - Project Vessel with Project Infrastructure	A Project Vessel contacts project infrastructure including during berthing; either FSRU onto Jetty or LNGC onto FSRU.	Mechanical defect / failure. Master, Pilot / Tug error, Adverse weather conditions. Poor communications between vessel and shore. Inadequate project fendering. Lack of pilot situational awareness.	Inexperience of pilots berthing LNGC vessels alongside FSRU resulting in light contact with FSRU. Superficial damage to both vessels and sub-frames. Multiple minor or single major injury. Moderate damage to vessels; Minor environmental impact; National publicity and temporary closure.	Inexperience of pilots berthing LNGC vessels alongside FSRU resulting in a heavy contact with FSRU. Substantial damage to both vessels and jetty. Multiple major injuries or a single fatality; Major damage; Major gas release; International media coverage; Operations and revenue seriously disrupted.	3	3	2	4	4.0	4	4	3	5	3.0	6.48	1 , 2 , 3 , 6 , 7 , 8 , 10 , 11 , 12 , 13 , 16 , 17 , 18 , 19 , 20 , 23 , 24.
23	Contact	Contact - Large Commercial / Dry Cargo Vessels with Project Infrastructure	A Large Commercial / Dry Cargo Vessel contacts project infrastructure including Jetty, FSRU or a moored LNGC.	Mechanical defect / failure. Master / pilot error. Adverse weather conditions.	Vessel not under command or disabled drifts at slow speed across the estuary. Multiple minor or single major injury. Moderate damage to vessels; Minor environmental impact; National publicity and temporary closure.	Propulsion control failure leading to heavy contact with FSRU or LNGC by cruise ship or bulker. Substantial damage to both vessels and jetty. Multiple major injuries or a single fatality; major damage; Gas release; International media coverage; Operations and revenue seriously disrupted.	2	2	1	4	2.5	4	4	2	5	1.0	4.13	1 , 4 , 5 , 6 , 15 , 16, 20 , 23.
24	Contact	Contact - Small Passenger Vessels with Project Infrastructure	A Small Passenger Vessel contacts project infrastructure including Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure. Master error. Adverse weather conditions.	Vessel not under command or disabled drifts at slow speed across the estuary. Dolphin watch operating near terminal gets too close or loses propulsion or steering and drifts at slow speed into FSRU. Single minor injury. Minor damage to vessels; Negligible environmental impact; Bad local publicity.	Propulsion control failure leading to heavy contact with FSRU or LNGC by Dolphin Watch Vessel. Moderate damage to Dolphin Watch Vessel. Multiple minor or single major injury; Moderate damage to Dolphin Watch Vessel; Negligible environmental impact; Bad widespread local media coverage.	2	2	1	2	2.0	3	3	1	3	1.0	2.06	1 , 4 , 5 , 6 , 15 , 16 , 20.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence: People	Most Likely Consequence: Property	Most Likely Consequence: Environment	Most Likely Consequence: Business	Most Likely Consequence: Frequency	Worst Credible Consequence: People	Worst Credible Consequence: Property	Worst Credible Consequence: Environment	Worst Credible Consequence: Business	Worst Credible Consequence: Frequency	Risk Score	Possible Additional Mitigation Measures
25	Contact	Contact - Small Commercial / Port Services Vessels with Project Infrastructure	A Small Commercial / Port Services Vessel contacts project infrastructure including Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure. Tug error. Adverse weather conditions. Poor communications between vessel and shore.	Inexperience of tug masters berthing LNGC vessels alongside FSRU resulting in light contact with FSRU. Project tugs and workboats are in routine contact with LNG vessels and jetty. Single minor injury. Negligible damage to vessel; Negligible environmental impact; Negligible publicity.	Inexperience of tug masters berthing LNGC vessels alongside FSRU resulting in a heavy contact. Moderate damage to LNGC / FSRU or jetty. Multiple minor or a single major injury; No gas release, negligible environmental impact; Bad local publicity.	2	1	1	1	5.0	3	3	1	2	2.0	3.28	1 , 2 , 4 , 5 , 6 , 12 , 13 , 15 , 20 , 23.
26	Contact	Contact - Recreational Vessels with Project Infrastructure	Recreational Vessel contacts project infrastructure including Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure, Skipper error and / or adverse weather conditions causes recreational vessel to get too close to LNG terminal. Visiting yachtsman with poor local knowledge.	Recreational vessel bounces off LNG terminal or FSRU and sustains superficial damage. Single minor injury, negligible damage, negligible environmental impact, negligible publicity.	Recreational vessel becomes entangled in LNG jetty structure or makes heavy contact with FSRU / LNGC in adverse weather / tidal conditions, vessel sinks. Multiple minor injuries or a single major injury; Minor damage; Negligible environmental impact; Temporary suspension of activities; Minor commercial impact.	2	1	1	1	4.0	3	2	1	2	2.0	2.42	1 , 4 , 5 , 6 , 13 , 15 , 20.
27	Contact	Contact - Tanker with Non- Project Infrastructure	A Tanker contacts non-project infrastructure including vessel at anchor, stationary vessels alongside, piers and jetties.	Result of tanker taking IRPCS avoiding action with LNGC or FSRU Underway. Mechanical defect / failure, Master, Pilot / tug error. Adverse weather conditions.	Loss of tanker control / mechanical failure resulting in low velocity impact with non-project estuary infrastructure e.g. Money Point jetty. Single minor injury, Minor damage; Minor environmental impact; Bad widespread publicity.	Tanker on passage in the estuary suffers mechanical breakdown and contacts anchored vessel. Multiple minor or single major injury; Moderate damage to vessel; Minor environmental impact; Major national publicity; disruption to operations.	2	2	2	3	2.0	4	3	2	4	1.0	3.24	1 , 5 , 6 , 10 , 11 , 14 , 20 , 21.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
28	Contact	Contact - Project Vessel with Non-Project Infrastructure	A Project Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of avoiding action with 3rd party vessel. Mechanical defect / failure, Master / Pilot / tug error. Loss of control. Adverse weather conditions. Berthing error.	As a result of steering or mechanical failure, project vessel is blown or swept onto non-project infrastructure such as Money Point jetty. Very minor impact, absorbed by fenders tugs and anchoring. Single minor injury; Minor damage to vessel; Negligible environmental impact; Moderate bad widespread local publicity, temporary suspension of operations.	As a result of steering or mechanical failure, project vessel strikes non-project infrastructure such as Money Point jetty very heavily and is holed or possibly founders. Multiple minor or single major injury; Major damage to vessel; Moderate environmental damage, Tier 2 spill criteria; International publicity, temporary closure of LNG / stakeholder operations.	2	2	1	3	3.0	3	4	3	5	2.0	4.28	1 , 2 , 5 , 6 , 7 , 10 , 11 , 12 , 13 , 20 , 23.
29	Contact	Contact - Large Commercial / Dry Cargo Vessels with Non- Project Infrastructure	A Large Commercial / Dry Cargo Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of Large Commercial /Dry Cargo Vessel taking IRPCS avoiding action with LNGC or FSRU Underway. Mechanical defect / failure, Master, Pilot / tug error. Adverse weather conditions.	Large Commercial / Dry Cargo Vessel loses control resulting in low velocity impact with non-project estuary infrastructure e.g. Money Point jetty. Single minor injury, Minor damage; Minor environmental impact; Bad widespread publicity.	Large Commercial / Dry Cargo Vessel on passage in the estuary suffers mechanical breakdown and contacts anchored project LNGC. Multiple minor or single major injury; Moderate damage to vessel; Minor environmental impact; Major national publicity; disruption to operations.	2	2	2	3	2.0	4	3	2	4	1.0	3.24	1 , 5 , 6 , 10, 11 , 14 , 20 , 21.
30	Contact	Contact - Small Passenger Vessel with Non- Project Infrastructure	A Small Passenger Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of small passenger vessel taking IRPCS avoiding action with LNGC or FSRU Underway. Mechanical defect / failure, Master, Pilot / tug error. Adverse weather conditions.	Dolphin watch vessel loses propulsion / control and drifts onto anchored vessel/ jetty / fails to take avoiding action. Multiple minor or single major injury; minor damage to vessel; minor environmental impact; bad local publicity.	Dolphin watch vessel makes heavy contact with anchored vessel and is holed / sinks. Multiple major injuries / single fatality; moderate damage; Tier 2 spill criteria reached; moderate environmental impact; Bad widespread local publicity.	2	2	2	2	2.0	4	3	3	3	1.0	2.74	1 , 5 , 11 , 20 , 21.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
31	Contact	Contact - Small Commercial / Port Services Vessel with Non- Project Infrastructure	A Small Commercial / Port Services Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Tug berthing error or Project tug or pilot launch suffer a breakdown and are disabled in the estuary. Result of avoiding action with 3rd party vessel. Mechanical defect / failure. Master error. Loss of control. Adverse weather conditions.	As a result of steering or mechanical failure, project tug / workboat / pilot boat is blown or swept onto non-project infrastructure such as Money Point jetty. Very minor impact, absorbed by fenders tugs and anchoring. Single minor injury; Minor damage to vessel; Negligible environmental impact; Bad local publicity, temporary suspension of operations.	As a result of steering or mechanical failure, project tug / pilot boat / workboat strikes non-project infrastructure such as Money Point jetty very heavily and is holed or possibly founders. Multiple minor or single major injury; Major damage to vessel; Minor environmental damage; Bad widespread local publicity, temporary closure of LNG / stakeholder operations.	2	2	1	2	2.0	3	4	2	3	1.0	2.53	1 , 2 , 5 , 7 , 11 , 13 , 20 , 21 , 23.
32	Contact	Contact - Recreational Vessels with Non- Project Infrastructure	Recreational Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of avoiding action with an approaching LNGC or FSRU. Mechanical defect / failure. Master error. Adverse weather conditions.	Recreational vessel loses propulsion / control and drifts onto anchored vessel / jetty. Vessel fails to take avoiding action. Multiple minor or single major injury; minor damage to vessel; Negligible environmental impact; bad local publicity.	Recreational vessel makes heavy contact with anchored vessel and is holed / sinks. Multiple major injuries / single fatality; moderate damage; Tier 2 spill criteria reached; moderate environmental impact; Bad widespread local publicity.	2	2	1	2	4.0	4	3	3	3	2.0	3.70	1 , 2 , 5 , 6 , 10 , 11 , 13 , 14 , 20 , 21.
33	Contact	Contact - Tanker with Navigation Buoy	A Tanker contacts a navigational buoy in the approach channel.	Mechanical defect / failure. Master error. Pilot error. Adverse weather. Reduced visibility. Result of avoiding action with 3rd party vessel.	Glancing blow. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Navigation buoy is sunk. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Bad widespread local publicity.	2	2	1	3	2.5	2	3	1	3	2.0	2.91	1 , 6 , 10 , 11 , 20 , 21.
34	Contact	Contact - Project Vessel with Navigation Buoy	A Project Vessel contacts a navigation buoy in the approach channel.	Mechanical defect / failure. Master error. Pilot error. Adverse weather. Reduced visibility. Result of avoiding action with 3rd party vessel.	Glancing blow on the Doonaha buoy as pilot misjudges turn. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services. Bad widespread publicity.	Navigation buoy is sunk. Single minor injury; Moderate damage to property; Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services; National publicity.	2	2	1	3	3.0	2	3	1	4	2.0	3.54	1 , 2 , 6 , 10 , 11 , 12 , 13 , 14 , 20 , 21 , 23.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
35	Contact	Contact - Large Commercial / Dry Cargo Vessels with Navigation Buoy	A Large Commercial / Dry Cargo Vessels contacts a navigational buoy in the approach channel.	Mechanical defect / failure. Master error. Pilot error. Adverse weather. Reduced visibility. Result of avoiding action with 3rd party vessel.	Glancing blow. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Navigation buoy is sunk. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services; Bad widespread local publicity.	2	2	1	3	3.0	2	3	1	3	2.0	3.12	1 , 6 , 10 , 11 , 20 , 21.
36	Contact	Contact - Small Passenger Vessels with Navigation Buoy	A Small Passenger Vessel contacts a navigation buoy in the approach channel while avoiding an LNGC, FSRU underway.	Result of small passenger vessel taking avoiding action with approaching LNGC. Mechanical defect / failure or master /pilot error, adverse weather or reduced visibility.	Glancing blow on a buoy. Single minor injury; Very minor damage to property; Negligible environmental impact; Minor Local publicity.	Navigation buoy / small passenger vessel is sunk. Multiple major injuries or a single fatality; Moderate damage / vessel lost; Tier 2 spill criteria; National publicity.	2	2	1	2	2.5	4	3	3	4	2.0	3.18	1 , 5 , 6 , 10 , 11 , 20 , 21.
37	Contact	Contact - Small Commercial / Port Services Vessels with Navigation Buoy	A Small Commercial / Port Services Vessel contacts a navigation buoy in the approach channel.	Project tug / pilot launch / workboat has a mechanical defect / failure or as a result of Master error, Adverse weather or Reduced visibility. Or as a result of small commercial vessels taking avoiding action with approaching LNGC and strikes buoy.	Glancing blow on the Doonaha buoy as master misjudges turn. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Bad local publicity.	Navigation buoy is sunk. Single minor injury; Moderate damage to property; Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services; Bad local publicity.	2	2	1	2	3.5	2	3	1	2	1.0	2.34	1 , 2 , 6 , 10 , 11 , 12 , 13 , 14 , 20 , 21 , 23.
38	Contact	Contact - Recreational Vessels with Navigation Buoy	A Recreational Vessel contacts a navigation buoy in the approach channel.	As a result of avoiding action with LNGC on entry or departure, recreational vessel hits navigational buoy. Also as a result of mechanical defect / failure, skipper error, adverse weather or reduced visibility.	Glancing blow. Single minor injury; Negligible damage to property; Negligible environmental impact; Negligible business impact.	Recreational Vessel sinks; Multiple minor injuries or a single major injury; Moderate damage to vessel; Tier 1 small operational oil spill; Temporary closure, Bad widespread local publicity.	2	1	1	1	4.0	3	3	2	3	2.5	2.94	1 , 5 , 6 , 10 , 11 , 20 , 21.
39	Contact	Contact - Tanker with LNGC at anchor	A Tanker underway contacts LNGC at anchor.	Mechanical defect / failure, Pilot or Master error, Adverse weather conditions.	Mechanical failure causes tanker to collide with the anchored LNGC. Impact minimised by tanker using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes tanker to collide with the anchored LNGC. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	2.0	4	3	4	5	1.0	3.20	1 , 4 , 7 , 15 , 16 , 20 , 23 , 25 , 26 , 27.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence: People	Most Likely Consequence: Property	Most Likely Consequence: Environment	Most Likely Consequence: Business	Most Likely Consequence: Frequency	Worst Credible Consequence: People	Worst Credible Consequence: Property	Worst Credible Consequence: Environment	Worst Credible Consequence: Business	Worst Credible Consequence: Frequency	Risk Score	Possible Additional Mitigation Measures
40	Contact	Contact - Project Vessel with LNGC at anchor	FSRU forced to sail due to extreme weather and contacts anchored LNGC.	Mechanical defect / failure. Master, Pilot / Tug error, Adverse weather conditions. Lack of pilot situational awareness.	Mechanical failure causes FSRU to collide with the anchored LNGC. Impact minimised by FSRU using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes FSRU to collide with the anchored LNGC. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	3	3	2	4	2.0	4	4	3	5	1.0	4.35	1 , 2 , 3 , 6 , 7 , 8 , 10 , 13 , 20 , 23 , 26 , 27.
41	Contact	Contact - Large Commercial / Dry Cargo Vessels with LNGC at anchor	A Large Commercial / Dry Cargo Vessel contacts LNGC at anchor.	Mechanical defect / failure, Pilot or Master error, Adverse weather conditions.	Mechanical failure causes Large Commercial / Dry Cargo Vessel to collide with the anchored LNGC. Impact minimised by vessel using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes Large Commercial / Dry Cargo Vessel (Cruise Ship) to collide with the anchored LNGC. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	1	4	2.5	4	4	2	5	1.0	4.13	1 , 4 , 5 , 7 , 15 , 16, 20 , 23 , 25 , 26 , 27.
42	Contact	Contact - Small Passenger Vessels with LNGC at anchor	A Small Passenger Vessel contacts anchored LNGC.	Mechanical defect / failure. Master error. Adverse weather conditions.	Vessel not under command or disabled drifts at slow speed across the estuary. Dolphin watch operating near terminal gets too close or loses propulsion or steering and drifts at slow speed into LNGC at anchor. Single minor injury. Minor damage to vessels; Negligible environmental impact; Bad local publicity.	Propulsion control failure leading to heavy contact with LNGC at anchor by Dolphin Watch Vessel. Multiple minor or single major injury; Moderate damage to Dolphin Watch Vessel; Negligible environmental impact; Bad widespread local media coverage.	2	2	1	2	2.0	4	3	1	3	1.0	2.44	1 , 4 , 5 , 6 , 15 , 16 , 25 , 26 , 27.
43	Contact	Contact - Small Commercial / Port Services Vessels with LNGC at anchor	A Small Commercial / Port Services Vessel contacts LNGC at anchor	Mechanical defect / failure. Tug error. Adverse weather conditions. Inexperience of tug masters.	Tug makes light contact with anchored LNGC. Single minor injury. Negligible damage to vessel; Negligible environmental impact; Negligible publicity.	Tug makes heavy contact with anchored LNGC. Moderate damage to LNGC. Multiple minor or a single major injury; No gas release, negligible environmental impact; Bad local publicity.	2	1	1	1	2.0	3	3	1	2	1.0	1.75	1 , 2 , 4 , 6 , 12 , 13 , 25 , 26 , 27.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
44	Contact	Contact - Recreational Vessels with LNGC at anchor	Recreational Vessel contacts LNGC at anchor.	Mechanical defect / failure, Skipper error and / or adverse weather conditions causes recreational vessel to get too close to LNGC at anchor. Visiting yachtsman with poor local knowledge.	Recreational vessel bounces off LNGC at anchor and sustains superficial damage. Single minor injury, negligible damage, negligible environmental impact, negligible publicity.	Recreational vessel makes heavy contact with LNGC at anchor in adverse weather / tidal conditions, vessel sinks. Multiple minor injuries or a single major injury; Minor damage; Negligible environmental impact; Temporary suspension of activities; Minor commercial impact.	2	1	1	1	3.0	3	2	1	2	2.0	2.08	1 , 4 , 5 , 6 , 25 , 26 , 27.
45	Grounding	Grounding - Tanker	A Tanker runs aground	Tanker grounds while transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal. As a result of mechanical defect / failure, master / pilot error or adverse weather or reduced visibility or as a result of avoiding action with LNGC.	Vessel touches the bottom and re-floats. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Vessel heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier3 spill criteria reached; Adverse international publicity. Temporary suspension of operations, prolonged restrictions and loss of revenue.	2	2	1	2	2.0	3	3	4	5	1.5	3.19	1 , 6 , 10 , 11 , 20 , 21.
46	Grounding	Grounding - Project Vessel	A Project Vessel runs aground	LNGC grounds while transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal or on route to anchor. As a result of mechanical defect / failure, master / pilot error or adverse weather or reduced visibility or as a result of avoiding action with 3rd party vessel.	Vessel touches the bottom and refloats. Very minor injury; Minor damage to property; Negligible environmental impact. Moderate bad publicity.	Vessel heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier 2 spill criteria reached but capable of being limited to immediate area within site; Adverse international publicity. Temporary suspension of operations, prolonged restrictions and loss of revenue.	2	2	1	2	2.5	3	3	3	5	2.0	3.42	1 , 2 , 5 , 6 , 10 , 11 , 12 , 13 , 14 , 20 , 21 , 23 , 24 , 25.
47	Grounding	Grounding - Large Commercial & Dry Cargo Vessels	A Large Commercial Vessel runs aground	Large Commercial grounds while transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal. As a result of mechanical defect / failure, master / pilot error or adverse weather or reduced visibility or as a result of avoiding action with LNGC.	Vessel touches the bottom and re-floats. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Vessel (cruise ship) heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier 2 spill criteria reached but capable of being limited to immediate area within site; Adverse international publicity. Temporary suspension of operations, prolonged restrictions and loss of revenue.	2	2	1	2	2.5	4	3	3	5	2.0	3.51	1 , 6 , 10 , 11 , 20 , 21.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
48	Grounding	Grounding - Small Passenger Vessels	A Small Passenger Vessel runs aground	Result of small passenger vessel taking avoiding action with approaching LNGC in narrows. Mechanical defect / failure or master / pilot error or adverse weather or reduced visibility.	Dolphin watch vessel touches the bottom and re-floats. Single minor injury; Very minor damage to property; Negligible environmental impact; Minor Local publicity.	Dolphin watch vessel heavily aground requiring commercial salvage. Multiple minor injuries or single major; Moderate damage / vessel lost; Tier 1 - small operational oil spill; National publicity.	2	1	1	2	3.0	3	3	2	4	2.0	2.98	1 , 5 , 11 , 20 , 21.
49	Grounding	Grounding - Small Commercial / Port Services Vessel	A Small Commercial / Port Services Vessel runs aground	Project tug / workboat / pilot launch transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal suffers a mechanical defect / failure and drifts into shallows. Master error, adverse weather, reduced visibility or as a result of avoiding action with a 3rd party vessel.	Vessel touches the bottom and re-floats. Very minor injury; Minor damage to vessel; Negligible environmental impact. Moderate bad publicity.	Vessel heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier 1 - small operational oil spill; Bad widespread local publicity. Temporary suspension of operations, short term loss of revenue.	1	2	1	3	2.5	3	3	2	3	2.0	3.00	1 , 2 , 6 , 10 , 11 , 12 , 13 , 14 , 20 , 21 , 23.
50	Grounding	Grounding - Recreational Vessel	A Recreational Vessel runs aground.	Recreational vessel grounds on Beal Bar or the Doonaha Shoal as a result of avoiding action with 3rd party vessel / LNGC on entry or departure through narrows. Mechanical defect / failure, skipper error, adverse weather or reduced visibility.	Vessel touches the bottom and re-floats. Minor injury; Very minor damage to property; Negligible environmental impact; Negligible publicity, no loss of revenue.	Vessel heavily aground. Multiple minor or a single major injury; Minor damage to property; Small oil spill with little effect on environment; Widespread local publicity.	2	1	1	1	4.0	3	2	2	3	3.0	3.06	1 , 5 , 11 , 20 , 21.
51	Foundering / Swamping	Foundering / Swamping - Project Vessel	Project Vessel Founders.	Mechanical defect / failure, human error, malicious intent.	Vessel takes on water but source of water ingress is detected in time to avoid sinking. Single minor injury; minor damage to property; Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue, widespread local publicity.	Vessel sinks at berth or at anchor. Multiple minor injuries or single major; Major damage to vessel; Tier 2 may be declared but criteria not necessarily met; International publicity and operations and revenue seriously disrupted.	2	2	1	3	3.0	3	4	2	5	1.5	3.98	1 , 3 , 7 , 8 , 9 , 20 , 23 , 24 , 25 , 26 , 27.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
52	Mooring Incident	Mooring Incident / Breakout - Project Vessel	Project Vessel Mooring Incident / Breakout	Failure of ship's mooring gear. Failure of jetty / FSRU fixed mooring gear or anchor cable parts. Inadequate seamanship / watch keeping. Extreme weather. Excessive tidal stream. Vandalism.	A single mooring line parts. Very minor injury; Minor damage to property; Negligible environmental impact; Bad local publicity, short-term disruption to services.	All mooring lines part and vessel breaks away from the berth or anchor cable parts and drifts in the estuary. Multiple minor or single major injury; Moderate damage to property; Minor impact on environment. National publicity, temporary suspension of operations, prolonged estuary restrictions / stakeholder delays.	2	2	1	2	4.0	3	3	2	4	3.0	4.1	1 , 2 , 3 , 5 , 6 , 7 , 8 , 9 , 11 , 16 , 17 , 18 , 19, 20, 23 , 24 , 25 , 26 , 27.
53	Mooring Incident	Mooring Incident / Breakout - Small Commercial / Port Services Vessels	A Small Commercial Vessel / Port Services Vessel is ranged or breaks away from its mooring.	Failure of project tug / workboat's mooring gear. Failure of fixed mooring gear. Extreme weather. Excessive wash or draw-off. Water surge caused by large vessel. Vandalism.	A mooring line parts. Very minor injury; Very minor damage to property; Negligible environmental impact; Very short-term disruption to services.	All mooring lines part and vessel breaks away from the berth / jetty and drifts in the estuary/ runs aground. Multiple minor or single major injury; Moderate damage to property; Negligible impact on environment. Widespread local publicity; temporary suspension of operations.	1	1	1	1	2.5	3	3	1	3	2.0	1.53	1 , 2 , 5 , 6 , 7 , 9 , 20 , 23.
54	Tug Girting	Tug Girting / Towing Incident	A Tug Girts while Project Vessel under tow	Mechanical defect / failure in the tug or the project vessel being assisted. Master / Pilot / Skipper error (tug or vessel being assisted). Adverse weather, Inappropriate tugs utilised.	Tug overrun during towage operation. Single minor injury; Minor damage to property; Negligible environmental damage; Bad local publicity.	Tug girts. Multiple major injuries or single fatality; Major damage to vessel / vessel lost; No effect of note. Minor pollution; Adverse national publicity; Temporary suspension of operations.	2	2	1	2	3.5	4	4	3	4	2.0	3.60	1 , 2 , 6 , 7 , 10 , 11 , 12 , 13 , 14 , 17, 20 , 23.
55	Cable Snagging	Cable Snagged - Project Vessel	Cable Snagged by Project Vessel Anchor	Project vessel is disabled and drifts upstream on the tide, crew deploy anchor and snag underwater cables across the estuary. Mechanical defect / failure, breakout / mooring Incident, master / pilot error or adverse weather.	Anchor hooks cable causing: Negligible injury; Negligible damage to vessel; Negligible environmental impact. Bad widespread publicity and possible suspension of operations and interruptions to stakeholder supplies.	Anchor snags cable. Multiple minor or a single major injury; Moderate damage to vessel; Negligible environmental impact; Major national publicity. Medium-term suspension of operations or prolonged restrictions, major disruption to commercial activities.	1	1	1	3	3.0	3	3	1	4	2.0	3.34	1 , 7 , 20 , 22.

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score	Possible Additional Mitigation Measures
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency		
56	Fire / Explosion	Fire /Explosion - Project Vessel	Fire breaks out on berthed FSRU or LNG Supply Vessel.	Mechanical Defect / Failure. Crew error. Deliberate act.	Small fire, quickly under control. Single minor injury; Minor damage to property; Negligible impact on the environment; Minor disruption to operations; Bad widespread publicity.	Large persistent vessel fire while undertaking discharge operations. Fatalities; Major injuries or fatality; damage to vessel(s); Gas release; Tier 3 support required; Operations and revenue seriously disrupted; temporary closure, national media coverage.	2	2	1	3	2.0	5	4	4	5	1.0	3.74	1 , 3 , 6 , 8 , 9 , 13 , 20.

Annex E Hazard Log – Residual Assessment

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
1	Collision	Collision - Tanker ICW Tanker	Tanker collides with another Tanker	Tanker collides with another tanker as a result of taking avoiding action with an LNGC or FSRU underway. As a result of mechanical defect / failure, master or pilot error, reduced visibility or miscommunication between two vessels underway in vicinity of anchorages or within the narrows, scheduling error.	Single minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Multiple major injuries or single fatality; Major damage to property; Tier 3 criteria reached with pollution requiring national support. Adverse national publicity. Temporary suspension of activities.	2	2	2	2	2.0	4	4	4	4	1.0	2.96
2	Collision	Collision - Tanker ICW Project Vessel (FSRU or LNGC)	Tanker collides with a Project Vessel	Tanker collides with LNGC or FSRU while underway in the vicinity of anchorages or within the narrows as a result of mechanical defect / failure, master / pilot error, avoiding action with 3rd party vessel, reduced visibility, miscommunication between ships, scheduling error.	Glancing blow. Single minor injury; Moderate damage to property, Tier 1 may be declared but criteria not necessarily met; Widespread local publicity ensuing loss of revenue.	Head-on collision. Multiple major injuries or single fatality; Major damage to property; Tier 2 spill criteria reached but capable of being limited to immediate area. ; Adverse international publicity. Long-term suspension of LNG operations and prolonged restrictions.	2	2	2	2	1.5	4	4	3	5	1.0	3.10
3	Collision	Collision - Tanker ICW Large Commercial / Dry Cargo Vessel	Collision - Tanker ICW Large Commercial / Dry Cargo Vessel	Tanker collides with a Large Commercial Vessel / Dry Cargo Vessel (including cruise ship) as a result of taking avoiding action with an LNGC or FSRU underway. As a result of mechanical defect / failure, master or pilot error, reduced visibility or miscommunication between two vessels underway in vicinity of anchorages or within the narrows, scheduling error.	Large Commercial / Dry Cargo Vessel collides with Tanker on river passage. Single minor injury; Minor damage to property. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Tanker collides with cruise ship on estuary passage. Multiple major injuries or single fatality; Catastrophic damage to property; Tier 3 criteria reached with pollution requiring national support. Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	2.0	4	5	4	5	1.0	3.34
4	Collision	Collision - Tanker ICW Small Passenger Vessel	Tanker collides with a Small Passenger Vessel	Collision with DWV as a result of Tanker taking avoiding action with LNGC or FSRU underway or Dolphin watch vessel operating in vicinity of the narrows fails to take necessary IRPCS actions. As a result of mechanical defect / failure, master / skipper or pilot error, reduced visibility or misunderstanding between master of DWV and pilots.	Glancing blow at low speed in the narrows; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is knocked down; multiple fatalities; Moderate damage; Negligible environmental impact; International media publicity, operations disrupted for mrore than two days.	2	2	1	3	2.0	5	3	1	5	1.0	3.41

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
5	Collision	Collision - Tanker ICW Small Commercial / Port Services Vessel	Tanker collides with a Small Commercial / Port Services Vessel	Tanker taking avoiding action with LNGC or FSRU underway and collides with small commercial / port services vessel. Or Project tug en-route to LNGC / FSRU collides with Tanker in narrows. Result of mechanical defect / failure, master / skipper or pilots error or as a result of reduced visibility.	Glancing blow between tanker and ship assist tug or other workboat in the narrows or estuary. Single minor injury; Negligible damage to property; Tier 1 may be declared but criteria not necessarily met small operational oil spill; Very short-term disruption to services.	Port Services Vessel fails to take avoiding action and is knocked down; multiple minor injuries or a single major injury; Major damage; Moderate environmental impact; Major national publicity and temporary suspension of activities.	3	1	2	2	2.0	4	3	4	4	1.0	3.29
6	Collision	Collision - Tanker ICW Recreational Vessel	Tanker collides with a Recreational Vessel	Tanker taking avoiding action from an LNGC or FSRU underway and collides with recreational vessel. Or Tanker collides with Recreational Vessel in narrows. As a result of mechanical defect / failure, master / skipper error or pilot error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple fatalities; Major damage to vessel; Tier 1 may be declared but criteria not necessarily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	3.0	5	3	1	4	1.5	3.25
7	Collision	Collision - Project Vessel ICW Large Commercial / Dry Cargo Vessel	Project Vessel collides with a Large Commercial / Dry Cargo Vessel	Large Commercial / Dry Cargo collides with LNGC or FSRU while underway in the vicinity of anchorages or within the narrows as a result of mechanical defect / failure, master / pilot error, avoiding action with 3rd party vessel, reduced visibility, miscommunication between ships, scheduling error.	General Cargo Vessel collides with LNGC / FSRU on river passage. Single minor injury; Minor damage to property. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	LNGC or FSRU collides with cruise ship on river passage. Multiple major injuries or single fatality; Catastrophic damage to property; Tier 3 criteria reached with pollution requiring national support. Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	1.5	4	5	4	4	0.5	3.01
8	Collision	Collision - Project Vessel ICW Small Passenger Vessel	Project Vessel collides with a Small Passenger Vessel	Dolphin watch vessel operating in vicinity of the narrows fails to take necessary IRPCS actions when LNGC or FSRU is on approach. As a result of mechanical defect / failure, Master / Skipper error or Pilot error, avoiding action with 3rd party vessel, reduced visibility or misunderstanding between master of DWV and pilot.	Glancing blow at low speed in the narrows; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is knocked down; multiple fatalities; Moderate damage; Small operational oil spill with little environmental impact; International publicity, operations and revenue disrupted for more than two days.	2	2	1	3	2.0	5	3	2	5	1.0	3.50

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
9	Collision	Collision - Project Vessel ICW Small Commercial / Port Services Vessel	Project Vessel collides with a Small Commercial / Port Services Vessel	Collision during pilot boarding and landing or when tug on route to LNGC fails to take appropriate avoiding action or small commercial / Port Service Vessel fails to take necessary IRPCS actions when LNGC or FSRU is on approach. As a result of mechanical defect / failure, master / skipper / pilot error, avoiding action with 3rd party vessel, reduced visibility or misunderstanding between master of Port Service Vessel and pilot.	Glancing blow (in particular tug whilst towing). Single minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Head-on collision or Small Commercial / Port Services Vessel being overrun / sunk. Multiple major injuries or single fatality; Major damage to property; Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity; Adverse local publicity. Short-term loss of revenue including minor disruption to commercial activities.	3	1	2	2	2.5	4	4	3	4	1.0	3.45
10	Collision	Collision - Project Vessel ICW Recreational Vessel	Project Vessel collides with a Recreational Vessel	An LNGC or FSRU underway collides with Recreational Vessel. As a result of mechanical defect / failure, skipper or pilot error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligibile impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple fatalities; Major damage to vessel; Tier 1 criteria declared but not neccesserily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	2.5	5	3	1	4	1.5	3.10
11	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Large Commercial / Dry Cargo Vessel	Large Commercial / Dry Cargo Vessel collides with a large Commercial / Dry Cargo Vessel	Large Commercial / Dry Cargo Vessel collides with a large Commercial / Dry Cargo Vesse as a result of taking avoiding action with an LNGC or FSRU underway. As a result of mechanical defect / failure, Master or Pilot error, reduced visibility or miscommunication between two vessels underway in vicinity of anchorages or within the narrows, scheduling error.	Large Commercial / Dry Cargo Vessel collides with Large Commercial / Dry Cargo Vessel on estuary passage or manoeuvering in the anchorages. Single minor injury; Minor damage to property. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Large Commercial / Dry Cargo Vessel collides with cruise ship at passage speed within the estuary. Multiple fatalities; Catastrophic damage to property; Tier 2 spill criteria reached. Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	1.0	4	5	3	5	1.0	3.09

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
12	Collision	Collision - Large Commercial / Dry Cargo vessel ICW Small Passenger Vessel	Large Commercial / Dry Cargo Vessel collides with a Small Passenger Vessel	Collision with DWV as a result of Large Commercial / Dry Cargo Vessel taking avoiding action with LNGC or FSRU underway. Or Dolphin watch vessel operating in vicinity of the narrows failing to take necessary IRPCS actions. As a result of mechanical defect / failure, master / skipper or pilot error, reduced visibility or misunderstanding between master of DWV and pilots.	Glancing blow at low speed in the narrows; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is knocked down; Multiple fatalities; Moderate damage; Tier 1 or Tier 2 environmental impact; Major national publicity and temporary suspension of activities.	2	2	1	3	2.0	5	3	2	4	1.0	3.44
13	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Small Commercial / Port Services Vessel	Large Commercial / Dry Cargo Vessel collides with a Small Commercial / Port Services Vessel	Large Commercial / Dry Cargo Vessel taking avoiding action with LNGC or FSRU underway and collides with small commercial / port services vessel. Or Project tug en-route to LNGC / FSRU collides with Tanker in narrows. Result of mechanical defect / failure, Master / Skipper or Pilots error, schedule error or as a result of reduced visibility.	Glancing blow (in particular tug whilst towing). Single minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Head-on collision or Small Commercial / Port Services Vessel being overrun. Multiple major injuries or single fatality; Major damage to property; Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity; Adverse local publicity. Short-term loss of revenue including minor disruption to commercial activities.	3	1	2	2	2.0	4	3	2	4	1.5	3.29
14	Collision	Collision - Large Commercial / Dry Cargo Vessel ICW Recreational Vessel	Large Commercial / Dry Cargo Vessel collides with a Recreational Vessel	Large Commercial / Dry Cargo Vessel taking avoiding action from an LNGC or FSRU underway and collides with Recreational Vessel. Or Large Commercial / Dry Cargo Vessel collides with Recreational Vessel in narrows. As a result of mechanical defect / failure, Master / Skipper error or Pilot error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple fatalities; Major damage to vessel; Tier 1 may be declared but criteria not necessarily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	3.0	5	3	4	4	1.5	3.53

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
15	Collision	Collision - Small Passenger Vessel ICW Small Passenger Vessel	Small Passenger Vessel collides with a Small Passenger Vessel	Dolphin watch vessel operating in vicinity of the narrows fail to take necessary IRPCS actions and collides with other small passenger vessel as a result of avoiding action from approaching with LNGC / FSRU. Result of Master / Skipper error, reduced visibility, mechanical failure, miscommunication between skippers.	Glancing blow at low speed; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and one vessel is holed; multiple major injuries or a single fatality; Moderate damage; Negligible environmental impact; Major national publicity and temporary suspension of activities.	2	2	1	3	1.0	4	3	1	4	1.0	2.79
16	Collision	Collision - Small Passenger Vessel ICW Small Commercial / Port Services Vessel	Small Passenger Vessel collides with a Small Commercial / Port Services Vessel	Pilot vessels or tugs transiting through the narrows to LNGC or FSRU collide with Dolphin watch vessel. As a result of mechanical defect / failure, master / skipper error, result of avoiding action with 3rd party vessel, reduced visibility, miscommunication between skippers.	Glancing blow at low speed; multiple minor injuries or a single major; minor damage to property, negligible environmental impact; bad widespread local publicity.	Dolphin watch vessel with up to 50 passengers fails to take avoiding action and is holed; multiple major injuries or a single fatality; Moderate damage; Tier 1 or Tier 2 environmental impact; Major national publicity and temporary suspension of activities.	2	2	1	3	2.0	4	3	2	4	1.0	3.12
17	Collision	Collision - Small Passenger Vessel ICW Recreational Vessel	Small Passenger Vessel collides with a Recreational Vessel	Dolphin Watch Vessel takes avoiding action from an LNGC or FSRU underway and collides with Recreational Vessel. As a result of mechanical defect / failure, master / skipper error, or reduced visibility, or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations. Recreational vessel passing too close to dolphin watch vessel within the narrows.	Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational vessel sunk. Multiple major injuries or single fatality; Major damage to vessel; Tier 1 may be declared but criteria not necessarily met; National publicity. Temporary suspension of commercial activities and/or prolonged restrictions.	2	2	1	2	3.0	4	3	4	4	1.5	3.20

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
18	Collision	Collision - Small Commercial / Port Services Vessel ICW Small Commercial / Port Services Vessel	Small Commercial / Port Services Vessel collides with a Small Commercial / Port Services Vessel	Collision during pilot boarding and landing or when tug on route to LNGC fails to take appropriate avoiding action or small commercial / Port Service Vessel fails to take necessary IRPCS actions when LNGC or FSRU is on approach. As a result of mechanical defect / failure, master / skipper error or pilot error, avoiding action with 3rd party vessel, reduced visibility or misunderstanding between master of Port Service Vessel and pilot. Fishing activity (potting) within the narrows.	Glancing blow at low speed during towage operations; single minor injury; minor damage to property, negligible environmental impact; negligible publicity.	One vessel is holed and sinks; multiple major injuries or a single fatality; Moderate damage; Tier 1 or Tier 2 environmental impact; Local publicity and possible suspension of activities / operational delays.	2	2	1	1	3.0	4	3	2	2	1.0	2.55
19	Collision	Collision - Small Commercial / Port Services Vessel ICW Recreational Vessel	Small Commercial / Port Services Vessel collides with a Recreational Vessel	Collision between vessels as a result of either taking avoiding action with arriving LNGC / FSRU. Mechanical defect / failure, master / skipper error, reduced visibility or sailing vessel taking additional risks during racing or visiting vessels unfamiliar with local regulations. Increased likelihood of interaction in the narrows and north of Scattery Island.	Pilot vessel collides with a yacht. Glancing blow to recreational vessel at low speed. Single minor injury; Minor damage to property; Negligible impact on environment; Bad local publicity.	Recreational or Small Commercial Vessel sunk. Multiple major injuries or single fatality; Major damage to either vessel; Tier 1 may be declared but criteria not necessarily met; Local publicity. Temporary suspension of operations.	2	2	1	2	2.5	4	4	2	3	1.5	2.88
20	Collision	Collision - Recreational Vessel ICW Recreational Vessel	Recreational Vessel collides with another Recreational Vessel	2 recreational vessels collide as a result of taking avoiding action from approaching LNGC or FSRU. Mechanical defect / failure, Skipper error, reduced visibility, Sailing vessel taking additional risks during racing, visiting vessels unfamiliar with local regulations.	Glancing blow (especially during racing). Single minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Either or both recreational vessels sink. Multiple major injuries or single fatality; Moderate damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Adverse local publicity. Short-term loss of revenue including minor disruption to commercial activities.	2	2	1	2	3.0	4	3	1	2	2.0	2.91
21	Contact	Contact - Tanker with Project Infrastructure	A Tanker underway contacts project infrastructure including; Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure, Pilot or Master error, Adverse weather conditions.	Mechanical failure causes tanker to drift across the estuary towards the moored FSRU. Impact minimised by tanker using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes tanker to drift across the estuary and strikes the FSRU. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	1.0	4	3	4	5	1.0	3.02

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
22	Contact	Contact - Project Vessel with Project Infrastructure	A Project Vessel contacts project infrastructure including during berthing; either FSRU onto Jetty or LNGC onto FSRU.	Mechanical defect / failure. Master, Pilot / Tug error, Adverse weather conditions. Poor communications between vessel and shore. Inadequate project fendering. Lack of pilot situational awareness.	Inexperience of pilots berthing LNGC vessels alongside FSRU resulting in light contact with FSRU. Superficial damage to both vessels and sub-frames. Multiple minor or single major injury. Moderate damage to vessels; Minor environmental impact; National publicity and temporary closure.	Inexperience of pilots berthing LNGC vessels alongside FSRU resulting in a heavy contact with FSRU. Substantial damage to both vessels and jetty. Multiple major injuries or a single fatality; Major damage; Major gas release; International media coverage; Operations and revenue seriously disrupted.	3	3	2	4	2.0	4	4	3	5	1.0	4.35
23	Contact	Contact - Large Commercial / Dry Cargo Vessels with Project Infrastructure	A Large Commercial / Dry Cargo Vessel contacts project infrastructure including; Jetty, FSRU or a moored LNGC.	Mechanical defect / failure. Master / pilot error. Adverse weather conditions.	Vessel not under command or disabled drifts at slow speed across the estuary. Multiple minor or single major injury. Moderate damage to vessels; Minor environmental impact; National publicity and temporary closure.	Propulsion control failure leading to heavy contact with FSRU or LNGC by cruise ship or bulker. Substantial damage to both vessels and jetty. Multiple major injuries or a single fatality; major damage; Gas release; International media coverage; Operations and revenue seriously disrupted.	2	2	1	3	1.5	4	4	2	5	1.0	3.38
24	Contact	Contact - Small Passenger Vessels with Project Infrastructure	A Small Passenger Vessel contacts project infrastructure including; Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure. Master error. Adverse weather conditions.	Vessel not under command or disabled drifts at slow speed across the estuary. Dolphin watch operating near terminal gets too close or loses propulsion or steering and drifts at slow speed into FSRU. Single minor injury. Minor damage to vessels; Negligible environmental impact; Bad local publicity.	Propulsion control failure leading to heavy contact with FSRU or LNGC by Dolphin Watch Vessel. Moderate damage to Dolphin Watch Vessel. Multiple minor or single major injury; Moderate damage to Dolphin Watch Vessel; Negligible environmental impact; Bad widespread local media coverage.	2	2	1	2	1.5	3	3	1	3	1.0	1.98
25	Contact	Contact - Small Commercial / Port Services Vessels with Project Infrastructure	A Small Commercial / Port Services Vessel contacts project infrastructure including; Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure. Tug error. Adverse weather conditions. Poor communications between vessel and shore.	Inexperience of tug masters berthing LNGC vessels alongside FSRU resulting in light contact with FSRU. Project tugs and workboats are in routine contact with LNG vessels and jetty. Single minor injury. Negligible damage to vessel; Negligible environmental impact; Negligible publicity.	Inexperience of tug masters berthing LNGC vessels alongside FSRU resulting in a heavy contact. Moderate damage to LNGC / FSRU or jetty. Multiple minor or a single major injury; No gas release, negligible environmental impact; Bad local publicity.	2	1	1	1	4.0	3	3	1	2	1.0	2.26

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
26	Contact	Contact - Recreational Vessels with Project Infrastructure	Recreational Vessel contacts project infrastructure including; Jetty, FSRU or a moored LNG supply vessel.	Mechanical defect / failure, Skipper error and / or adverse weather conditions causes recreational vessel to get too close to LNG terminal. Visiting yachtsman with poor local knowledge.	Recreational vessel bounces off LNG terminal or FSRU and sustains superficial damage. Single minor injury, negligible damage, negligible environmental impact, negligible publicity.	Recreational vessel becomes entangled in LNG jetty structure or makes heavy contact with FSRU / LNGC in adverse weather / tidal conditions, vessel sinks. Multiple minor injuries or a single major injury; Minor damage; Negligible environmental impact; Temporary suspension of activities; Minor commercial impact.	2	1	1	1	2.5	3	2	1	2	1.5	1.85
27	Contact	Contact - Tanker with Non- Project Infrastructure	A Tanker contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of tanker taking IRPCS avoiding action with LNGC or FSRU Underway. Mechanical defect / failure, Master, Pilot / tug error. Adverse weather conditions.	Loss of tanker control / mechanical failure resulting in low velocity impact with non-project estuary infrastructure e.g. Money Point jetty. Single minor injury, Minor damage; Minor environmental impact; Bad widespread publicity.	Tanker on passage in the estuary suffers mechanical breakdown and contacts anchored vessel. Multiple minor or single major injury; Moderate damage to vessel; Minor environmental impact; Major national publicity; disruption to operations.	2	2	2	3	1.5	4	3	2	4	1.0	3.10
28	Contact	Contact - Project Vessel with Non-Project Infrastructure	A Project Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of avoiding action with 3rd party vessel. Mechanical defect / failure, Master / Pilot / tug error. Loss of control. Adverse weather conditions. Berthing error.	As a result of steering or mechanical failure, project vessel is blown or swept onto non-project infrastructure such as Money Point jetty. Very minor impact, absorbed by fenders tugs and anchoring. Single minor injury; Minor damage to vessel; Negligible environmental impact; Moderate bad widespread local publicity, temporary suspension of operations.	As a result of steering or mechanical failure, project vessel strikes non-project infrastructure such as Money Point jetty very heavily and is holed or possibly founders. Multiple minor or single major injury; Major damage to vessel; Moderate environmental damage, Tier 2 spill criteria; International publicity, temporary closure of LNG / stakeholder operations.	2	2	1	3	1.5	3	4	3	5	1.0	3.40
29	Contact	Contact - Large Commercial / Dry Cargo Vessels with Non- Project Infrastructure	A Large Commercial / Dry Cargo Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of Large Commercial /Dry Cargo Vessel taking IRPCS avoiding action with LNGC or FSRU Underway. Mechanical defect / failure, Master, Pilot / tug error. Adverse weather conditions.	Large Commercial / Dry Cargo Vessel loses control resulting in low velocity impact with non-project estuary infrastructure e.g. Money Point jetty. Single minor injury, Minor damage; Minor environmental impact; Bad widespread publicity.	Large Commercial / Dry Cargo Vessel on passage in the estuary suffers mechanical breakdown and contacts anchored project LNGC. Multiple minor or single major injury; Moderate damage to vessel; Minor environmental impact; Major national publicity; disruption to operations.	2	2	2	3	1.5	4	3	2	4	1.0	3.10

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
30	Contact	Contact - Small Passenger Vessel with Non- Project Infrastructure	A Small Passenger Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of small passenger vessel taking IRPCS avoiding action with LNGC or FSRU Underway. Mechanical defect / failure, Master, Pilot / tug error. Adverse weather conditions.	Dolphin watch vessel loses propulsion / control and drifts onto anchored vessel/ jetty / fails to take avoiding action. Multiple minor or single major injury; minor damage to vessel; minor environmental impact; bad local publicity.	Dolphin watch vessel makes heavy contact with anchored vessel and is holed / sinks. Multiple major injuries / single fatality; moderate damage; Tier 2 spill criteria reached; moderate environmental impact; Bad widespread local publicity.	2	2	2	2	1.5	4	3	3	3	1.0	2.64
31	Contact	Contact - Small Commercial / Port Services Vessel with Non- Project Infrastructure	A Small Commercial / Port Services Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Tug berthing error or Project tug or pilot launch suffer a breakdown and are disabled in the estuary. Result of avoiding action with 3rd party vessel. Mechanical defect / failure. Master error. Loss of control. Adverse weather conditions.	As a result of steering or mechanical failure, project tug / workboat / pilot boat is blown or swept onto non-project infrastructure such as Money Point jetty. Very minor impact, absorbed by fenders tugs and anchoring. Single minor injury; Minor damage to vessel; Negligible environmental impact; Bad local publicity, temporary suspension of operations.	As a result of steering or mechanical failure, project tug / pilot boat / workboat strikes non-project infrastructure such as Money Point jetty very heavily and is holed or possibly founders. Multiple minor or single major injury; Major damage to vessel; Minor environmental damage; Bad widespread local publicity, temporary closure of LNG / stakeholder operations.	2	2	1	2	1.5	3	4	2	3	1.0	2.45
32	Contact	Contact - Recreational Vessels with Non-Project Infrastructure	Recreational Vessel contacts non-project infrastructure including; vessel at anchor, stationary vessels alongside, piers and jetties.	Result of avoiding action with an approaching LNGC or FSRU. Mechanical defect / failure. Master error. Adverse weather conditions.	Recreational vessel loses propulsion / control and drifts onto anchored vessel / jetty. Vessel fails to take avoiding action. Multiple minor or single major injury; minor damage to vessel; Negligible environmental impact; bad local publicity.	Recreational vessel makes heavy contact with anchored vessel and is holed / sinks. Multiple major injuries / single fatality; moderate damage; Tier 2 spill criteria reached; moderate environmental impact; Bad widespread local publicity.	2	2	1	2	2.5	4	3	3	3	1.5	2.90
33	Contact	Contact - Tanker with Navigation Buoy	A Tanker contacts a navigational buoy in the approach channel.	Mechanical defect / failure. Master error. Pilot error. Adverse weather. Reduced visibility. Result of avoiding action with 3rd party vessel.	Glancing blow. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Navigation buoy is sunk. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Bad widespread local publicity.	2	2	1	3	1.5	2	3	1	3	1.0	2.36
34	Contact	Contact - Project Vessel with Navigation Buoy	A Project Vessel contacts a navigation buoy in the approach channel.	Mechanical defect / failure. Master error. Pilot error. Adverse weather. Reduced visibility. Result of avoiding action with 3rd party vessel.	Glancing blow on the Doonaha buoy as pilot misjudges turn. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services. Bad widespread publicity.	Navigation buoy is sunk. Single minor injury; Moderate damage to property; Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services; National publicity.	2	2	1	3	2.0	2	3	1	4	1.5	3.01

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
35	Contact	Contact - Large Commercial / Dry Cargo Vessels with Navigation Buoy	A Large Commercial / Dry Cargo Vessels contacts a navigational buoy in the approach channel.	Mechanical defect / failure. Master error. Pilot error. Adverse weather. Reduced visibility. Result of avoiding action with 3rd party vessel.	Glancing blow. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Navigation buoy is sunk. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services; Bad widespread local publicity.	2	2	1	3	2.0	2	3	1	3	1.5	2.61
36	Contact	Contact - Small Passenger Vessels with Navigation Buoy	A Small Passenger Vessel contacts a navigation buoy in the approach channel while avoiding an LNGC, FSRU underway.	Result of small passenger vessel taking avoiding action with approaching LNGC. Mechanical defect / failure or master /pilot error, adverse weather or reduced visibility.	Glancing blow on a buoy. Single minor injury; Very minor damage to property; Negligible environmental impact; Minor Local publicity.	Navigation buoy / small passenger vessel is sunk. Multiple major injuries or a single fatality; Moderate damage / vessel lost; Tier 2 spill criteria; National publicity.	2	2	1	2	2.0	4	3	3	4	1.0	2.70
37	Contact	Contact - Small Commercial / Port Services Vessels with Navigation Buoy	A Small Commercial / Port Services Vessel contacts a navigation buoy in the approach channel.	Project tug / pilot launch / workboat has a mechanical defect / failure or as a result of Master error, Adverse weather or Reduced visibility. Or as a result of small commercial vessels taking avoiding action with approaching LNGC and strikes buoy.	Glancing blow on the Doonaha buoy as master misjudges turn. Very minor injury; Very minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Bad local publicity.	Navigation buoy is sunk. Single minor injury; Moderate damage to property; Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services; Bad local publicity.	2	2	1	2	3.0	2	3	1	2	1.0	2.14
38	Contact	Contact - Recreational Vessels with Navigation Buoy	A Recreational Vessel contacts a navigation buoy in the approach channel.	As a result of avoiding action with LNGC on entry or departure, recreational vessel hits navigational buoy. Also as a result of mechanical defect / failure, skipper error, adverse weather or reduced visibility.	Glancing blow. Single minor injury; Negligible damage to property; Negligible environmental impact; Negligible business impact.	Recreational Vessel sinks; Multiple minor injuries or a single major injury; Moderate damage to vessel; Tier 1 small operational oil spill; Temporary closure, Bad widespread local publicity.	2	1	1	1	2.5	3	3	2	3	1.5	2.14
39	Contact	Contact - Tanker with LNGC at anchor	A Tanker underway contacts LNGC at anchor.	Mechanical defect / failure, Pilot or Master error, Adverse weather conditions.	Mechanical failure causes tanker to collide with the anchored LNGC. Impact minimised by tanker using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes tanker to collide with the anchored LNGC. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	2	2	1.0	4	3	4	5	1.0	3.02
40	Contact	Contact - Project Vessel with LNGC at anchor	FSRU forced to sail due to extreme weather and contacts anchored LNGC.	Mechanical defect / failure. Master, Pilot / Tug error, Adverse weather conditions. Lack of pilot situational awareness.	Mechanical failure causes FSRU to collide with the anchored LNGC. Impact minimised by FSRU using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes FSRU to collide with the anchored LNGC. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	3	3	2	4	1.0	4	4	3	5	1.0	4.00

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
41	Contact	Contact - Large Commercial / Dry Cargo Vessels with LNGC at anchor	A Large Commercial / Dry Cargo Vessel contacts LNGC at anchor.	Mechanical defect / failure, Pilot or Master error, Adverse weather conditions.	Mechanical failure causes Large Commercial / Dry Cargo Vessel to collide with the anchored LNGC. Impact minimised by vessel using anchor to slow closure rate. Single minor injury; minor damage to property, Possible moderate Tier 2 spill; Bad widespread publicity.	Mechanical failure causes Large Commercial / Dry Cargo Vessel (Cruise Ship) to collide with the anchored LNGC. Multiple minor or single major injury; moderate damage; Tier 3 Criteria reached, Adverse international publicity. Long-term suspension of operations, prolonged restrictions.	2	2	1	4	1.5	4	4	2	5	1.0	3.78
42	Contact	Contact - Small Passenger Vessels with LNGC at anchor	A Small Passenger Vessel contacts anchored LNGC.	Mechanical defect / failure. Master error. Adverse weather conditions.	Vessel not under command or disabled drifts at slow speed across the estuary. Dolphin watch operating near terminal gets too close or loses propulsion or steering and drifts at slow speed into LNGC at anchor. Single minor injury. Minor damage to vessels; Negligible environmental impact; Bad local publicity.	Propulsion control failure leading to heavy contact with LNGC at anchor by Dolphin Watch Vessel. Multiple minor or single major injury; Moderate damage to Dolphin Watch Vessel; Negligible environmental impact; Bad widespread local media coverage.	2	2	1	2	1.5	4	3	1	3	1.0	2.35
43	Contact	Contact - Small Commercial / Port Services Vessels with LNGC at anchor	A Small Commercial / Port Services Vessel contacts LNGC at anchor	Mechanical defect / failure. Tug error. Adverse weather conditions. Inexperience of tug masters.	Tug makes light contact with anchored LNGC. Single minor injury. Negligible damage to vessel; Negligible environmental impact; Negligible publicity.	Tug makes heavy contact with anchored LNGC. Moderate damage to LNGC. Multiple minor or a single major injury; No gas release, negligible environmental impact; Bad local publicity.	2	1	1	1	1.0	3	3	1	2	1.0	1.63
44	Contact	Contact - Recreational Vessels with LNGC at anchor	Recreational Vessel contacts LNGC at anchor.	Mechanical defect / failure, Skipper error and / or adverse weather conditions causes recreational vessel to get too close to LNGC at anchor. Visiting yachtsman with poor local knowledge.	Recreational vessel bounces offLNGC at anchor and sustains superficial damage. Single minor injury, negligible damage, negligible environmental impact, negligible publicity.	Recreational vessel makes heavy contact with LNGC at anshor in adverse weather / tidal conditions, vessel sinks. Multiple minor injuries or a single major injury; Minor damage; Negligible environmental impact; Temporary suspension of activities; Minor commercial impact.	2	1	1	1	2.5	3	2	1	2	1.5	1.85
45	Grounding	Grounding - Tanker	A Tanker runs aground	Tanker grounds while transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal. As a result of mechanical defect / failure, master / pilot error or adverse weather or reduced visibility or as a result of avoiding action with LNGC.	Vessel touches the bottom and refloats. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Vessel heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier3 spill criteria reached; Adverse international publicity. Temporary suspension of operations, prolonged restrictions and loss of revenue.	2	2	1	2	1.5	3	3	4	5	1.0	2.93

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							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
46	Grounding	Grounding - Project Vessel	A Project Vessel runs aground	LNGC grounds while transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal or on route to anchor. As a result of mechanical defect / failure, master / pilot error or adverse weather or reduced visibility or as a result of avoiding action with 3rd party vessel.	Vessel touches the bottom and refloats. Very minor injury; Minor damage to property; Negligible environmental impact. Moderate bad publicity.	Vessel heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier 2 spill criteria reached but capable of being limited to immediate area within site; Adverse international publicity. Temporary suspension of operations, prolonged restrictions and loss of revenue.	2	2	1	2	1.5	3	3	3	5	1.0	2.85
47	Grounding	Grounding - Large Commercial & Dry Cargo Vessels	A Large Commercial Vessel runs aground	Large Commercial grounds while transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal. As a result of mechanical defect / failure, master / pilot error or adverse weather or reduced visibility or as a result of avoiding action with LNGC.	Vessel touches the bottom and refloats. Very minor injury; Minor damage to property; No effect of note. Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue.	Vessel (cruise ship) heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier 2 spill criteria reached but capable of being limited to immediate area within site; Adverse international publicity. Temporary suspension of operations, prolonged restrictions and loss of revenue.	2	2	1	2	1.5	4	3	3	5	1.0	2.93
48	Grounding	Grounding - Small Passenger Vessels	A Small Passenger Vessel runs aground	Result of small passenger vessel taking avoiding action with approaching LNGC in narrows. Mechanical defect / failure or master / pilot error or adverse weather or reduced visibility.	Dolphin watch vessel touches the bottom and refloats. Single minor injury; Very minor damage to property; Negligible environmental impact; Minor Local publicity.	Dolphin watch vessel heavily aground requiring commercial salvage. Multiple minor injuries or single major; Moderate damage / vessel lost; Tier 1 - small operational oil spill; National publicity.	2	1	1	2	2.0	3	3	2	4	2.0	2.76
49	Grounding	Grounding - Small Commercial / Port Services Vessel	A Small Commercial / Port Services Vessel runs aground	Project tug / workboat / pilot launch transiting in the vicinity of the Beal Bar, the Doonaha Shoal or the Carrig Shoal suffers a mechanical defect / failure and drifts into shallows. Master error, adverse weather, reduced visibility or as a result of avoiding action with a 3rd party vessel.	Vessel touches the bottom and refloats. Very minor injury; Minor damage to vessel; Negligible environmental impact. Moderate bad publicity.	Vessel heavily aground. Multiple minor or single major injury; Moderate damage to property; Tier 1 - small operational oil spil; Bad widespread local publicity. Temporary suspension of operations, short term loss of revenue.	1	2	1	3	2.0	3	3	2	3	1.0	2.56
50	Grounding	Grounding - Recreational Vessel	A Recreational Vessel runs aground.	Recreational vessel grounds on Beal Bar or the Doonaha Shoal as a result of avoiding action with 3rd party vessel / LNGC on entry or departure through narrows. Mechanical defect / failure, skipper error, adverse weather or reduced visibility.	Vessel touches the bottom and refloats. Minor injury; Very minor damage to property; Negligible environmental impact; Negligible publicity, no loss of revenue.	Vessel heavily aground. Multiple minor or a single major injury; Minor damage to property; Small oil spill with little effect on environment; Widespread local publicity.	2	1	1	1	3.0	3	2	2	3	2.5	2.49

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
51	Foundering / Swamping	Foundering / Swamping - Project Vessel	Project Vessel Founders.	Mechanical defect / failure, human error, malicious intent.	Vessel takes on water but source of water ingress is detected in time to avoid sinking. Single minor injury; minor damage to property; Tier 1 may be declared but criteria not necessarily met; Very short-term disruption to services with ensuing loss of revenue, widespread local publicity.	Vessel sinks at berth or at anchor. Multiple minor injuries or single major; Major damage to vessel; Tier 2 may be declared but criteria not necessarily met; Interantional publicity and operations and revenue seriously disupted.	2	2	1	3	2.0	3	4	2	5	1.0	3.44
52	Mooring Incident	Mooring Incident / Breakout - Project Vessel	Project Vessel Mooring Incident / Breakout	Failure of ship's mooring gear. Failure of jetty / FSRU fixed mooring gear or anchor cable parts. Inadequate seamanship / watch keeping. Extreme weather. Excessive tidal stream. Vandalism.	A single mooring line parts. Very minor injury; Minor damage to property; Negligible environmental impact; Bad local publicity, short-term disruption to services.	All mooring lines part and vessel breaks away from the berth or anchor cable parts and drifts in the estuary. Multiple minor or single major injury; Moderate damage to property; Minor impact on environment. National publicity, temporary suspension of operations, prolonged estuary restrictions / stakeholder delays.	1	2	1	2	2.0	3	3	2	4	1.5	2.58
53	Mooring Incident	Mooring Incident / Breakout - Small Commercial / Port Services Vessels	A Small Commercial Vessel / Port Services Vessel is ranged or breaks away from its mooring.	Failure of project tug / workboat's mooring gear. Failure of fixed mooring gear. Extreme weather. Excessive wash or draw-off. Water surge caused by large vessel. Vandalism.	A mooring line parts. Very minor injury; Very minor damage to property; Negligible environmental impact; Very short-term disruption to services.	All mooring lines part and vessel breaks away from the berth / jetty and drifts in the estuary/ runs aground. Multiple minor or single major injury; Moderate damage to property; Negligible impact on environment. Widespread local publicity; temporary suspension of operations.	1	1	1	1	2.0	3	3	1	3	1.5	1.38
54	Tug Girting	Tug Girting / Towing Incident	A Tug Girts while Project Vessel under tow	Mechanical defect / failure in the tug or the project vessel being assisted. Master / Pilot / Skipper error (tug or vessel being assisted). Adverse weather, Inappropriate tugs utilised.	Tug overrun during towage operation. Single minor injury; Minor damage to property; Negligible environmental damage; Bad local publicity.	Tug girts. Multiple major injuries or single fatality; Major damage to vessel / vessel lost; No effect of note. Minor pollution; Adverse national publicity; Temporary suspension of operations.	2	2	1	2	3.0	4	4	3	4	2.0	3.40
55	Cable Snagging	Cable Snagged - Project Vessel	Cable Snagged by Project Vessel Anchor	Project vessel is disabled and drifts upstream on the tide, crew deploy anchor and snag underwater cables across the estuary. Mechanical defect / failure, breakout / mooring Incident, master / pilot error or adverse weather.	Anchor hooks cable causing: Negligible injury; Negligible damage to vessel; Negligible environmental impact. Bad widespread publicity and possible suspension of operations and interruptions to stakeholder supplies.	Anchor snags cable. Multiple minor or a single major injury; Moderate damage to vessel; Negligible environmental impact; Major national publicity. Medium-term suspension of operations or prolonged restrictions, major disruption to commercial activities.	1	1	1	3	2.0	3	3	1	4	1.0	2.72

ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence					Worst Credible Consequence					Risk Score
							People	Property	Environment	Business	Frequency	People	Property	Environment	Business	Frequency	
56	Fire / Explosion	Fire /Explosion - Project Vessel	Fire breaks out on berthed FSRU or LNG Supply Vessel.	Mechanical Defect / Failure. Crew error. Deliberate act.	Small fire, quickly under control. Single minor injury; Minor damage to property; Negligible impact on the environment; Minor disruption to operations; Bad widespread publicity.	Large persistent vessel fire while undertaking discharge operations. Fatalities; Major injuries or fatality; damage to vessel(s); Gas release; Tier 3 support required; Operations and revenue seriously disrupted; temporary closure, national media coverage.	2	2	1	3	2.0	4	4	4	4	1.0	3.36

CHAPTER 14
Major Accidents and Disasters

Shannon LNG Limited
August 2021

Shannon Technology and Energy Park
Environmental Impact Assessment Report

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14. Major Accidents and Disasters

14.1 Introduction

This chapter describes the potential Major Accidents and Disaster (MA&D) scenarios which are pertinent to the Proposed Development, taking into consideration the materials, operations and location of the Proposed Development and associated facilities.

This chapter contains an overview of the regulatory requirements to identify and assess major accidents and disasters. The methodology for identification of such is initially by consideration of the substances which will be present onsite, and which have the potential for major accident, by virtue of their chemical or physical properties. Substances which have the potential to initiate and/ or contribute to a major accident will be identified within this chapter for qualitative assessment.

The potential for natural disasters such as flooding and seismic events is primarily determined by the location of the facilities.

14.2 Competent Expert

This assessment has been undertaken by Alison Couley, Associate Director Process Safety, BEng (Hons) Chemical Engineering with Energy Resource Engineering. Alison has over 25 years' experience in Process Engineering and Process Safety Consultancy and is a Chartered Chemical Engineer (CEng) and Member of the Institution of Chemical Engineers (MIChemE).

Alison has worked on the process engineering design and operation of facilities within the chemicals, power, upstream and downstream oil and gas processing industries. Since 1999, Alison has worked as a Process Safety consultant and has been responsible for facilitating numerous hazard identification and risk assessment studies for clients including Upper Tier COMAH Installations, which require detailed assessment of safety and environmental hazards. This experience and knowledge is directly applicable to the identification of MA&Ds within this EIAR.

14.3 Regulatory Overview

An EIAR is defined in the EIA Regulations (Government of Ireland, 2018) as:

'*A statement of the effects, if any, which proposed development, if carried out, would have on the environment*'.

Specifically:

'*The significant effects to be identified, described and assessed include, where relevant, the expected significant effects arising from the vulnerability of the proposed development to major accidents or disasters that are relevant to that development*'.

'*A description of the expected significant adverse effects of the development on the environment deriving from the vulnerability of the development to risks of major accidents and/ or disasters, which are relevant to the project concerned'.*

An assessment of the risk of MA&D relevant to the Proposed Development is therefore required to inform decision making on the project, to ensure a high level of protection is incorporated in the design of the project and that appropriate emergency policies and procedures are prepared for the Proposed Development.

This assessment is a preliminary review, based on the current engineering design, drawings and documentation.

Further detailed hazard and risk analysis studies will be carried out throughout the project lifecycle. The engineering design of the project will be subject to formal process safety risk assessments, such as Hazard Identification (HAZID), Hazard and Operability (HAZOP) and Layers of Protection Analysis (LOPA) at the appropriate project/ design stage(s). The purpose of these studies is to subject the design to a rigorous, structured assessment by suitably qualified, experienced people, to identify potential hazards. These hazards can then be subject to analysis to identify measures to manage the hazards and to reduce the level of risk.

14.4 Overview of Proposed Development

A detailed description of the Proposed Development is contained in Chapter 02 of the EIAR and the following section lists the key features.

The facilities associated with the Shannon Technology and Energy Park include the Liquefied Natural Gas (LNG) Terminal and the Power Plant, which are summarised as follows:

- The proposed LNG Terminal will consist of:
  - A floating storage and regasification unit (FSRU), which will have an LNG storage capacity of approximately 170,000 m^3 (up to 180,000 m^3). The LNG vaporisation process equipment to regasify the LNG to natural gas shall be onboard the FSRU. The heat for LNG regasification shall be via seawater, supplemented by heat from gas fired heaters when the water temperature is inadequate. Loading of LNG onto the FSRU shall be via a ship to ship transfer from another LNG carrier (LNGC) berthed alongside.
  - Jetty and access trestle, with the jetty comprising of an unloading platform, mooring dolphins and breasting dolphins.
  - Infrastructure to accommodate four tugs moored on the proposed jetty for FSRU and LNGC mooring operations.
  - Onshore facilities including a nitrogen generation facility, a control room, a guard house, workshop and maintenance buildings, instrument air generator and fire water system.
  - An Above Ground Installation (AGI) to include an odourisation facility, gas heater building, gas metering and pressure control equipment. The AGI facilitates the connection of the LNG Terminal to the consented 26 km Shannon Pipeline.
  - It is standard practice for safety reasons to add an odorant to natural gas, as this substance has little or no smell. The gas will therefore be odorised so that any natural gas leaks are detectable by human beings. The odorisation tanks, associated pipework, and control systems will be provided to inject carefully controlled amounts of odorant into the natural gas at a rate to ensure compliance with GNI and statutory requirements (typically 6 milligrams of odorant per cubic metre of gas). The odorant storage and injection system will include bulk storage tanks containing Odourant NB liquid, which will be held under a nitrogen gas blanket.
- The proposed Power Plant will comprise of:
  - A flexible modular Power Plant design with three (3) blocks of Combined Cycle Gas Turbines (CCGT), each block with a capacity of approximately 200 MW for a total installed capacity of up to 600 MW. The multishaft arrangement of the Power Plant provides fast acting response with very low minimum stable generation and is ideally suited to support increased intermittent renewable generation.
  - Each block will comprise of two (2) gas turbine generators, two (2) heat recovery steam generator and one (1) steam turbine generator and an air-cooled condenser.
  - A 120 MW for 1 hour (120 MWhr) Battery energy storage facility (BESS). Due to its very fast response, the BESS supports intermittent renewable generation.

Figure 14-1 shows the layout of the onshore facilities.

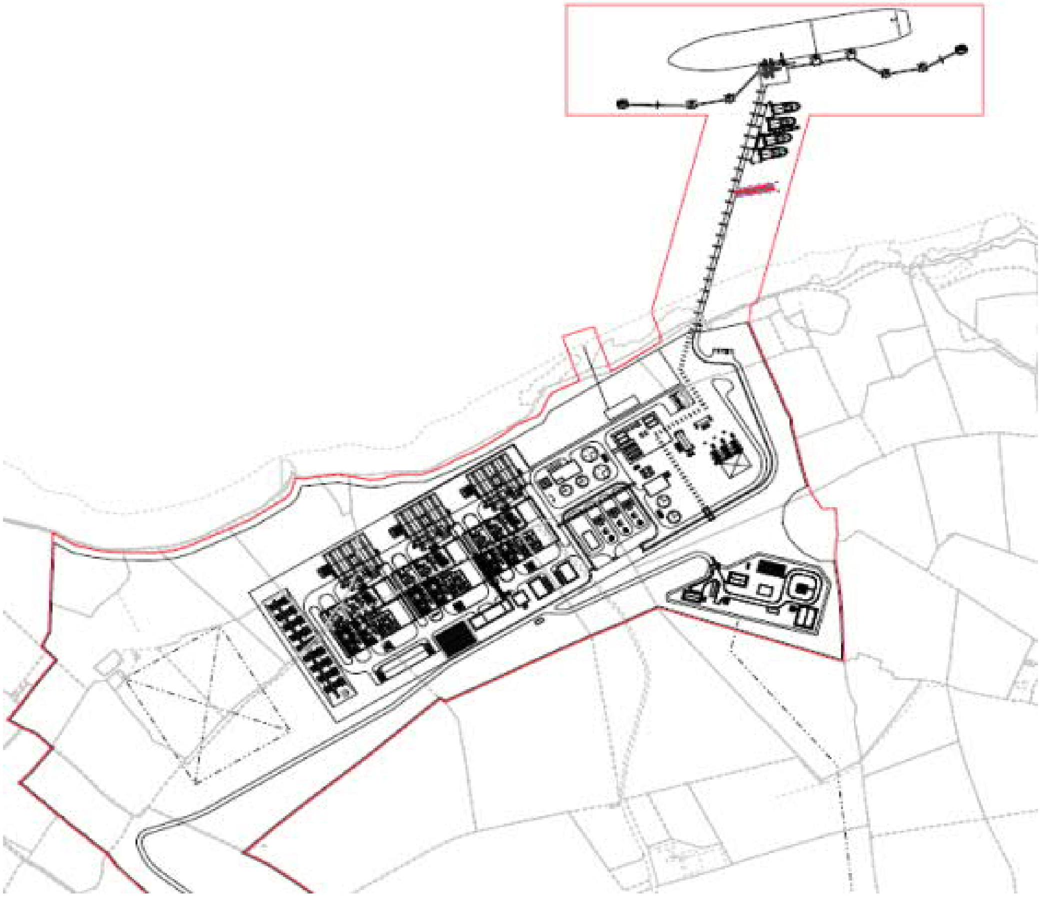

Figure 14-1 Onshore Facilities Layout

Bulk storage of LNG is within the FSRU and LNGC, there is no bulk storage of LNG or natural gas onshore. The FSRU is connected to the jetty via hydraulically operated unloading arms and a team of trained and experienced personnel will operate the facilities. Personnel will be based both onshore and on the FSRU.

The FSRU will be moored at the jetty head, which comprises a concrete unloading platform with mooring dolphins. An access trestle connects the jetty head to the onshore facilities.

The planning application boundary of the Proposed Development is shown by the red line in Figure 14-1. The quantity of LNG and natural gas present within this boundary has been assessed to be above the Upper Tier qualifying threshold at which regulation under the Chemicals Act (Control of Major Accident Hazards (COMAH) involving Dangerous Substances) Regulations 2015, S.I. 209, will apply. Compliance with the COMAH Regulations places a number of duties on the operators of installations. These include the preparation and submission of a detailed COMAH Safety Report.

Consultation with the HSA has been ongoing throughout the design development of the Proposed Development. COMAH notifications and documentation will be submitted for regulatory review at the appropriate juncture.

The COMAH Safety Report will include a detailed description of the technical standards used in the design of process, mechanical, electrical and civil engineering equipment and structures. These include International and European standards such as:

- EN 1473: Installation and equipment for liquefied natural gas - Design of onshore installations.

This European Standard gives guidelines for the design, construction and operation of all onshore liquefied natural gas (LNG) installations for the liquefaction, storage, vaporization, transfer and handling of LNG.

- BS EN ISO 28460: Petroleum and natural gas industries. Installation and equipment for liquefied natural gas. Ship-to-shore interface and port operations.
- The National Fire Protection Association (NFPA) suite of Recommended Practise (RP) documents, specifically NFPA 850: RP for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations.
- ISGOTT; International Safety Guide for Tankers and Terminals.
- Lloyds Register: Rules for the Classification of Ships for the Carriage of Liquefied Gases in Bulk; and
- Institution of Gas Engineers and Managers suite of standards, including IGEM/ SR/ 16 Edition 2 - Odorant systems for gas transmission and distribution.

14.4.1 Site Location

The Proposed Development is located on a site adjacent to the Shannon Estuary, between Tarbert and Ballylongford in Co. Kerry. The Proposed Development site is zoned as industrial by Kerry Co. Council (Kerry County Development Plan 2015 – 2021) and is owned by Shannon Commercial Enterprises DAC (formerly Shannon Free Airport Development Company Limited) having its registered address at Shannon Airport, Co. Clare. Shannon LNG has entered into an agreement for the purchase of the lands.

The Proposed Development site is located approximately 4.5 km from Tarbert and 3.5 km from Ballylongford in Co. Kerry. This area is characterised by predominantly improved grassland in an agricultural setting. Field boundaries predominantly consist of hedgerows with small drainage ditches. A small section of the Ralappane Stream which runs in a north westerly direction, discharging into the Shannon Estuary, is located in the most southern part of the site. The L1010 (Coast Road) is located to the south of the Proposed Development site.

There are a small number of residential properties located within 500 m of the onshore facilities and additional residential properties located along the L1010.

The nearest COMAH Establishments to the Proposed Development site are as follows:

- Tarbert Power Station which is an Upper Tier COMAH installation located approximately 5 km to the north east of the site,
- Moneypoint Power Generating Station which is an Upper Tier COMAH installation located on the northern shore of the Shannon Estuary, approximately 3 km to the north of the site.
- Shannon Airport Authority, fuel storage facility is an Upper Tier COMAH Installation, located approximately 60 km to the northeast.
- A Lower Tier COMAH Installation, Enva Ireland Ltd is also located approximately 60 km to the northeast, at Smithstown Industrial Estate near Shannon Airport.

Tarbert and Moneypoint power plants are scheduled to be decommissioned within the next 5 years. There are no other Upper Tier COMAH sites or significant industrial establishments within the area of the Proposed Development, therefore no potential domino effects have been identified. A domino effect is defined in the COMAH Regulations is an accident which occurs at a facility which can be the source of a major accident or increase the risk or consequences of a major accident at the Proposed Development.

There is no local Fire station within the environs of the Proposed Development. A firewater system will be installed within the Proposed Development including fire water storage and fire pumps. Additional mobilisable resources such as fire tenders will be considered along with provision of specialist training to site personnel.

There are a number of designated environmental sites in the area of the Proposed Development, including the Lower River Shannon Candidate Special Area of Conservation (cSAC) which is adjacent to the Proposed Development site, along the northern/ north-western boundary and also along part of the eastern boundary. The Ballylongford Bay proposed Natural Heritage Area (pNHA) is adjacent to a part of the north-western boundary of the Proposed Development site. The Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries Special Protection Area (SPA) extend along the north-western shoreline boundary of the Proposed Development site. These sites are identified within Figures F7-1 and F7-2 in Volume 3.

The proposed jetty extends into the Lower River Shannon cSAC and the River Shannon and River Fergus Estuaries SPA.

The Proposed Development is not located within a groundwater drinking water source protection area. A search of the Geological Survey of Ireland well records found no springs and a relatively small number of low-yielding groundwater abstraction wells recorded between 1 and 2 km from the Proposed Development site. These groundwater abstractions are likely to be wells serving single houses or farms and all are hydraulically up gradient of the Proposed Development site and therefore are unlikely to be impacted by the Proposed Development.

A number of surveys and test trench excavations have been carried out to inform previous planning applications on lands owned by Shannon Commercial Enterprises DAC which includes the Proposed Development site. The surveys and test trenches were carried out to assess the presence of areas of archaeological potential. A ringfort (fortified settlement dating approximately to the Bronze Age) has been identified. These sites are constructed from earth and stone, and largely buried, therefore they are not considered to be vulnerable to the potential major accidents and disasters pertinent to this Proposed Development.

The Proposed Development will source local materials such as rock and stone for use during construction, with materials such as concrete and tarmac also being used. Lime and concrete (specifically, the cement component) is highly alkaline and any spillage which migrates through subsoil could impact groundwater quality, therefore a Construction Environmental Management Plan (CEMP) will be produced for the construction stage (See Outline Construction Environmental Management Plan (OCEMP) in Appendix A2-4 of Volume 4) and will incorporate measures for safety and environmental protection during the construction of buildings, pipelines and concrete structures such as pavements and culverts.

The jetty platform has been set at an elevation of +9 m Ordinance Datum (above sea level), to be clear of extreme water levels and waves and will be aligned in the direction of the prevailing wind and tidal stream. Detailed monitoring and modelling has been carried out in a Coastal Modelling Report to assess the current speeds, water levels and wave conditions at the jetty location (Moffat & Nichol, 2020).

The onshore operational equipment will be enclosed within a security fence provided with pedestrian and vehicular access. The AGI compound will be remotely operated and normally no personnel will be present in this area.

The drainage system has been designed so that all stormwater will be collected and discharged, where possible, to existing streams/ drainage ditches, or discharge directly to the Shannon Estuary via a discharge pipe that will extend across the foreshore to below the low water mark. All drainage falling on paved surfaces will pass through A Class 1 hydrocarbon interceptor which will be installed upstream of the discharge to the Shannon Estuary. This interceptor will collect any accidental spills of fuels or oils used in vehicles or ancillary equipment.

Spill kits will be located at strategic points around the Proposed Development. If used, these will be disposed of via a licenced waste disposal contractor and in accordance with all relevant EU and Irish waste management legislation (i.e. the Waste Management Acts 1996 – 2011 and any regulations made thereunder, and the Waste Framework Directive).

The EPA Guidance Note ‘Storage and Transfer of Materials for Scheduled Activities’ shall be taken into account when designing material storage and containment onsite.

14.5 Methodology

14.5.1 Potential Hazards

The potential hazards associated with substances present at the Proposed Installation which are described in Table 14-1 and have the potential for a major accident are summarised in the following section. All the identified hazards listed below require a loss of containment to occur, such as catastrophic damage or failure of pipework or equipment.

- Fire:
  - Flash Fire: A flash fire can occur following a loss of containment of flammable liquid, vapour or gas which results in a flame which passes through the mixture at less than sonic velocity such that explosion overpressures are negligible. A flash fire may be caused by releases at high or low pressure into an open, unconfined area which contacts an active source of ignition.
  - Jet Fire: A jet fire can occur following a loss of containment of high pressure gas, liquid or vapour released via a source such as a leak or failure of flanged pipework joints, pipework or another asset which contacts an active source of ignition.
  - Pool Fire: A pool fire involves the combustion of vapour from a pool of flammable liquid. It may occur within a clearly defined boundary or be unconfined. Flames generated by a pool fire are often accompanied by quantities of smoke with both flames and smoke orientated downwind.
- Explosion:
  - Vapour Cloud Explosion (VCE): A loss of containment of flammable gas or vapour which does not ignite immediately may form a cloud of flammable material depending on the conditions of the release. If this cloud enters an area of confinement and contacts an active source of ignition, a VCE can result and generate potentially harmful overpressures.

    Overpressures generated by explosions are related to the degree of confinement or congestion in the area in which the material is released. For example, in complex industrial structures with a lot of pipework and equipment in close proximity, the pressures generated are much larger than in open areas, due to the effect of these structures accelerating and/ or reflecting the pressure wave.
  - Boiling Liquid Expanding Vapour Explosion (BLEVE): A BLEVE can occur if a storage vessel containing a flammable liquid held under pressure is heated to a temperature above its boiling point, for example, by exposure to a fire, which eventually causes the vessel to rupture. Material released from the vessel will likely ignite, resulting in a fire and potentially harmful overpressures.
  - Rapid Phase Transition (RPT): This can occur following a loss of containment of LNG which rapidly vaporises on contact with the ground or water, releasing large amounts of energy causing potentially harmful overpressures.
- Major Accident to the Environment:
  - A loss of containment of liquids such as fuel oils which are accidentally released to water, land and/ or groundwater in significant quantities can cause harm to the environment.

Quantitative Risk Assessment (QRA) including consequence modelling carried out for the Proposed Development has analysed these hazards in greater detail. The results of this modelling have demonstrated that flash and jet fires are credible scenarios for accidental releases of LNG and natural gas, however explosion overpressures were determined to be negligible, as potential release points are in open, well ventilated areas.

A release of diesel has the potential for a pool fire if a loss of containment were to occur. The only material with the potential for a BLEVE is the odourising chemical, injected into natural gas for safety reasons.

Substances which if accidentally released have the potential to harm to the environment include diesel, marine fuel oils, black and grey water effluent generated onboard the FSRU and LNGC. Fire water which may or may not contain foam along with products of combustion may also have the potential to cause harm to the environment in the event of a loss of containment from the dedicated retention area following a fire.

A detailed description of the properties of these substances and an assessment of their potential hazards is contained in Section 14.7.

14.5.2 Definitions

For this purposes of this assessment, the definition of a MA&D is taken to be that which is contained within Article 3 of the Seveso Directive as enacted in Irish law by Regulations (Government of Ireland, 2015), which is as follows:

'*A 'major accident' means an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by this Directive and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances.*'

The impact of major accidents can be significant, with the potential to effect people both on and offsite, assets and property on and offsite, and the surrounding environment.

Disasters can be naturally occurring events, such as earthquakes, landslides and flooding or can be caused by humans, such as fires and explosions.

Both natural and human causes are considered in this assessment to determine the potential impact on:

1. Population and human health, including persons employed at the Proposed Development and in the local community.
2. Biodiversity, with particular attention to species and habitats protected under Directive 92/ 43/ EEC for the protection of habitats/ flora/ fauna (EU, 1992) and Directive 2009/ 147/ EC for the protection of birds (EU, 1992).
3. Land, soil, water and groundwater, air and climate; and
4. Material assets, cultural heritage and the landscape.

14.6 Assessment Methodology

The substances associated with the Proposed Development, which are potentially dangerous and could therefore be a credible source of Major Accident Hazard (MAH) during the lifecycle of the development, are described in Table 14-1.

Substances are generally classified in accordance with the Classification, Labelling and Packaging (CLP) Regulations (EC, 2008). This is a harmonized system of identifying the hazardous properties of materials, for example those which are flammable, toxic and harmful to the environment. Where substances are not classified by CLP, for example, wastes, the general characteristics are considered in order to determine the potential for a Major Accident Hazzard (MAH).

This assessment considers the potential interactions of substances present on the FSRU and onshore areas of the Proposed Development, which could potentially create harmful materials or the release of energy.

Where substances are identified as being dangerous by their properties, the means by which they could result in harm is then considered. Where there is the potential for a MAH, this is identified for further assessment, which is contained in Table 14-2.

Where a major fire and/ or explosion could cause harm both on and offsite, this would be considered as a MAH. This aligns with the criteria for the notifiable incident referred to in Regulation 20 the COMAH Regulations, which is a fire involving a dangerous substance that may result in suspension of normal work in the establishment for more than 24 hours (Government of Ireland, 2015).

If a release of a dangerous substance resulted in significant damage to the environment or property, this would be considered an MAH. The Guideline on Environmental Risk Tolerability for COMAH Establishments (CDOIF, V2 March 2016) contains information on the severity of harm at sensitive receptors resulting from accidents which might be considered to be a Major Accident to the Environment (MATTE). This guidance has been taken into consideration in the review of releases within Table 14-1.

As the Proposed Development will be required to notify as a COMAH site, the principals of the COMAH Regulations have been used to identify and assess scenarios which could result in a MAH or MATTE. These principals present a clear and robust methodology for facilities where substances such as natural gas are present.

The vulnerability of the Proposed Development to natural disasters such as flooding, earthquakes and the impact of climate change is substantially dependant on location. These factors are considered/ assessed in Table 14-3.

Table 14-1 Dangerous Substances and Major Accident Hazard (MAH) Screening Assessment

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
LNG	LNG (hydrocarbon mixture predominantly methane) stored within FSRU and LNGC moored at jetty.	Extremely flammable gas (Hazard Code H220). Liquefied gas (Hazard Code H281). An accidental release of LNG from the FSRU/ LNGC could result in a fire if ignited.	A release of LNG from the FSRU could ignite and result in a fire potentially causing harm to people onboard the FSRU, LNGC and at the jetty. The potential for an explosion following a release of LNG has been assessed using QRA modelling and the overpressures generated were determined to be negligible due to the low degree of confinement. There is the potential to cause harm to the environment in the event of a major fire, for example - via damage to the FSRU and LNGC resulting in a release of fuel or other fluids stored onboard, - a release of firewater which could contain foam and other substances used for fire suppression along with products of combustion, and - thermal radiation causing harm to flora/ fauna. A fire scenario could therefore be a MAH/ MATTE and is considered further in Table 14-2.	Y

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
Sodium Hypochlorite (Generated by treatment of abstracted seawater)	Seawater used to regasify LNG will be subject to treatment onboard the FSRU to prevent biological fouling of the vaporising equipment. Without treatment, these systems would frequently become blocked and inoperable. An electrolysis system will be installed on the FSRU to protect the regasification system. These units are used extensively in industrial applications onboard vessels and in the offshore industry. Using this system prevents bulk storage of liquid-based chemicals being required for this purpose onboard the FSRU.	Within these systems, an electric current is passed through a tank of seawater which generates a small amount of sodium hypochlorite which is then dosed into water used for regasification. Seawater discharged from the regasification system will be monitored to ensure the concentration of sodium hypochlorite does not exceed permitted limits. Released material will be rapidly dispersed in the estuary.	Hypochlorite generation is a proven, reliable technology which produce small quantities of sodium hypochlorite. In the event of an accidental release to the estuary, the quantities which could be generated onboard the FSRU will be insufficient to cause harm to the environment due to rapid dilution and dispersion, therefore would not result in a potential MAH/ MATTE.	N
Natural Gas	Gaseous hydrocarbon mixture, predominantly methane. Natural gas is present downstream of regasification unit onboard the FSRU to the distribution pipeline and to the Power Plant. Natural gas may also be present on the LNGC in the event that LNG is released for safety purposes such as emergency venting. In the event of emergency depressurisation being required, the gas would be vented at a safe location where it would be dispersed by natural ventilation.	Extremely flammable gas (Hazard Code H220). An accidental release of natural gas from FSRU, LNGC or onshore systems, such as pipework connections, could result in a fire if ignited. The potential hazards of new gas pipework onshore are identical to the current pipeline infrastructure of GNIs gas transmission network for the movement of natural gas fuel around Ireland.	Onshore gas pipework above ground is located in an open, well ventilated area. An accidental release of natural gas could ignite and result in a jet or flash fire potentially causing harm to people in the immediate area. The potential for an explosion following a release of natural gas has been assessed using QRA modelling and the overpressures generated were determined to be negligible due to the low degree of confinement. Firewater may be applied to cool equipment and prevent the escalation of a fire to other areas. Firewater will be contained within a firewater impoundment basin, however there is the potential for harm to the environment from the fire, as a direct result of thermal radiation or soot deposition on flora and fauna. Consequently, this scenario could be a MAH/ MATTE and is therefore considered further in Table 14-2.	Y

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
Odorant NB	Natural gas/ methane do not have an odour. Consequently, as a safety precaution, so as to identify leaks primarily in consumer appliances and piping, an Odorant NB is added to the natural gas before distribution. This is a requirement of the grid operator. Odorant NB is a mixture of tertiary butyl mercaptan (78-82%) and dimethyl sulphide (18-22%)[1]. Odorant NB is a liquid and is stored onshore within two bulk tanks, each of 22.7 m^3 capacity. The liquid is stored under a nitrogen gas blanket at a pressure of 2 barg.	Highly flammable liquid (Hazard Code H225). Toxic to the aquatic environment (Category 2) (Hazard Code H411). Also, classified as an irritant (H319) and Skin Sensitizer (H317). An accidental release of odorant from onshore storage systems could result in a fire and/ or explosion (BLEVE) if vapour released following failure of the vessel was in contact with a source of ignition. For the failure of a vessel to occur leading to a BLEVE, heat input via direct jet fire impingement or a liquid pool fire below the storage tank p be required. An accidental release of this liquid which enters the environment, has the potential for harm to aquatic systems.	Gas chromatography systems will be installed to continuously analyse the composition of natural gas, ensuring that the concentration of odorant is at the appropriate set point. Alarms will be installed to provide a warning should the concentration deviate from this. The equipment used to inject odorant into the gas stream would be controlled and monitored by instrumentation and end elements which have been subject to Safety Integrity Levels (SIL) assessment to determine the required reliability. This material purposefully has a very low odour threshold (i.e. is very odorous) therefore there is the potential to cause a nuisance or distress to local residents in the event of minor accidental leaks, who may believe this to be odorized natural gas. Odourant is classified as flammable and harmful to the environment, therefore a scenario in which this is released accidentally could potentially be a MAH and/ or MATTE and is therefore considered further in Table 14-2.	Y

[1] 50102216-TN03: Assessment of Odorant Facility Lloyds Register April 2013

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
Diesel Fuel	Liquid hydrocarbon mixture, predominantly kerosene. Diesel will not be used as a source of secondary fuel in the Power Plant, therefore small quantities only will be present in the following equipment installed at the Proposed Development. The typical quantities of diesel will be as follows: • Blackstart generator: 3.2 m^3 tank. • Emergency power generator (backup Power Plant in case of electricity loss): 3.2 m^3 tank. • LNG firefighting standalone fire water pumps: 2 m^3 tank. • Power Plant firefighting standalone fire water pumps 1.4 m^3 tank. During construction, there may be small quantities of diesel present in temporary equipment such as mobile cranes and mobile power generators.	Flammable liquid and vapour (Hazard Code H226). Toxic to the aquatic environment (Category 2) (Hazard Code H411). Toxic if inhaled (H332) and Skin Sensitizer (H315). An accidental release of diesel could result in a pool fire. If diesel enters the environment, there is the potential for harm.	Bulk diesel will be stored in fully bunded tanks (110% containment) either offered by an integral bund (i.e. double skin) or exterior containment (i.e. civil bund infrastructure). In the event of an accidental leak or spillage of diesel, material will be retained onsite within bunds and containment systems (i.e. fuel interceptors), preventing material from being released to the environment. In the event of a fire within areas where diesel is present, the material would be combustible. Un-combusted material present in firewater runoff will be contained within site drainage systems, which are fitted with interceptor(s) to facilitate the recovery of oils. Taking into consideration the above factors and the relatively limited quantities of diesel onsite, this substance is not considered to have the potential to be a MAH and/ or MATTE.	N

Marine Fuel Oil (MFO)	The type of fuel which will be used in the FSRU and LNGC has not yet been confirmed, however this is likely to be MFO. Other fuels are available such as Heavy Fuel Oil (HFO) and LNG to power ships' systems. MFO is a liquid hydrocarbon mixture, predominantly kerosene. MFO is stored onboard the FSRU and LNGC in fuel tanks, typical quantities present could be approximately 600 tonnes.	Hazardous properties of MFO are similar to diesel. An accidental release of MFO could result in a pool fire and if this liquid enters the environment, there is the potential for harm to aquatic systems.	Preventing oil spills from the FSRU and LNGC is the responsibility of the ship's crew. In the event of accidental spills or leaks, there is a significant quantity of MFO which could be released to the estuary, there is therefore the potential for a MAH. The FSRU and LNGC will comply with the International Maritime Organization (IMO) convention for the prevention of pollution (MARPOL, 1973), Annex I which entered into force in 1983. This annex covers requirements for management of oil onboard including monitoring and control systems and the production of a Shipboard Oil Pollution Emergency Plan (SOPEP). An emergency spill response plan(s) will also be developed by the Harbour management organisation in consultation with managers of the Proposed Development, including maintenance of a stock of emergency equipment such as absorbent booms. Oil Spill Response Plans (OSRP) for the FSRU and LNGC will be developed and will comply with the National Contingency Plan for Oil and HNS Spills 2019. The FSRU and LNGC will contain other substances, such as grey water, which could be slightly contaminated with oils/ MFO. This could be potentially harmful to the environment, however the concentration of pollutants such as oils in grey water will be low. Consequently, a release of pure MFO from the FSRU or LNGC, through loss of primary containment represents a 'worst case' potential MAH/ MATTE scenario and is therefore considered further in Table 14-2.	Y

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
Black Water / Grey Water/ Ballast Water	Black, Grey and Ballast water can contain pollutants such as biological matter and are stored onboard FSRU and LNGC within dedicated tanks.	Black water consists of material from toilet facilities. Grey water is effluent generated by hand washing and showers. An accidental release of grey water, which enters the environment, could result in harm to aquatic systems. Ballast is the fluid used onboard the FSRU and LNGC to provide stability. Ballast water discharge may contain biological materials which if released, may be harmful to the environment.	Releases of ballast, grey and black water are controlled via the regulations established in Annex IV of the MARPOL convention which entered into force on 27th September 2003. MARPOL specified equipment requirements include the provision of a sewage treatment plant or disinfection systems, compliant with standards and test methods established by the IMO. Locations where the vessel can safely discharge the treated material are specified in Annex IV. Whenever the ships are in port, all black and grey water will be retained onboard and discharged ashore via vacuum lorry for safe treatment and disposal. Seawater will be taken in through seawater intakes as ballast water on the FSRU during regasifying operations and released back to the estuary during LNG loading as required. Visiting LNG carriers will not need to discharge ballast water locally; however they may take on seawater as ballast as they unload their cargo. Consequently, a release of black, grey or ballast water from the FSRU is not considered a potential MAH/ MATTE scenario.	N

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
Concrete	Construction material, which is applied as a paste, comprising sand aggregates and other additives.	Concrete is not classified by CLP; however, concrete paste is alkaline (pH 10-14) and therefore harmful to people if in contact with skin or eyes. If concrete enters the environment via a release to water, it can raise the pH causing harm to aquatic ecosystems. Concrete released to the environment can also cause sedimentation on aquatic beds, which could harm flora and fauna.	During construction, concrete use will be strictly controlled to prevent any wet material from entering the environment. This will be established in a CEMP produced for the Proposed Development, containing the appropriate control measures. In the event of a fire, the pH of water applied to areas where dry concrete is present may increase slightly, however firewater will be contained within the firewater impoundment basin and would not enter the environment. Consequently, no credible MAH/ MATTE scenarios are identified for concrete.	N
Nitrogen	Nitrogen is an inert gas generated onshore. A small quantity of nitrogen will be continuously injected into the natural gas pipeline in accordance with the GNI gas specification requirements. Nitrogen will also be used as a blanketing gas for the odorant storage vessel(s). Nitrogen will also be used during maintenance operations to purge equipment and pipework.	Nitrogen is not classified as dangerous but can be harmful to people if a release occurs within confined, unventilated areas.	Nitrogen gas generation systems will be located in external, well ventilated areas and therefore an accidental release would disperse readily. There will be no impact on people, or the environment, and therefore a loss of nitrogen containment would not be a MAH. Gas cylinders are not expected to be permanently present onsite, but a small number may be used as a back-up to the main nitrogen generator. Gas cylinders may explode if exposed to fire, however their use will be carefully controlled and when not in use, housed in storage cages for safety. Consequently, no credible MAH/ MATTE scenarios are identified for nitrogen.	N

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
Hydraulic Fluids/ Lubrication Fluids	Hydraulic fluids are synthetic oils present in the hydraulic sections of the loading arms at the jetty. Lubrication fluids are also typically synthetic oils which will be present in various items of equipment, particularly in the Power Plant which contains turbines, pumps and compressors.	Hydraulic and lubrication fluids are not classified by CLP and whilst they may be combustible, they are not generally categorised as flammable. If released to water, they could be harmful to the environment by rapidly forming a film on the surface of water and/ or land.	The quantity of hydraulic fluids contained in jetty systems such as those which will be installed at the Proposed Development is relatively low, typically less than 1 tonne will be expected. A release of this substance will be rapidly detected by site operations. The leak would be isolated, and any material released would be contained using marine booms for collection and safe disposal. The design and construction of the hydraulic loading systems for cryogenic fluids (i.e. LNG) will be to established industry standards such as BS EN 1474-3:2008 (British Standard, 2008) and all applicable National Regulations. In the event that the full inventory of this substance was released, there will be no significant effects on people or the environment, therefore the release would not be a MAH/ MATTE. Small quantities of lubrication oils are present within equipment items and maintenance storage areas, therefore no credible MAH/ MATTE scenarios associated with this material.	N

Substance	Description	Hazard Classification and Description	Screening and Identification of Potential MAH	Included in Assessment (Y/ N)
Power Plant Chemicals – Boiler Water Treatment Plant	Substances are typically be used to treat the boiler water systems within the Power Plant to control biological growth, prevent scale build up and to limit corrosion. In addition, any effluent discharges will be pH adjusted using appropriate substances.	The substances used in these applications will be specified prior to operation and may include sodium hypochlorite (biocide), which is classified by CLP as harmful to the environment. Substances present in the Power Plant could include acids and alkalis for pH adjustment of liquids. These substances are typically classified as corrosive. Acids and alkalis are incompatible and shall be stored separately to avoid the potential for hazards caused by mixing.	The quantities of these substances will be typically a maximum of a few tonnes, stored in dedicated, bunded, storage tanks. In the event of an accidental release, this material will be contained in tank bunds and rapidly detected by site personnel. If, however, the secondary containment systems (i.e. bunds) and tertiary containment systems (i.e. isolatable drains) both failed simultaneously, there will be minimal impact on people or the environment, primarily due to the small volumes of chemicals stored onsite. Consequently, no credible MAH/ MATTE scenarios for Power Plant chemicals have been identified.	N

14.7 Assessment of Major Accidents and Disasters

Identification of potential MAH/ MATTE scenarios in this assessment has been based on the application of industry standard risk assessment methodology, which considers the substances which could be present on the Proposed Development and their properties, including potential health, safety and environmental hazards.

The potential MAH/ MATTE scenarios which have been identified for the Proposed Development are presented in Table 14-2. These represent 'worst-case' events which, although they have the potential for significant consequences, they have a very low probability of occurrence. This is borne out by the historic evidence presented in Section 14.7 – Safety in Design, which contains a description of key safety systems used in the engineering design and operation of LNG and natural gas systems, similar to the Proposed Development.

A QRA will be carried out within the COMAH Safety Report for these potential MAH/ MATTE scenarios and will provide a detailed analysis of these hazards, including calculations of individual and societal risk.

The potential natural disasters identified following consideration of the location of the Proposed Development are presented in Table 14-3.

Table 14-2 Assessment of Major Accidents

Scenario Ref.	Substance	Major Accident Scenario	Risks/ Effects	Prevention/ Mitigation Measures
1	LNG	A major fire onboard the FSRU/ LNGC following loss of containment of LNG and the availability of an ignition source	A release of flammable gas or liquid could be caused by mechanical failure, impact damage or an operator error resulting in a loss of containment. Immediate ignition of the gas could lead to a flash or jet fire on the FSRU/ LNGC/ jetty depending on gas pressure. Delayed ignition could lead to an explosion and/ or fire. In the event of a fire, there is the potential for harm to people working onboard the FSRU, LNGC and at the jetty. A major fire could impact flora and fauna at the Shannon Estuary as a result of thermal radiation. Water for firefighting may be applied at the FSRU and/ or jetty. Firewater would be likely to runoff into the Shannon Estuary.	A QRA study carried out for the Proposed Development has assessed the consequences of a release of LNG and concluded that a major fire is credible, however very low overpressures would be generated by an explosion. Therefore, the credible MAH scenario is a fire only. The design and operation of the FSRU and LNGC will incorporate many safety features, primarily the robust design of the ship and cargo tanks, which typically incorporate a double-hull construction. Lloyds Register publish a list of standards for these ships, contained in 'The Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk', published July 2020. LNG transfer systems, including ship-to-ship bunkering, are designed to operate in a range of weather conditions and incorporate Emergency Release Systems (ERS) and Quick Connect/ Disconnect Coupling (QC/ DC) systems for safety. Control systems including Emergency Shutdown (ESD) systems, will be designed and installed to the appropriate engineering design standards, such as those published by International Electrotechnical Commission (IEC). These systems minimise the potential for human error and mitigate the consequences should an error be made, by a fast, safe shutdown of the transfer systems. Instrumentation to detect gas releases will be installed and linked to fire alarm and fire suppression systems. Firewater will be supplied at the jetty head from the onshore storage tank and pump system. The design of the fire system is being developed in consultation with the local Fire Officer. Two 1,600 m3 firewater tanks will be installed which have been sized on the worst-case fire scenario at the jetty and LNG Terminal. Contaminated firewater will not be expected to contain significant quantities of uncombusted hydrocarbons or other chemical waste residues, therefore a discharge of fire water to the environment will only contain conventional pollutants from fire damage of assets. The Regulatory Authorities will be closely involved throughout the design, construction and operation of the facilities to ensure compliance with all legislative

				requirements and to ensure compliance with design specifications and codes. This information will be presented in the COMAH Safety Report along with other documents. Implementation of the preventative and mitigation measures as described above reduce the risk associated with this MAH scenario.
2	LNG	RPT incident following loss of containment of LNG at the FSRU/ LNGC. In this scenario, liquified gas is rapidly vaporised following a loss of containment (see description in Section 14.4).	A release of LNG could be caused by mechanical failure, impact damage or operator error resulting in a loss of containment of LNG. If a release of LNG was not immediately ignited, on contact with water there is the potential for LNG to vaporise with a corresponding release of energy. This energy has the potential to cause harm to persons onboard the FSRU/ LNGC, on the jetty and fauna present within the immediate environment.	Significant quantities of LNG would have to be released to the surface of the Shannon Estuary for RPT effects to be appreciable. The measures described in Scenario 1 to prevent a release of LNG are the primary controls to mitigate this hazard and implementation of these as described will reduce the risk associated with this MAH scenario.
3	LNG and Natural Gas	Loss of containment of LNG or natural gas which does not ignite but impacts through toxicity or asphyxiation. This could be at the FSRU/ LNGC (LNG) or onshore facilities (natural gas).	A release of flammable gas or liquid could be caused by mechanical failure, impact damage or operator error resulting in a loss of containment. In the absence of a source of ignition being active, there is the potential for harm to persons nearby if LNG/ natural gas is inhaled. Contact of LNG with the skin can result in cryogenic burns. At this point in the process, the natural gas may not contain an odourising agent therefore persons onsite may be unaware a release has occurred. It is considered highly unlikely that an unignited release could reach persons offsite at a concentration which could cause harm, due to the distances involved. This risk is	The design and operation of the FSRU, LNGC, gas equipment and pipework will be to industry codes and standards to reduce the potential for a loss of containment. Welded connections rather than flanged are preferred. This is established in the Lloyds Register Rules and Regulations, Chapter 5 Process Pressure Vessels and Liquid, Vapour and Pressure Piping Systems Systems will be installed onboard the FSRU and LNGC to continuously monitor LNG pressure and will immediately detect a loss of containment, isolating the appropriate area(s) and alerting staff via alarms. Isolation of pipework and equipment will minimise the volume of gas release and prevent escalation of an emergency. If persons are present in the vicinity of the equipment/ pipework which is damaged, they will be alerted immediately via gas detection and alarm systems. Onsite training and emergency plans for this scenario will be developed prior to operation and when the development is operational, these plans will be subject to

			therefore considered only applicable to the FSRU/ LNGC and immediate onshore site personnel.	frequent testing. This is a fundamental requirement of COMAH regulated sites such as the Proposed Development. Implementation of the preventative and mitigation measures as described above reduce the risk associated with this MAH scenario.
4	MFO	Loss of containment of MFO to the estuary and surrounding beaches and land.	A release of MFO could be caused by mechanical failure, impact damage or operator error resulting in a loss of containment reaching the estuary. In the event of a release of liquid MFO, the substance would form a layer on the surface of water and land. Films formed on water may affect oxygen transfer and damage organisms. The major constituents of MFO are inherently biodegradable. Volatile constituents would oxidize rapidly by photochemical reactions in air and MFO would partly evaporate from water or soil surfaces, but a significant proportion could remain until collected by emergency systems such as absorbent booms. Large volumes of MFO released to ground may penetrate soil and could contaminate groundwater.	The fuel systems on the FSRU/ LNGC will be designed to the appropriate maritime engineering standards. These include the technical integrity of the storage systems, leakage detection and containment. Fuel leaks will be readily detected and isolated to minimise the loss of containment. Oil spillages will be dealt with using the SOPEP produced prior to operation as required by MARPOL Annex 1 Regulation 26. Procedures to prevent and respond to accidents involving a loss of containment will be developed, taking into consideration The National Maritime Oil & Hazardous Noxious Substance (HNS) Spill Contingency Plan (NMOSCP). This establishes Ireland's national framework and strategy to coordinate marine pollution preparedness and response. Implementation of the preventative (engineering design and operation) and mitigation (emergency response) measures as described will reduce the risk associated with this potential MAH scenario.
5	Natural Gas	Major fire/ explosion at the onshore facilities including gas receiving and conditioning area, AGI and the Power Plant.	A significant release of flammable gas at the onshore facilities could be caused by mechanical failure of equipment or impact damage such as a vehicle collision with pipework. Immediate ignition of natural gas would result in a fire, delayed ignition could result in an explosion and/ or fire. There is the potential for harm to people working at these facilities, however it is considered unlikely that a fire/ explosion would have an impact offsite at residential areas or environmental receptors due to the distances involved.	The QRA has concluded that a fire is a credible MAH scenario, however explosion overpressures were calculated to be negligible as a result of the open, unconfined areas of the onshore facilities. The design of the natural gas equipment and pipework will be to industry codes and standards to reduce the potential for a loss of containment, including the use of fully welded connections to avoid potential leak sources. Pipework at the AGI will be predominantly routed below ground, further reducing the potential for a loss of containment. Pipeline safety systems and gas/ liquid pressure regulation is to be installed along with operational controls and monitoring. Instrumentation and control systems will monitor the process and detect leaks. ATEX compliant equipment to be installed as required by Explosives Atmosphere Risk Assessment, to be carried out during the detailed engineering design of the Proposed Development.

				In the event of a major fire, damage to process equipment could occur which may release potentially harmful materials such as lubrication or hydraulic oils which are contained within firewater runoff. A fuel interceptor will be installed within the drainage systems on the Proposed Development, which will contain any spilt oil or hydrocarbon material within drainage and firewater runoff. This can then be collected and disposed of safely offsite. The onshore facility will be designed to contain firewater runoff within a retention area, which would prevent this material reaching unmade ground or other environmental receptors. Fire and gas detection and fire protection systems will be installed throughout the Proposed Development as appropriate, including passive and active fire suppression systems. The firewater system located onshore consists of storage tanks, firewater pumps and a ring main with a jockey pump to maintain pressure within the ringmain. Firewater will be supplied from this system via the trestle to the jetty head for the FSRU/ LNGC. This system has been specified in consultation with the local Fire Officer. In the event of a major fire, products of combustion could be generated, therefore there is the potential for emissions to air. However, gas is likely to achieve almost complete combustion, reducing the quantity of hydrocarbons and particulate matter which could be generated. Implementation of the preventative and mitigation measures as described above reduce the risk associated with this MAH scenario.
6	Odorant NB	Loss of containment, with/ or without subsequent fire/ explosion at the onshore facilities	A significant release of odorant material could be caused by mechanical failure of equipment or impact damage such as a vehicle collision with pipework resulting in a loss of containment. This material is selected for its characteristic odour, which is detectable by people at very low concentrations. Consequently, in the event of a loss of containment, there is the potential for this to create confusion to local people who may mistake this for a release of natural gas. There is also the potential for odour nuisance. Odorant is stored as a liquid in a closed, pressurised system held under a blanket of nitrogen which provides an inert atmosphere.	The design, operation and maintenance of equipment and pipework storing odorant will be to industry codes and standards to reduce the potential for a loss of containment, including the use of fully welded joints to reduce the potential for leaks. These design standards will be in alignment with the expectations of the Regulatory Authorities. The Proposed Development site is located in a predominantly rural location, therefore if a release of odorant was to occur, the number of residents who could detect an odour will be substantially less than in a more built-up location. In the event of a major fire, the emergency plans will include a firefighting strategy developed for all areas of the Proposed Development, including the odorant storage and injection system. This will potentially include using large volumes of water to cool the vessel contents. The plan will be developed in consultation with the emergency services.

Therefore, if the contents of the vessel are heated, for example in a fire to a temperature above its boiling point, this could result in a BLEVE. The likelihood of such an accident occurring is extremely low but could cause harm to people if exposed to explosion overpressure, debris and/ or thermal radiation resulting from this scenario.

A detailed analysis of this scenario will be included in the QRA and consequence analysis which will further inform the development of the firefighting strategy and emergency response procedures.

Implementation of the preventative and mitigation measures as described above reduce the risk associated with this MAH scenario.

Table 14-3 Assessment of Natural Disasters

Scenario Ref.	Description	Risks/ Effects	Preventative/ Mitigation Measures
7	Maritime navigation hazards including: • Vessel Collision in Estuary • Contact of Vessel with Infrastructure • Contact with Anchor • Grounding • Foundering • Cable Snagging • Mooring/ Breakout	The impact of a vessel colliding with the FSRU/ LNGC in the estuary could result in damage to vessels, a potential loss of containment of LNG and other fluids such as ballast, and harm to persons onboard. There are a number of submarine cables in the estuary. Impact with a cable could result in the interruption of electrical or communication supplies. The potential consequences of a release have been described in Scenarios 1 and 2.	A Navigation Risk Assessment (NRA) has been produced for the Proposed Development in consultation with stakeholders including the Port Company, Harbour Authority, the local Maritime Club, fishing clubs and environmental groups (dolphin and whale groups). This study has included a traffic analysis, gate analysis at the narrows area and a comprehensive review of historic incidents in the Shannon Estuary. An assessment of cumulative impacts has been included in the NRA, considering the impacts of future growth plans for the Shannon Estuary. The NRA has identified a number of potential hazards (56) associated with the Proposed Development associated with increased traffic frequency and other aspects. A detailed assessment of these hazards has concluded that the majority of identified risks are at a level which is considered 'Low' (38) or 'Negligible' (2). The remaining risks (15) have been reduced to a level which represents ALARP by the mitigation measures which will be implemented. These include for example, the size and depth of the estuary, low numbers of commercial shipping vessels, and the introduction of mobile control zones. The NRA concluded that mitigation measures embedded in the existing facilities and Proposed Development were suitable and sufficient to reduce risks, therefore the risk of a MAH/ MATTE as a result of a maritime navigation hazard is therefore considered to be very low.
8	Earthquake/ Seismic Event	An earthquake in the area of the development could result in damage to the FSRU, LNGC, pipelines and onshore equipment, with the potential for subsequent fires if LNG or natural gas was released.	The Irish National Seismic Network (INSN, 2021) documents a complete list of earthquakes since 1980. There have been minor, low magnitude events; however, Ireland is recognised as having a low level of seismic activity, with most earthquakes being recorded in the south-east or north-west of Ireland. Mechanical and civil engineering design codes used for the Proposed Development will take into consideration the requirement for appropriate earthquake resilient equipment and structures, for example, the structural strength of pipeline supports to accommodate natural movement and expansion. The risk of a MAH/ MATTE as a result of an earthquake is therefore considered to be very low.

Scenario Ref.	Description	Risks/ Effects	Preventative/ Mitigation Measures
9	Climate Change – Storm Water Flooding and Increasing Sea Levels	Surface water flooding from storms could result in damage to pipelines and equipment, with the potential for subsequent fires and/ or explosions if LNG or natural gas was released. An increase in the tidal range of the Shannon Estuary could result in operational instability of the FSRU, LNGC and jetty operation.	Marine studies and flood risk assessments have been undertaken for the Proposed Development, which have assessed future sea levels, storm surges and sea level rise (Halcrow, 2007; Mott MacDonald, 2013). Flooding and drainage is also considered in detail within Chapter 06. The Stage 3 – Detailed Flood Risk Assessment concluded that with the exception of crossings of the watercourses for the access road, there is no development proposed within either Flood Zone 'A' or Flood Zone 'B' and therefore the Proposed Development has a negligible impact on the existing flood regime in the area. The output of these studies and further/ updated work will be used to inform the engineering design of the development. The risk of a MAH/ MATTE as a result of flooding and increasing sea levels is therefore considered to be very low.
10	Climate Change – Temperature Extremes	Increasing atmospheric temperatures could result in operational instability of vaporisation and cooling systems. This could potentially impact the operation and efficiency of the Proposed Development but would be unlikely to result in a major accident or disaster.	The engineering design of the Proposed Development would consider the predicted ambient temperatures over the operational lifetime of the Proposed Development. This includes consideration of materials of construction suitable for expected temperature variations. The risk of a MAH/ MATTE as a result of temperature extremes is therefore considered to be very low.

Scenario Ref.	Description	Risks/ Effects	Preventative/ Mitigation Measures
11	Climate Change – Severe Winds	Potential accidents caused by severe winds could include impact damage from windblown debris and premature failure of structures, such as the jetty, loading arms and onshore process facilities. Severe winds could potentially initiate accidents such as vessel collisions or contact between vessels and infrastructure.	Wind speeds approaching hurricane force have been recorded by Met Eireann in Ireland (Met Eireann, 2021) and there is the potential for these storms to increase in frequency. Consequently, the Proposed Development recognises that appropriate engineering design, to withstand the forces generated by wind on the FSRU, jetty and all structures, must be considered. During storms, disconnection of the FSRU from the jetty and LNGC (if applicable) will be carried out, with the FSRU and LNGC moved to a designated safe mooring position. The potential for vessel collisions with infrastructure and other vessels is considered in Scenario 7 and assessed within the NRA. The risk of a MAH/ MATTE as a result of severe winds is therefore considered to be very low.
12	Increased Noise and Vibration Levels	The Shannon Estuary is home to protected species of fauna such as bottlenose dolphins. An increase in noise levels resulting from the Proposed Development, including onshore facilities and vessel movements, could potentially impact animal communications causing harm to local wildlife.	Increased noise in the Shannon Estuary associated with transiting and stationary ships both on jetties and on anchor has been considered in detail within the Noise section of the EIAR. This section also considers construction and operational phases of the onshore facilities associated with the Proposed Development, including noise associated with potential increases in traffic on local roads. There are a limited number of potential noise sources associated with the LNG Terminal, however the Power Plant will contain equipment with the potential for high noise levels if unabated. Mitigation measures to reduce noise levels will be incorporated in the design of the Power Plant, including acoustic barriers for equipment such as cooling fans and compressors and the acoustic design of buildings such as the turbine hall. All reasonably practicable measures will be adopted by the Proposed Development to minimise the noise impact of the facilities and Best Available Techniques (BAT) would be used in the selection and implementation of appropriate noise mitigation measures and controls. The risk of a MAH/ MATTE as a result of noise and vibration is therefore considered to be very low.

Scenario Ref.	Description	Risks/ Effects	Preventative/ Mitigation Measures
13	Acts of Terrorism/ Arson/ Cyber Terrorism	Acts of vandalism and/ or terrorism could have hazardous consequences, such as fire and/ or explosion. Acts of terrorism could also include unauthorised access to IT and control systems associated with the onshore process, jetty and FSRU/ LNGC. The worst-case risks and effects are as described in Scenario 1.	Security measures will be installed throughout the Proposed Development, including security guards, Closed Circuit Television (CCTV) and appropriate security fencing to deter intruders. The most up-to-date security advice will be obtained from the appropriate authorities for inclusion within a site Security Plan. IT security systems will be installed to prevent unauthorised access to control systems and the appropriate marine standards will be installed on the FSRU. The risk of a MAH/ MATTE as a result of unauthorised access to the Proposed Development is therefore considered to be very low.
14	Lightning	A lightning strike could cause a major accident, harm to people working at the Proposed Development and damage to the site infrastructure. Lightning could also present a source of ignition to flammable materials resulting in a major fire, which could harm people both onsite and offsite.	The engineering design of the Proposed Development will include the appropriate electrical earthing and bonding systems installed to provide a safe route for lightning to earth. Electrical and mechanical equipment will be specified in accordance with the requirements of the ATEX Directive 2014/ 34/ EU (EU, 2014), which defines standards for equipment. An explosion risk assessment will be carried out in accordance with ATEX Directive 1999/ 92/ EC (EC, 1999) which establishes the required standards to protect people. This will also consider the potential for lightning to be a source of ignition to flammable gases and vapours. Lightning risks will be assessed in accordance with recognised standards such as BS EN/ IEC 62305. The risk of a MAH/ MATTE as a result of a lightning strike is therefore considered to be very low.

Scenario Ref.	Description	Risks/ Effects	Preventative/ Mitigation Measures
15	Aircraft/ Drone Strike	The impact of an aircraft on the Proposed Development could result in significant asset damage, with subsequent fires and explosions from potentially released LNG/ natural gas.	The nearest airport is Shannon, located approximately 50 km in an easterly direction. The flight path to and from this airport is to the north of the Proposed Development. Personnel vigilance and security systems are the key mitigation measures to prevent drones being used in the area of the Proposed Development. The risk of a MAH/ MATTE as a result of an aircraft/ drone strike is therefore considered to be very low.
16	Road/ Rail Impact	The accidental impact of a vehicle on pipework and assets associated with the Proposed Development containing natural gas could result in asset damage and loss of containment. Ignition of gas could result in a major fire, potentially causing harm to people onsite and offsite.	The Proposed Development will be located in a rural area which has very low levels of road traffic and is not located near a railway. The local road infrastructure was not originally designed to accommodate delivery of large assets to the Proposed Development, such as major items of equipment. Therefore, an abnormal load assessment is being produced to identify potential pinch points and develop the appropriate mitigation measures and controls. The onshore pipework within the Proposed Development will connect to a major gas pipeline routed below ground for distribution to users. The risk of a MAH/ MATTE as a result of a vehicle impact is therefore considered to be very low.

14.8 Safety in Design

14.8.1 LNG Industry Safety History

Information provided by the Society of International Gas Tanker and Terminal Operators (SIGTTO) states the LNG industry is mature and well established, with LNG tankers in use around the world from around 1960 (SIGTTO, 2021). The global LNG tanker fleet continues to grow year-on-year along with regasification capacity. SIGTTO was incorporated as a non-profit making organisation in 1979, with the objective to share best practise and publish technical guidance for operators.

The safety and security of facilities is the highest priority for the LNG industry and there are a number of international organisations who share safety information, statistics and best practise, such as the International Group of Liquefied Natural Gas Importers (GIIGNL) (GIIGNL, 2021).

There have been very few major accidents involving LNG worldwide, with the last significant incident occurring over forty years ago (October 1979) at an onshore LNG storage facility in the United States. Lessons were learned following this accident, with the specification of materials for cryogenic service being reviewed and improved, along with the issue of new design codes and standards.

There have been a small number of minor accidents at LNG installations in the UK, with only small amounts of LNG being released and they did not result in any injuries to people. Operators such as National Grid in the UK maintain a register of accidents and incidents (with high potential), which are shared throughout the industry to drive continuous improvement in operations and standards.

LNG carriers must meet the required standards of the International Maritime Organisation (IMO) regulations for safety and security of shipping and the prevention of marine pollution by ships (IMO, 2021). These regulations cover the operations on the FSRU.

14.8.2 Technical Guidance

There is a significant volume of information and guidance available to developers on the identification and control of MA&D associated with the design and operation of LNG offloading and vaporisation facilities. This includes both national and international standards, such as the following which will be used in the engineering design of the facilities.

- European Norm (EN) standards - equipment and pipework design codes for cryogenic service, inspection and testing procedures.
- National Fire Protection Association (NFPA) – fire protection system design codes, general guidance on process equipment and electrical equipment specifications.
- International Electrotechnical Commission (IEC) – functional safety standards for instrumentation and control systems.

14.9 Cumulative Impacts and Effects

Cumulative impacts or effects are defined as the addition of many minor or insignificant effects, including other projects, to create larger more significant effects. The purpose of the MA&Ds assessment is to determine significant credible major accident or disaster scenarios for the Proposed Development, taking into consideration the multiple, cumulative failures which would have to happen, as a single isolated failure would not result in a major accident. The impact assessment which has been carried out for the Proposed Development as detailed in Section 14.7 takes into consideration these multiple, cumulative failures, an example of which is described below.

For a major fire to occur, a mechanical system such as an item of process equipment or a section of pipe would be required to fail, releasing flammable gas. For this failure to occur, a metal or weld defect would be required to be created and undetected during the manufacturing and installation process. Once installed, testing and routine visual inspection would have to fail to identify the presence of this defect, which over time could deteriorate via mechanisms such as fatigue caused by pressure cycling, until a catastrophic failure occurs. This results in a release of flammable gas which ignites in contact with a source of ignition such as non-ATEX compliant electrical systems resulting in a fire.

Other failure mechanisms and sources of ignition exist which could result in a loss of containment and subsequent fire. These include for example instrumentation, operational and human factors related failures.

There are multiple layers of prevention and mitigation measures in place for the Proposed Development to prevent major accidents such as the fire scenario described above from occurring which are described in Section 14.7. These include for example the emergency shutdown system which can be initiated by a number of systems including automatic fire and gas detection and manual activation.

Inherent safety principals have been adopted in the Proposed Development, principally reduction of the quantities of flammable materials present onshore and the location of systems/ equipment.

Facilities such as the Power Plant and major electrical equipment to be installed as part of this Proposed Development will be designed to incorporate a separation distance to prevent major accidents such as fires and explosions originating in one area from spreading to another area or escalating via domino effects. This separation distance is based on established engineering guidance for industrial site layout.

Inherent design measures to prevent defects include mechanical design codes for equipment and pipework, and quality assurance testing prior to installation using techniques such as x-ray examination and dye penetration. Once installed, regular inspection as required by Statutory Regulations will be carried out to identify defects. The equipment and pipework will be fitted with instrumentation to monitor the pressure and flowrate of gas, alerting operators to deviations from set points, preventing fatigue. If a failure was to occur even after all these design and operating measures were in place, mitigation measures to prevent ignition of gas which include the specification of installed ATEX compliant mechanical and electrical equipment. Process Safety ATEX specialists will be involved at all stages of the Proposed Development to assure compliance with these Directives and providing input to the layout of the facilities.

Cumulative effects also require the consideration of other projects and developments nearby which include the existing industrial infrastructure such as the Tarbert and Moneypoint power plants, scheduled for decommissioning, as described in Section 14.4.1. These facilities are located at a distance which should a major accident such as a fire or explosion occur, would not have an effect on the Proposed Development. The location of current planning applications will be considered collectively to ensure that these are located in an appropriate location such that they would not have the potential to initiate or escalate major accidents or disasters at the Proposed Development.

The risk of cumulative effects leading to potential MA&D at the Proposed Development is therefore considered to be **low** and detailed safety studies such as QRA are ongoing to identify where risks can be further reduced.

14.10 Residual Impacts and Effects

Residual effects are defined as those impacts that remain following the implementation of mitigation measures. As per the EPA draft guidelines, the effects from the residual impacts that remain after all assessment and mitigation are referred to as 'Residual Effects' (EPA, 2017). This assessment of MA&Ds has identified the potential for major hazards to occur at sensitive environmental receptors, such as a fire caused by damage or failure of systems containing gas. These events have significant consequences; however, the likelihood will be extremely low due to measures such as the engineering design of assets and protective systems.

Hazardous events such as these have been demonstrated to be extremely unlikely, however the risk cannot be entirely eliminated therefore will be reduced to ALARP. Further analysis of mitigation measures and residual effects are to be included within the QRA study report.

14.11 Summary

The assessment has reviewed the potential MA&D applicable to the Proposed Development, associated with the substances present and the operation of the Proposed Development, including the FSRU, LNGC, jetty and onshore areas including the Power Plant. Principally, these include fires following the accidental release of LNG or natural gas into the receiving environment. These incidents have an extremely low probability of occurrence but could have significant effects on people and the environment. Similar facilities have been in operation for many years across the world and the LNG industry has a very good safety record.

The engineering design of the Proposed Development will incorporate all of the appropriate standards and mitigation measures necessary to reduce the risks of accidents and disasters to an acceptable level, i.e. ALARP.

The key preventative and mitigating measures to prevent major accidents and disasters, are summarised as follows:

1. No LNG storage tanks will be installed onshore, minimising the inventory of LNG. In the event of an accidental release of natural gas from the onshore facilities such as pipework, the consequences will be significantly reduced in comparison to a release of LNG from a large onshore storage tank.
2. The natural gas pipelines will have integral isolation valves which can be closed very quickly in an emergency to isolate the inventory and reduce the consequences of an accident. Isolation valves used in this application are typically tested in accordance with International Standards such as BS EN ISO 10497:2004. This standard specifies fire type-testing requirements and a fire type-test method for confirming the pressure-containing capability of a valve under pressure during and after the fire test. Isolation valves can be closed automatically, and in the event of a problem with automatic isolation they can be closed manually. The automatic isolations are operated using highly reliable process control systems. SIS will be installed to provide highly reliable control functions, such as ESD. These systems and emergency procedures such as pipeline depressurisation will be subject to detailed safety studies during the engineering design process.
3. The FSRU can be safely disconnected from the jetty in the event of adverse weather conditions such as storms. The vessel will be moved to a safe mooring location away from the coast, reducing the risk of an accident, which could have an impact onshore. Due to the influence of climate change, serious storms could become more frequent. Storm Ophelia in October 2017 resulted in wind speeds reaching up to 156 km/h in Co. Cork (Burns, S., 2018), with a Status Red warning issued by Met Éireann. The LNG facilities will be designed to take events such as these into consideration.
4. Fires are the most significant hazards associated with natural gas and therefore the inventory has been minimised to store as little flammable material as possible at the onshore site. The facilities will be designed to take into consideration the ATEX Directives (EU, 2014; EC, 1999), which place controls on the use of electrical and mechanical equipment where flammable materials are present to prevent sources of ignition being available in the unlikely event of a release of flammable gas. Operational procedures including access controls will be in place to control potential ignition sources within all areas of the Proposed Development, but in particular, the trestle area.

5. Climate change may have an impact on atmospheric temperatures and increase the frequency of storms, however the engineering design of the Proposed Development will take these impacts into consideration. For example, the height of the jetty considers the potential for a rise in sea level. The majority of gas pipework will be below ground, therefore storms and increasing wind speeds will not have an appreciable impact on these structures. Overall, there are no changes to the identified major accidents or disasters as a result of the currently predicted climate changes.

6. Appropriate segregation distances will be provided onshore between the natural gas systems and other operators, including the Power Plant. This reduces the potential for an incident at one site to have an impact on another site nearby, commonly referred to as a 'domino effect'.

7. In the event of a release of LNG, rapid vaporisation and dispersion will result in very limited potential for this material to enter environmental receptors, such as the protected areas encompassing the estuaries, mudflats and other features along the coast. Compared with substances such as crude oil and fuels, such as diesel, the environmental impact of a release of LNG or natural gas will be significantly lower.

8. Shannon Airport is located approximately 80 km north east of the Proposed Development and the Proposed Development site is below the flight path used by national and international flights, particularly to the United States and Canada. An aircraft crash into the facilities would have catastrophic consequences, but the probability is extremely low and the design of facilities to withstand such a crash is not required.

Table 14-4 Summary

Proposed Development Stage	Aspect/ Impact Assessed	Existing Environment/ Receptor Sensitivity	Effect/ Magnitude	Significance (Prior to Mitigation)	Mitigation and Monitoring Measures (the Proposed Development design embedded environmental controls and all mitigation and monitoring measures detailed herein are included in the OCEMP)	Residual Impact Significance
Operation	Fires following the accidental release of LNG or natural gas into the receiving environment	Low	Very High	Significant	The key preventative and mitigating measures to prevent major accidents and disasters, are summarised as follows: • No LNG storage tanks will be installed onshore, minimising the inventory of LNG. • The natural gas pipelines will have integral isolation valves which can be closed very quickly in an emergency to isolate the inventory and reduce the consequences of an accident. • The FSRU can be safely disconnected from the jetty in the event of adverse weather conditions such as storms. • Fires are the most significant hazards associated with natural gas and therefore the inventory has been minimised to store as little flammable material as possible at the onshore site. • Appropriate segregation distances will be provided onshore between the natural gas systems and other operators, including the Power Plant. • In the event of a release of LNG, rapid vaporisation and dispersion will result in very limited potential for this material to enter environmental receptors, such as the protected areas encompassing the estuaries, mudflats and other features along the coast.	Minor adverse

14.12 References

British Standard, (2008). BS EN 1474-3:2008 - Installation and equipment for liquefied natural gas. Design and testing of marine transfer systems. Offshore transfer systems

Burns, S., (2018). Storm Ophelia was farthest east major hurricane in Atlantic. https://www.irishtimes.com/news/environment/storm-ophelia-was-farthest-east-major-hurricane-in-atlantic-1.3665322

CDOIF, (V2 2016). Chemicals and Downstream Oil Industries Forum (CDOIF) Guideline on Environmental Risk Tolerability of COMAH Establishments V2.

EC, (1999). Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31999L0092

EC, (2008). Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

EU, (1992). Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

EU, (2009). Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (codified version)

EU, (2014). Directive 2014/34/EU of the European Parliament and of the Council on equipment and protective systems intended for use in potentially explosive atmospheres https://ec.europa.eu/growth/sectors/mechanical-engineering/atex_en

GIIGNL, (2021). International Group of Liquefied Natural Gas Importers (GIIGNL) https://giignl.org/

Government of Ireland, (2015). Chemicals Act (Control of Major Accident Hazards involving Dangerous Substances) Regulations 2015.

Government of Ireland, (2018). S.I. No. 296/2018 - European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018 http://www.irishstatutebook.ie/eli/2018/si/296/made/en/print

Halcrow, (2007). Shannon LNG Marine Concept Study.

IEC, (2021). IEC 61511 Functional safety - Safety instrumented systems for the process industry sector https://webstore.iec.ch/publication/5527

IMO, (2021). International Maritime Organisation (IMO) http://www.imo.org/en/Pages/Default.aspx

INSN, (2020). The Irish National Seismic Network (INSN) https://www.insn.ie/

MARPOL, (1973). MARPOL The International Convention for Prevention of Marine Pollution for Ships. Adoption: 1973 (Convention), 1978 (1978 Protocol), 1997 (Protocol - Annex VI); Entry into force: 2nd October 1983 (Annexes I and II).

Marico Maritime, (2021). Shannon Technology and Energy Park NRA Update, Marico Maritime. March 2021.

Met Eireann, (2021). Major Weather Events. https://www.met.ie/climate/major-weather-events

Moffat & Nichol, (2020). Metocean Analysis and Coastal Modelling Report 19th March 2020.

Mott MacDonald, (2013). Flood Risk Assessment Technical Memorandum.

National Maritime Oil/HNS Spill Contingency Plan 2020 https://assets.gov.ie/77980/6c9a5734-b3c9-4510-a5e6-d40d5414b81c.pdf

SIGTTO, (2021). The Society of International Gas Tanker and Terminal Operators (SIGTTO) https://www.sigtto.org/

Vysus Group Shannon Technology and Energy Park (STEP) – QRA Revision Summary for HAS. June 2021.

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