Risk Assessment of Marine Operations at LNG Terminal for Shannon Estuary

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Operational Risk Assessment
Marine Operations at Shannon LNG Terminal

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EXECUTIVE SUMMARY

This document records the outcome of a quantified navigational risk assessment for the Shannon Estuary carried out in connection with the proposed LNG Terminal. The work was commissioned by the Shannon Foynes Port Company Limited.

In addition to the Shannon Foynes Port Company Limited staff and pilots, the following port stakeholders were consulted during the process: Shannon LNG development team; Commissioners for Irish Lights (CIL); Irish MSA/Coastguard; current ship operators; ESB Moneypoint and Tarbert, Aughinish Alumina Plant; Celtic Towing Ltd.; Shannon Ferry Group; mooring gangs; local yacht clubs; "dolphin watch" operators; commercial and recreational fishing; other recreational users.

The overall conclusion was that the level of risk associated with the proposed LNG operations in the Shannon Estuary is acceptable and that such operations may be conducted in safety, subject to the additional risk mitigation measures identified in the report being addressed.

The main findings are:

1. From a navigational perspective, the Shannon Estuary may be considered to be a very suitable location. With the exception of two pinch points the route taken by future LNG carriers within port limits is wide, deep and offers a variety of abort locations and anchorages.

2. The Risk Assessment undertaken in the context of potential LNG operations has demonstrated that the existing aggregated risk levels within the port are broadly within or below the level to be expected in an established and effectively managed port. This relatively low risk level is due in large measure to the absence of high densities of shipping and the spacious characteristics of the Shannon Estuary.

3. In the context of LNG operations, however, there are a few areas where the risk level for an individual consequence within the aggregated score, is in the "Heightened Risk" category. These merit further mitigation. In addition, there are some fourteen hazards where the level of risk associated with an individual consequence is at the upper limit of the ALARP range, and these too warrant scrutiny with view to reducing risk where both practicable and reasonable.

4. Given the difficulty of embarking pilots to seaward of the Ballybunnion Buoy in extreme weather, the Shannon LNG policy that no LNG Carrier will enter port when the wind at the berth exceeds the defined berthing parameters, and that in such circumstances LNG Carriers will remain at sea until the has weather

abated, will greatly reduce the associated risks to both personnel and navigation. These decisions complement the findings of the risk assessment and are fully endorsed by Marico Marine.

5. Notwithstanding environmental conditions, continuity of service is dependent on the reliability and suitability of the pilot cutter(s). Records show, the operability of a single cutter is hard to maintain and it is strongly recommended that consideration be given to pilot cutter provisions in an era of LNG operations and anticipated enhanced traffic volumes.

6. The use of VTS in monitoring and organising vessel traffic is recognised best practice for all LNG ports worldwide. As currently configured and used, the SFPC system does not meet international standards, and is thus not utilising its full risk mitigation potential. Shannon Foynes Port Company should therefore give serious consideration to enhancing the technical capability of the present system, and importantly, to introducing properly accredited VTS operators. In sum, the risk assessment process cannot demonstrate that LNG Carrier operations may be conducted safely without a comprehensive and effective VTS in operation during the period leading up to and whilst a LNG Carrier is in port.

1 INTRODUCTION AND METHODOLOGY

1.1 Introduction

Marico Marine, in conjunction with Sea Sense Limited (hereafter jointly known as MARICO Marine), was contracted by the Shannon Foynes Port Company (SFPC) to carry out a quantified risk assessment of the marine operations associated with the proposed LNG terminal in the Shannon Estuary. Work commenced on 8 January. A draft Final Report was submitted on 28 March.

1.2 Methodology

The approach taken by Marico Marine in carrying out this project is based on the concept of Formal Safety Assessment. Formal Safety Assessment comprises five separate stages:-

1. Hazard Identification
2. Risk Assessment
3. Risk Controls and Future Mitigation
4. Cost Benefit Analysis
5. Conclusions and Recommendations

This report covers stages 1, 2, 3 and 5 of the FSA process including discussion and recommendations for future risk management decisions.

1.3 Hazard Identification

Hazard identification comprises a number of complementary processes. In the context of this project, these were:

- Gathering documented data and information.
- Interviews with stakeholders
- Monitoring operational procedures
- Site visits
- Electronic recording of vessel traffic movements within the port
- Preparing a draft Hazard List
- Developing a final Ranked Hazard List with the participation of stakeholders at a Hazard Identification (HAZID) meeting.

A full description of the hazard identification processes as undertaken on behalf of SFPC are documented in Section 4.

1.4 Risk Assessment

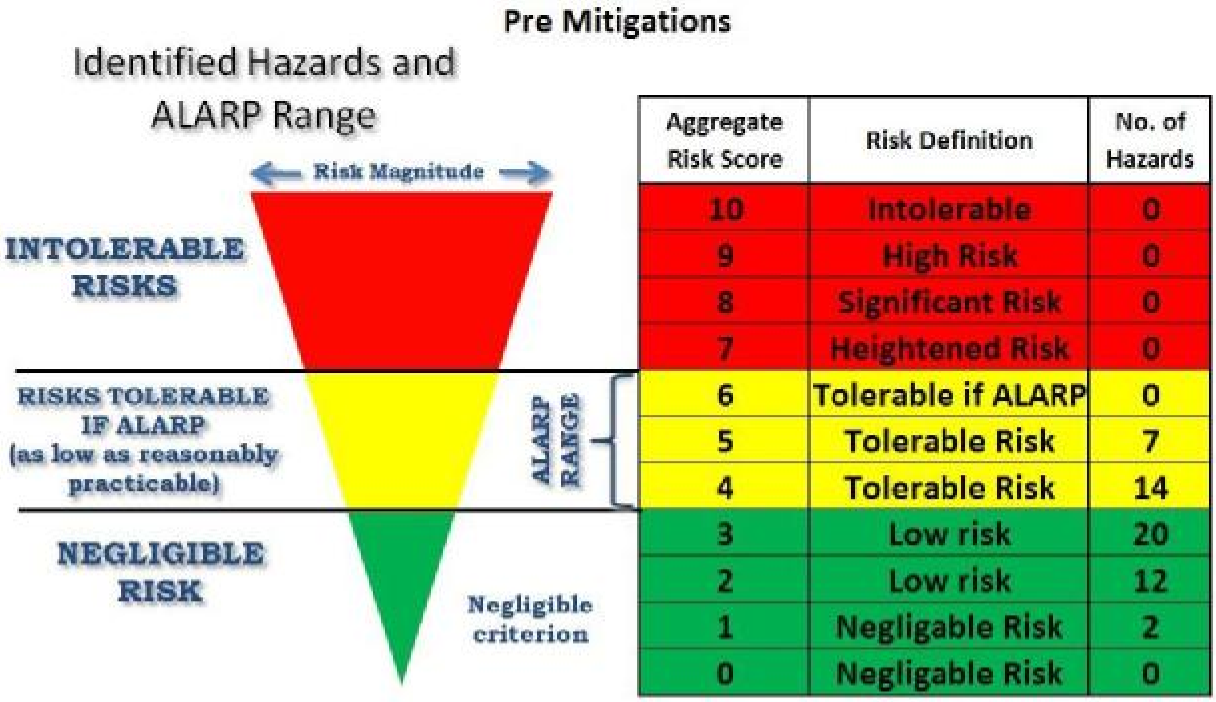
Following the finalisation of the Hazard List at the HAZID meeting, each hazard is reviewed in terms of its Likelihood and Consequence. Likelihood is scored on a scale of 1 to 5; Consequence is assessed in respect of safety of people, impact on the environment, damage to infrastructure, and effect on port reputation/business. The assessment of Consequence is made for both the "Most Likely" (ML) and "Worst Case" (WC) scenarios and is scored on a scale of 0 to 4. It is important to recognise that the scores assigned during this process will *de facto* take into account the risk control measures that already exist within the port.

The scores for both Likelihood and Consequence, as agreed at the HAZID meeting, are then fed into Marico Marine's HAZMAN software. This converts the scores into Risk Factors for each hazard on a linear scale of 1 to 10, as illustrated in Fig. 1 below. It does so in respect of the Most Likely and Worst Case scenarios and for all categories of Consequence. The resultant eight scores are then aggregated to produce an overall Risk Factor for each hazard. These are then ordered into a Ranked Hazard List showing each hazard in descending order of severity.

Consequence	4	5	6	7	8	10
	3	4	5	6	7	9
	2	3	3	4	6	8
	1	1	2	2	3	6
	0	0	0	0	0	0
	Likelihood	**Less than once per 100 years**	**10 to 100 years**	**1 to 10 years**	**More than once per year**	**More than once per month**

Fig 1 – Illustrative Risk Matrix

Those with scores below 4 can be considered to pose little or no risk. Those above 6 indicate a level of risk which requires additional mitigation. Those lying in the middle range 4 to 6 can be considered tolerable, provided that they are As Low As Reasonably Practical (ALARP), as illustrated in the Figure 2 below. It is for the port authority to review those in this range in order to consider whether additional mitigation may be desirable and practicable.



Aggregate Risk Score	Risk Definition	No. of Hazards
10	Intolerable	0
9	High Risk	0
8	Significant Risk	0
7	Heightened Risk	0
6	Tolerable if ALARP	0
5	Tolerable Risk	7
4	Tolerable Risk	14
3	Low risk	20
2	Low risk	12
1	Negligable Risk	2
0	Negligable Risk	0

Fig 2 –Illustrative Risk Factor Table showing ALARP

Further details on the methodology used by Marico Marine Ltd can be found at Annex A. The risk assessment undertaken for this project together with the subsequent Ranked Hazard List is described in detail in Sections 5.

1.5 Risk Controls and Future Mitigation

In order to consider what additional mitigation might be required to reduce the risk associated with hazards scored in the “intolerable” category, and possibly those lying at the higher end of the ALARP range, it is first necessary to document the existing risk control mechanisms which currently contribute to the management of risk.

These will generally fall into one of three categories, as will any additional mitigation considered necessary, namely:

- Documentary (Procedural Controls)
- Hardware (Engineered Controls)
- Personnel competence (Experience and Training Controls)

When subsequently considering possible additional mitigation measures to reduce the Risk Factors of the higher rated hazards, the likely effect on both Likelihood and the four categories of Consequence of each measure also needs to be assessed and recorded. By so doing, those measures which achieve the required reduction most cost effectively can be readily appreciated. Where such an appreciation is not obvious, it may be necessary to undertake a more detailed Cost Benefit Analysis.

1.6 Cost Benefit Analysis

Formalised Cost Benefit Analysis (CBA) is not addressed as part of this project. It remains available as a technique, however, should SFPC consider it necessary.

1.7 Conclusions and Recommendations

The report concludes with comments and discussions about those additional mitigation measures which SFPC is recommended to consider, so as to ensure that all risks associated with the proposed LNG operations in the Shannon Estuary have been reduced to acceptable proportions.

2 EXISTING ARRANGEMENTS

2.1 Overview

Shannon Foynes Port Company (SFPC) is the statutory harbour authority for the Shannon Estuary. Its jurisdiction runs from a line running between Loop Head and Kerry Head in the west, upstream to Limerick Dock in the east. SFPC has the power to issue Byelaws pursuant to Section 42 of the Harbours Act, 1996 – 2000 (as amended). The current Byelaws came into effect on 10 November 2004. The Harbourmaster is vested with the power to issue Directions to the masters of vessels arriving, departing, or lying within the port.

2.2 Environmental Conditions

2.2.1 Wind Conditions

Wind conditions have been obtained from Shannon Airport Weather Station and data is available for the last 30+ years. The station is well inland but is assumed to be accurate for the proposed berth but may not be accurate for the entrance and approaches.

Valentia Observatory is further south but the observatory gives a clearer overview of offshore conditions. Whilst at any moment in time the weather may be quite different between Valentia and Shannon Approaches, the amalgamated 30 year records are likely to match reasonably well; for this reason they are included to show offshore winds[1].

Wind anemometers are located at Foynes, Cappa Point and Shannon Airport. The output from these sensors (wind strength, direction and recent historical data) is fed electronically and presented graphically at the Foynes and Cappa SFPC offices.

The local area has a maritime climate with periods of unsettled weather and gales that can occur at any time of the year. The prevailing wind is primarily from the southwest with an average of about 12 days annually with gale force winds; however, Valentia has an average of 31 days per year so it can be expected that the port approaches will have in excess of 12 days which could affect marine operations[2].

Fog is relatively infrequent, occurring on an average of only 19 days a year (generally radiation fog occurring at dawn in winter). Rainfall is frequent and low cloud/rain can obscure the coast. Over a 22 year period there was an

[1] Valentia is a marine area reporting station for sea area “Shannon”.
[2] Climate Information summaries for 33 year period 1974 – 2006.

average of 211 days per year at Shannon and 237 days at Valentia for the same period.

Procedures will need to be considered in respect of LNG Carrier movements during periods of restricted visibility. Thunderstorms, which could affect cargo operations, are infrequent at only 7 days per year.

The lack of metrological weather data suggests the need for monitoring equipment to establish a true representation of the local weather at the entrance and boarding grounds. This was confirmed by the pilots who consider the interpolation of gale frequency between Shannon and Valentia to be "less than accurate" and suggest the installation of wind measuring equipment at Kilcredaun, to collect more accurate weather data.

Although there is a wave buoy adjacent to Ballybunnion it cannot record data and is therefore not able to support the analysis of historical records[3]. Shannon Foynes Port Authority is considering upgrading the software to allow the recording of data. The previous historical navigational study, in 1983, wave data was recorded with a wave rider buoy over a period of 1½ years outside the Shannon Estuary and it was recorded that:

- The average significant wave height in the navigation channel was 1.40m
- Spring swell is above 2.0 metres for 28% of the time
- Summer swell is above 2.0 metres for 52% of the time
- Autumn swell is above 2.0 metres for 73% of the time
- Winter swell is above 2.0 metres for 80% of the time
- Waves average 6.8 seconds with 93% of time in the 6 to 8 second range
- Wave direction for about 80% of the time is from SW to NW

The pilots, and SFPC, question the Lievense results and consider them to be too high, particularly in view of the pilot cutter operability records documented at paragraph 2.6.3. Without commissioning a further study or upgrading the existing wave-rider buoy to record and analyse the wave spectral data, it is difficult to assess and validate the existing results. If, subsequently, the data is found to be incorrect the current underkeel, software also created by Lievense using the results of their 1983 study, will warrant scrutiny.

[3] Shannon Estuary, Study of Navigation Channel, Ir. L.W. Lievense b.v. Jan 1983

2.3 Commercial Navigation

Commercial navigation, and its associated cargo handling arrangements, vary considerably. The majority of activity is made up of vessels trading to the following locations:

2.3.1 Limerick Dock

The dock comprises 12 berths, including a small graving dock. It can handle vessels up to 4,400 DWT. Current cargoes include fuel oils, cement, stone, scrap metal, general cargo,

2.3.2 Aughinish Alumina Plant

The jetty consists of two berths capable of securing vessels 225m loa, 12.5m draught, and 80,000 DWT on the outer berth, and 180m loa, 11m draught, and 40,000 DWT on the inner berth. Currents at the berth can be very strong, especially on the ebb, with 6kts being a regular occurrence. The risk of break out is therefore very real, but is mitigated by thorough securing arrangements and line tending procedures.

Annual vessel movements are currently as follows: 70 Panamax vessels, 10 oil tankers (<30,000 GT), 45 chemical tankers (<8,000 GT), 200 – 180 dry bulk (alumina) (6,000 GT). These are expected to increase with time.

2.3.3 Foynes Port

This complex, situated close to the main road in Foynes itself, comprises a total of seven berths at three jetties (West Quay, East Jetty and the Oil Dolphins). Maximum vessel size is 204m LOA and 29m beam. Vessel traffic currently varies between 700 and 900 vessel movements per annum. This is expected to rise significantly with the completion of additional fuel storage tanks now under construction. A further 140 to 160 tanker movements per annum are anticipated.

2.3.4 Tarbert Island Jetty

Purpose built to supply heavy fuel oil to ESB Tarbert Power Station, the jetty can accommodate tankers up to 259m. loa and 14.6m draught. Current traffic levels are in the region of one tanker per month. This could well change as the future of ESB Tarbert is presently under consideration as part of a national strategic review of power generation facilities. One possible outcome is for the jetty and holding tanks to be used for storing and distributing fuel oil. Such an arrangement could result in a significant increase in tanker movements.

2.3.5 Moneypoint Jetty

This jetty is also purpose built, and supplies ESB Moneypoint with coal. Capable of handling vessels up to 380m loa and 25m draught, it currently handles one Capesize bulker every six weeks. With the predicted move to

Panamax vessels for the transportation of coal from its principal supplier, the number of vessel movements is expected to double in the near future.

2.4 Other Navigation

2.4.1 Ferries

Shannon Ferry Group operates a car ferry between Killimer and Tarbert. In winter, crossings are made once per hour in each direction using the newest ferry. In the summer a secondary stand by ferry is brought into service, thus facilitating crossings every 30 minutes.

The primary ferry is powered by four directional thrusters each of 600HP. The standby ferry has four 450HP thrusters. Serviceability is very good, with only one trip lost in 5 years (due to fog). Each ferry is fitted with radar and AIS. Man Overboard drills are exercised weekly using the boarding ramps to retrieve a dummy. Rescue procedures using the ferry's Gemini is carried monthly.

Following a "near miss" between a ferry leaving Tarbert Point and an inward vessel avoiding the ebb tide close to the southern shore, Reporting Points were established upstream and downstream of the ferry crossing.

2.4.2 Commercial Fishing

As a consequence of the Shannon Estuary being designated a Special Conservation Area, fishing on a commercial scale within the estuary is generally limited to shrimp and lobster pot fishing. Pots are normally laid in shallow water and well clear of the main shipping routes. It is reported, however, that pots are occasionally laid in the navigational channel for a few weeks in winter. Shannon pilots have no experience of such practice being an impediment to commercial navigation.

2.4.3 Dolphin Watching

The Shannon Estuary is unique in that it boasts the only Irish water to have resident bottlenose dolphins. As a result, marine tourism in the form of "dolphin watching" has developed into a significant activity. Two companies provide dolphin watching tours, one operating to the east of Kilrush; the second to the west.

Self-evidently, these tours operate in areas where dolphins are visible. They do not therefore navigate to any fixed pattern and may from time to time operate close to, or in the main navigational channel. Conversely, they are often to be seen in close proximity to Moneypoint Jetty where the warm water discharge from the power station attracts fish, and hence food for dolphins. There are no reported incidents of "dolphin watch" boats, all of which are registered and inspected as “passenger boats” by the Irish MSA, impeding commercial navigation.

2.4.4 Angling Charters

Another marine tourist activity is rod fishing. Boats can be hired from a variety of locations, mainly in the western estuary. Bottom fishing on the edge of deeper water, particularly at the turn of the tide can provide excellent sport. Navigational conflict with commercial vessel traffic is not reported to be an issue, even though the narrows in the vicinity of the Beal Bar is a popular angling location.

2.4.5 Recreational Sailing and Boating

Blessed with spectacular scenery and sheltered water the Shannon Estuary has a large and active recreational sailing and boating community. The main locations within the estuary at which recreational craft are moored in significant numbers are as follows:

i. Foynes Yacht Club

The club is made up of both sailing and motor boats, totalling about 30 in number, and ranging in size from 16 to 50ft in length. The main boating season runs from mid March to late October. Cruising between Cork and Galway is a popular pursuit for many members, as are regular sailing races, organised either in and around Foynes, or sometimes off Kilrush.

Whilst strong currents, especially in the narrows around Foynes, can bring challenge and excitement, close quarters situations with commercial vessels are not reported to be a problem. Commercial traffic is comparatively light (i.e. 8 to 10 vessel movements per day). Moreover, there is generally usable sailing water outside the main channel.

ii. Western Yacht Club

The Western Yacht Club, comprising approximately 70 sailing or motor boats, operates out of Kilrush, with the majority of the boats being moored in the Kilrush Marina. Over the winter season (Nov – Mar) a large number of boats are lifted out and stored on the adjacent hard standing. Sailing races are a regular feature of the Club during the active season, and are organised on well established courses. Most of the racing marks used to identify a course are laid by the Club itself. Courses have been designed to keep clear of the main navigational channels. Close quarters situations with commercial shipping are reportedly very rare.

One event which does potentially impact of commercial navigation, and which will require careful management is the West Ireland Yacht

Regatta. This regatta is hosted by different ports on the west coast and usually occurs in the Shannon Estuary once every 4 to 5 years. Up to 100 yachts can be expected to participate.

iii. Kilrush Marina
Kilrush is strategically placed towards the seaward end of the Shannon Estuary. With a modern marina, and comprehensive facilities, it is a popular location for both local and cruising yachts. It provides 120 fully serviced moorings, which can accommodate vessels up to 30 metres in length and 3 metres draught. Of the 120 berths approximately 40% are occupied on a permanent basis. There are plans for a major development of the marina area, involving the construction of an adjacent hotel and residential accommodation.

iv. Tarbert Yacht Club and Ballylongford Creek
Tarbert Yacht Club consists of approximately 30 boats ranging in size from 18 to 30ft. In the adjacent creek at Ballylongford, a further dozen or so boats are moored. These are used in the main for recreational angling.

2.5 Towage

The present towage operations are handled by Celtic Towing Limited. The tugs are chartered by the Electricity Supply Board (ESB) for their berths at Money Pilot and Tarbert. The SFPC has no formal contract with the tugs but there is an agreement that the tugs are available for use elsewhere as required (predominantly Aughinish and Foynes). Being the charterers, ESB have priority when tugs are required. That said, present volumes of vessel traffic rarely result in a conflict of priorities. Three tugs are used when berthing a loaded Capesize bulker.

Celtic Tugs meet this obligation with the following vessels:

Vessel	Type	Bollard Pull	BHP	Foam litres	Towing Winches	Fwd m	Aft m
Celtic Banner	Stern ASD	46t	3500		2	3.2	4.0
Celtic Rebel	Stern ASD	47t	3500	700	1	3.2	4.0
Celtic Isle	Stern ASD	56t	4000	10000	1	3.8	5.2

All tugs are of Japanese design, ASD stern driven, with primary tow position forward. All are approximately 21 years old. The vessel Celtic Banner is the only tug with dual redundancy on the towing winches. None of the existing tugs are equipped to conduct “escort towage” duties.

The tugs are also leased out to other ports: CELTIC ISLE assists with SBM hook-ups at Bantry Bay and CELTIC REBEL assists in Fenit. All tugs have fire-fighting capabilities and the CELTIC REBEL maintains 600/700 litres of foam on board with a 600m^3 per hour fire pump.

The towing equipment for the tugs utilise a NUTEC 12 stranded multi-plat 10" 150mt breaking strain rope for the main tow rope with a Dynema Cosalt 80mm covered pennant. The covered pennant reduces friction wear within the ships panama but does make it more difficult to inspect. The winches have hydraulic brakes but no free-wheel capability; this requires the winches to be operated by a crew member when 'paying out'.

Only the CELTIC ISLE has shore power capability but Celtic Towing Ltd are investigating shore power for the other two tugs to reduce start up times.

The tugs have four crews working 2 days on 2 days off. Each crew consists of Master, Engineer and qualified AB.

Communications appear to be well understood and fairly standardised between pilot and tug.

Whilst the existing fleet of tugs have the capability of handling an LNGC in winds below 25 knots they are not designed for escort towing and may have high point loadings.

2.6 Pilotage

2.6.1 Background

Pilotage is presently being undertaken by eight self-employed pilots, who are licensed by Shannon Foynes Port Authority. All pilots are Class 1 "Unrestricted" and work in two groups; Outbound and Inbound. This system was derived from an historical arrangement whereby an inbound pilot would hand over to a river pilot at Tarbert to take a vessel up to Foynes or Limerick; this has evolved into dedicated Inbound and Outbound pilots. However, all are licensed for both directions, and occasionally help each other, if there is a backlog of vessels. Whilst the system is unusual, it appears to work reasonably well at current traffic levels, with the pilots managing their work schedule themselves.

The system also has merit in that it optimises competence. This can be especially beneficial when manoeuvring vessels in strong and sometimes unpredictable tidal flows. Conversely, it could be detrimental when, say an outbound, and less practised pilot suddenly has to berth an inbound vessel at a difficult location.

Shannon Foynes Port Authority oversees the training and licensing of all pilots. Ongoing training utilises a ship bridge simulator where all pilots are able to simulate emergency situations and differing environmental conditions. There is no formalised peer-review system, but pilots do observe each other and discuss manoeuvres on the simulator. Whilst this is beneficial in terms of ship handling, the Master-Pilot information exchange, including discussion about the passage plan, both of which are critical to safety, are not exercised or assessed.

To assist in berthing a vessel, SFPC has invested in "carry aboard" GPS laptops. These are generally regarded by the Inward pilots as being particularly useful as a docking aid. Their utility for assisting with navigation in transit is more varied. Some pilots claim the laptops are very useful for navigation particularly for large slow moving vessels in strong tides, but it was also suggested that such use can be limited for some transits, and that setting up procedures can act as a distraction.

2.6.2 Boarding and Landing

SFPC Pilotage Directions state:

Pilotage is compulsory for all vessels navigating eastwards of Scattery Island. Pilots will board a vessel in the following approximate positions:

- Vessels over 13m draught: 2nm to the west Ballybunnion Lt buoy
- Vessels greater than 20000 GT: 52°33'.40N 09°43'.70W
- Vessels greater than 5000 GT: 52°35'.40N 09°38'.00W
- Vessels less than 5000 GT: 52°36'.34N 09°28'.71W

When weather conditions prevent safe embarkation at this position, Masters <u>may</u> be given the option of either being guided in to calmer water inside the Beal entrance channel by the pilot using radar and VHF, or waiting outside for the weather conditions improve.

In exceptional circumstances when sea conditions preclude the use of the Pilot Boat to board a Pilot on a deep drafted ship west of Ballybunnion Buoy, it may be possible to board the Pilot using an Irish Coastguard helicopter. This is likely to be an option only when the vessel is large and not prone to violent deck movement. Even so, the helicopter will not land on the ship but will winch the Pilot to the deck.

2.6.3 Pilot Cutters

Pilotage Boarding and Landing is conducted using a certificated Pilot Cutter (LOOP HEAD) based at Kilrush. When unavailable due to breakdown or maintenance, an alternative launch can occasionally be made available from Foynes. This secondary craft is not certificated as a pilot cutter and cannot operate in heavy weather. The principal cutter is normally moored alongside the Cappa public pier, close to the pilot office. It is manned 24 hours per day. In adverse weather, it is able to take refuge in Kilrush Marina. The cutter is a 13m Aquastar hull, powered by Caterpillar engines and capable of 20knots. It is fitted with AIS, radar and VHF.

As a matter of policy, the cutter is restricted, to 2 metres significant wave height as measured by the wave measuring meter in the vicinity of the Ballybunnion Racon Buoy. This equates to about 3 metres equivalent wave height at the outer pilot B&L station (2 miles to seaward). In 2007, the cutter was recorded as being off station due to adverse weather on 8 occasions only, i.e. on 2.2% of the year. However, the engine serviceability record is less impressive, and reflects the difficulty in trying to maintain a vessel in daily use without a readily available back up.

2.6.4 Pilotage Administration

As indicated earlier, there are currently 8 pilots, all of whom are Class1 and are licensed to handle all sizes of vessel. New pilots, having completed initial training, start as Class 4 and are licensed progressively to handle larger ships as indicated below. It takes approximately four years to achieve Class 1 status.

- Class 4 < 100 metres (LOA)
- Class 3 < 150 metres
- Class 2 < 225 metres
- Class 1 > 225 metres

As described earlier, the current pattern of operations whereby there are four Inward and four Outward pilots is largely historical and reflects the time when Limerick and Foynes were the predominant destinations. With the advent of the Tarbert and, Moneypoint power station jetties, and as vessel sizes have increased, port activity has tended to migrate downstream.

Scheduling requires each pilot to be on duty for three weeks, followed by one week off, i.e. six pilots are on duty at any one time with three available on each shift. The three pilots work a predominantly rotational system within their shift (i.e. a turn by turn basis). With present day traffic patterns there is enough spare capacity to accommodate an increase in traffic before having to consider additional pilots.

2.7 Vessel Traffic Services (VTS)

SFPC does not provide Vessel Traffic Services, as defined by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA). It does however generate a traffic image using radar and AIS. Radar transceivers are located at Loop Head, Kilcredaun Head and Tarbert Point. The digitalised output from these systems is integrated with AIS information as received at base stations situated at Loop Head and Limerick; the resultant vessel traffic image is displayed on a three screen work station at the company offices in Foynes. It is also available on a single screen work station at the Cappa Pilot Offices.

Currently, these work stations are not manned on a permanent basis, nor does SFPC employ VTS trained and certificated operators. The information available at the two work stations is monitored on an “as required” basis by the Harbourmaster and his staff in Foynes, and sometimes by Inward pilots at Kilrush when confirming vessel location prior to boarding. It is also used on the rare occasion when a pilot cannot embark due to adverse weather and following discussion with the vessel Master, opts to “talk” the vessel into calmer water.

The provision of information at the work stations is satisfactory for its current purpose. It would, however require further development and refinement in order to support full Vessel Traffic Services, as defined by IALA, and in particular if SFPC decided to implement a Navigational Assistance Service.

2.8 Aids to Navigation

2.8.1 Hydrographic Survey

It is understood that following the Anglo-Irish Treaty of 1921, no Irish Government Agency was given legal responsibility for conducting hydrographic surveys in Irish waters. As a consequence, the source data for the charts of the Shannon Estuary originates either from that derived from the UK Hydrographic surveys of 1842, or in the case of the main navigational channel within port limits, from 1969 and 1979 surveys conducted in conjunction with the development of the Moneypoint ESB power station. SFPC has no in-house survey capability of this magnitude.

2.8.2 Buoys

The Commissioners for Irish Lights (CIL) has responsibility for the provision and maintenance of aids to navigation within Irish territorial limits. This responsibility includes 12 buoys in the approaches to, and within, the Shannon Estuary as far as Scattery Island and the Rineanna buoy. It also includes the leading lights located at Corlis Point. SFPC has responsibility for aids to navigation to the east of these limits starting with the North Carrig buoy, and including 63 other marks and lights. CIL, as the General Lighthouse Authority, has responsibility for inspecting all SFPC lights annually and for approving any new lights within SFPC limits.

2.8.3 Lighthouses

Lighthouses are located at:

i. Loop Head,
ii. Kilcredaun Head
iii. Rineanna Point.
iv. Tarbert Point
v. Garraubaun Point
vi. Rinealaon Point, and
vii. Beeves Rock

Of these (iv) to (vii) inclusive are maintained by SFPC.

2.8.4 Tide Gauges

Tide gauges are located at located at Limerick, Foynes and Carrigaholt. The output from all three locations can be displayed graphically at the SFPC offices in Foynes and at the pilot office at Cappa.

2.9 Mooring Boats and Mooring Gangs

The handling of mooring ropes is undertaken by various companies depending on the location of the berth. Mooring gangs usually wear the correct personal protection equipment (boots, helmet and lifejacket), although instances have been noted where a helmet was not worn in the mooring boat. At Tarbert Oil jetty, two gangs of three are used when securing a vessel. This is in keeping with other ports.

The mooring boats, although not built specifically for purpose, are generally suitable for the required task. Boats, however, do differ between berths. For example Aughinish uses a boat with a protective cage over the superstructure. Crews appear to know their job, albeit they have no formalised training or certificated competence. Mooring operations at Aughinish are particularly challenging given the size of vessel, the limited manoeuvring room, and the strong currents. However, berthing operations at all berths can be equally hampered by tidal currents..

3 PROPOSED LNG PROJECT

3.1 The Terminal

The development site is located immediately to west of Ardmore Point. It is on State (Shannon Airport Development Co) owned land and is designated for development with a four year option. Shannon LNG is the developer. The company is required to achieve planning permission within 2 years.

An onshore risk assessment has been completed by ERM. An Environmental Impact Statement (EIS) has been prepared by ARUP. Berthing manoeuvres have been simulated with the participation of local Shannon pilots using a bridge simulator in Cork.

The jetty which will be built in the vicinity of the 20 metre contour line has specifically been designed to accommodate LNG tankers up to Q-Max size. The bridge simulation was conducted using two vessels:

Size (m3)	Engine	LOA m	Beam (m)	Draught (m)
138,000	Stream Turbine	287.0	45.7	11.0
265,000	Twin-Screw Motor	345.0	55.0	12.0

The simulation confirmed the feasibility of berthing all tankers at low water, port side to, head out on the first of the flood tide.

The envisaged manoeuvre for LNG carriers will be to swing off the terminal, slightly upstream, before making an approach to the jetty. Head out (i.e. heading approximately west) is preferred as it assists in expediting a quick departure in event of an emergency.

3.2 Future Towage

The developers have indicated that they will seek tenders from tug operators for the provision of four new tractor type tugs of about 70 TBP. Two are to be capable of Active Escort operations. All four will have Fifi 1 fire fighting capabilities. Although simulated berthing and other manoeuvres have already been carried out, more are intended in order to confirm tug design and power requirements.

It is intended that two of the new tugs will escort the LNG Carrier from the pilot boarding station. One will be in the Active Escort mode. A third tug will meet the vessel before commencing the swing and berthing manoeuvre.

It is also intended that one tug will be stationed underway at the berth whenever a LNG carrier is alongside. Its primary function will be to police the intended 150m “Control Zone” around the berth. It will also augment the jetty fire fighting capabilities.

Escort tugs will have the capability of stabilising a disabled LNG before a dangerous navigational situation can arise. Although connecting up an escort tug in the outer port approaches could be unsafe in extreme swell conditions, it is anticipated that if conditions permit the embarkation of a pilot, the operation will be possible without undue hazard. Moreover, there is always the option of connecting up on the final approach to the entrance channel, where the prevailing swell is likely to be much reduced and on the LNG quarter. Should tug assistance be required before the active escort tug is connected, a modern escort tug can still provide effective assistance even when unconnected.

Vessel speed for effective active escorting is normally between 3 and 7 knots with a maximum of 10 to 12 knots[4]. Ship speed must be high enough to retain adequate directional control, but slow enough to ensure the escorting tugs can be effective, particularly in the event of a LNGC power or steering failure. The escort tug should be capable of speeds 1.5 times the LNGC approach speed. This will permit it to operate effectively at wide angles to the ship's direction of travel. With significant transverse forces being generated in such circumstances, a wide beam and low towing points will help prevent excessive heel angles.

Dynamic winches are also considered essential so that higher bollard pulls may be safely deployed in relatively high wave heights. Empirical evidence from tug companies suggests that the maximum wave height for effective active towing is approximately 4 metres5 for a large escort tug.

3.3 The LNG Carriers

The vessels normally have a double hull configuration containing 4 or 5 separate cargo tanks with membrane, or MOSS cargo containment. They have a managed cargo boil off system. No fuel oil or other pollutants are carried in the double bottoms and the after peak is a void space.

The expected ships have main engine power of 36,000 to 39,000 bhp; some will be twin screwed; some will have bow thrusters fitted. Steering gear has been designed with a minimum of three pumps & motors, and will be capable of secondary operation. Emergency diesel generators with auto-start are fitted to all LNG Carriers.

A comprehensive planned maintenance system will be in use for all machinery and operational equipment. The LNG Carrier master will be required to inform the LNG terminal of the status of all critical equipment (navigational, propulsion, steering, cargo systems etc). This will be forwarded

[4] Henk, Tug Use in Port, 2nd Edition, chapter 9
[5] Henk, Tug Use in Port, 2nd Edition, chapter 9

and acknowledged by Port Control prior to the vessel being accepted for entry into the port.

The LNG Carriers are expected to have 4 capstans for rope handling. Although detailed mooring arrangements will vary; a common arrangement is for vessels to be fitted with 75 ton working load and 150 ton maximum load sunken bits, with a set on each side at both loaded and ballast draughts. Non-recording CCTV is also sometimes fitted.

3.3.1 Wind Loadings

The LNG Carriers are high sided and can be subjected to considerable wind forces. Leeway can therefore be considerable in strong beam winds and headway will often need to be maintained in order to reduce its effect.

These characteristics need to be taken into account when assessing tug requirements. Sufficient power should be available to ensure that in the event of a LNGC power failure, or a sudden increase in wind, the planned manoeuvre can be undertaken safely. It is a generally accepted rule of thumb that there should be a reserve of 25% tug power, over and above that required to undertake the manoeuvre, in order to stabilise a situation in the event of an emergency. Also when a vessel is underway, a tug has to use some of its power capacity to maintain position (in relation to the vessel) thereby resulting in a loss of available power for the required movement.

The following diagrams assess the wind loadings on Q-Max and Q-Flex LNGC Carriers for loaded and ballasted conditions. They are compared against the capacity of the existing tugs and the proposed new 4 x 70mt tug fleet. Towing capacity is also considered when one tug is out of service.

As mentioned in Section 2.5, the existing tugs could work within the 75% capacity limit for winds below 25 knots for a Q-Flex LNGC so should be able to handle a vessel of this size in mean wind speeds of 20 knots. This diagram is included as the minimum baseline because the tug capacity is already available. They could be utilised in conjunction with the new tug fleet for berthing operations. Such use could facilitate an increased lead in and staggered building phase for the new tug fleet.

The capacity of the new tug fleet (proposed is approx 280mt) would be able to handle a Q-Flex up to 30 knots and gusts of 35 knots; winds for a Q-Max is slightly lower. Thus a mean wind speed of 25 knots would be an appropriate guideline, and 30 knots if the wind was steady and in a favourable direction. It can also be seen that if one tug was out of service then operations should still be possible with mean wind speeds of 25 knots and maximum gusts of 30 knots.

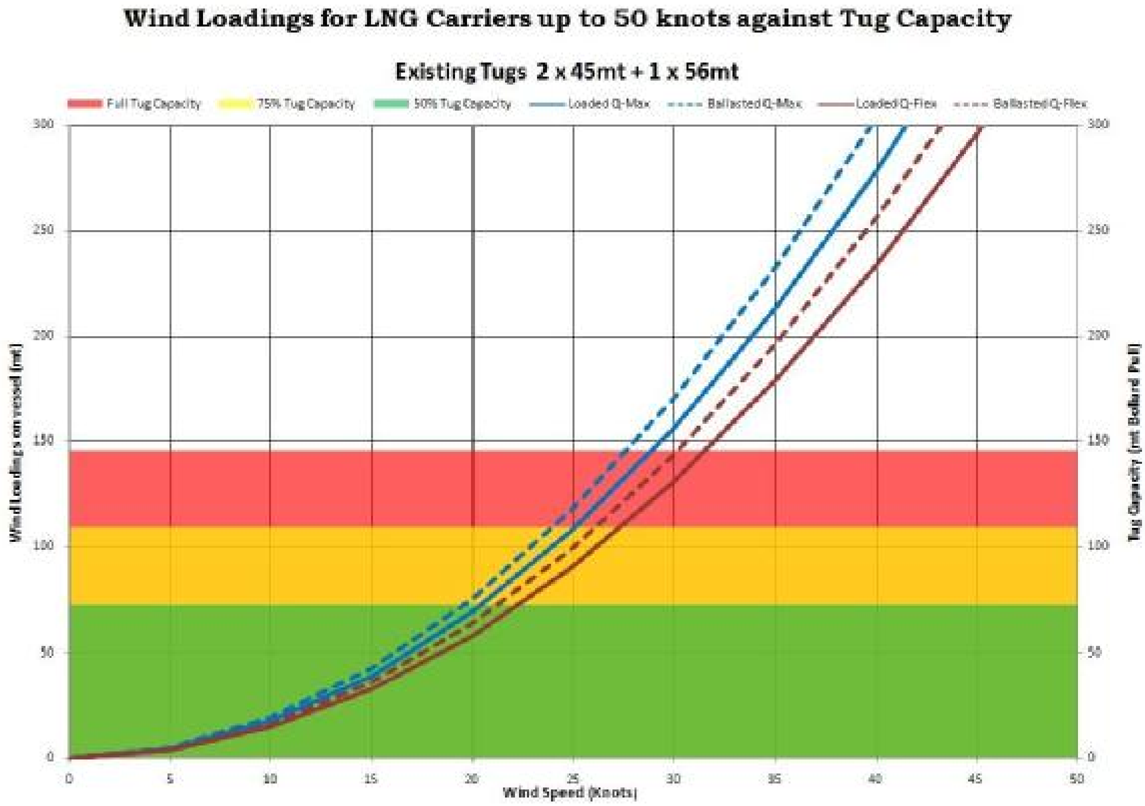


Diagram 1: Baseline Case: Existing Tug Fleet

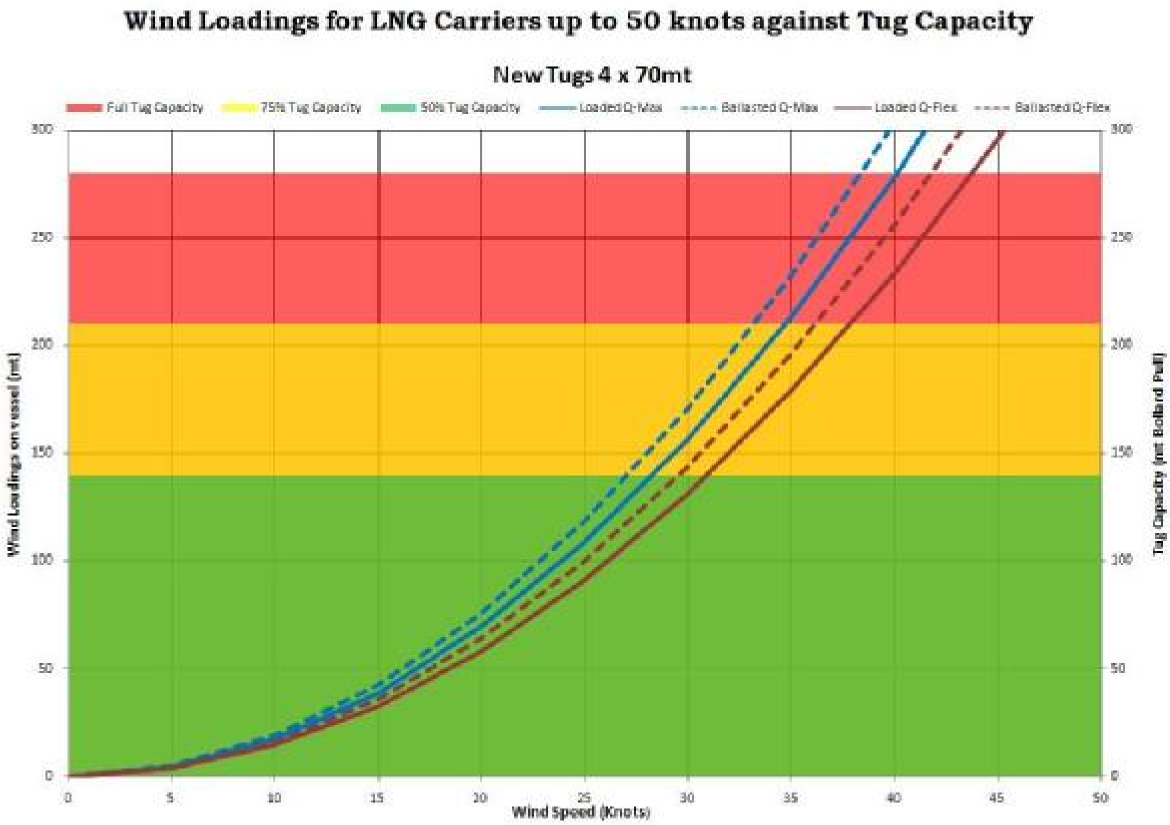


Diagram 2: New Tug Fleet

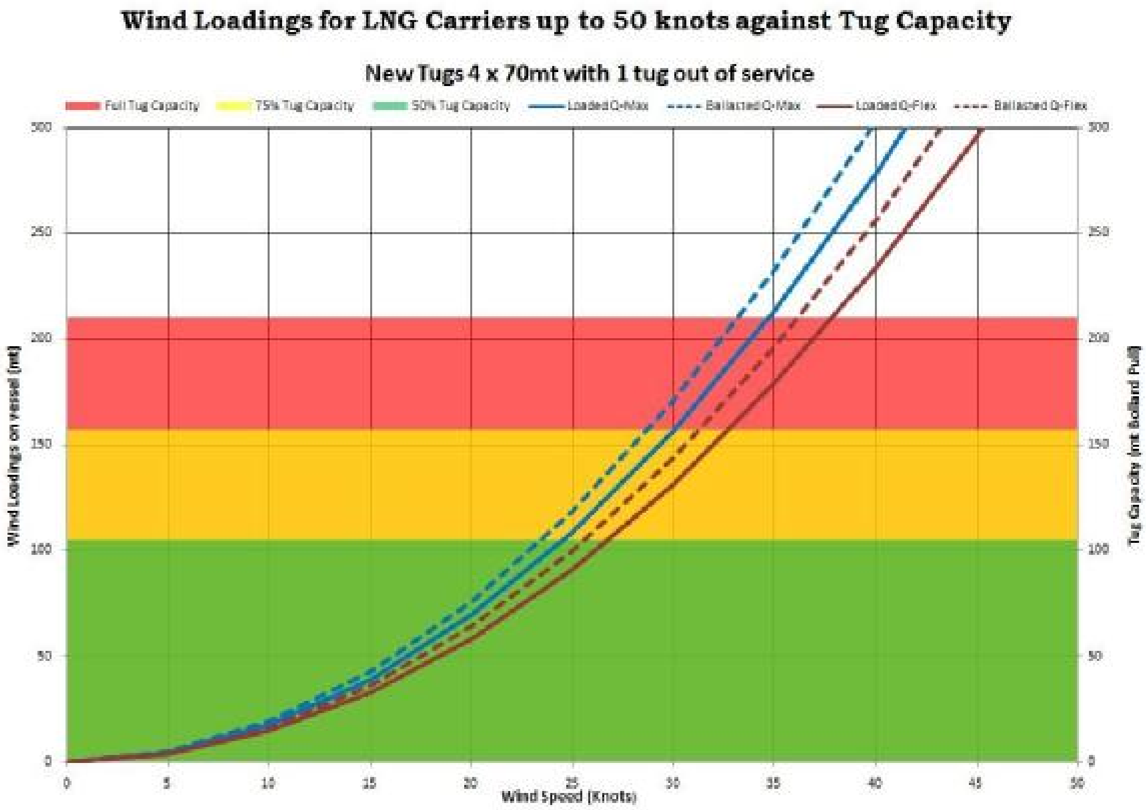


Diagram 3: New Tug Fleet (one out of service)

3.4 Future Vessel Movements

Current overall traffic levels generate approximately 1800 to 2000 vessel movements per year.

Initial LNG traffic, which is expected to start in 2012, will comprise, at least one visit per week, i.e. 104 movements per annum. In addition, port traffic volumes are expected to increase by 70 – 80 oil tanker visits to Foynes, and up to 100 oil tanker movements at a possible oil storage depot close to the proposed LNG site, as depicted in the following table:

TRADE	Ships	Movements	Ships	Movements
	Low	Low	High	High
Current Level	964	1928	964	1928
LNG	52	104	104	208
Foynes NH_3	70	140	80	160
Oil Storage	100	200	100	200
TOTALS ships/moves per year	1186	2372	1248	2496
TOTALS ships/moves per day	3.25	6.50	3.42	6.84
Overall Percentage Increase	23.0%		29.46%	

If all three trade projects come to fruition, the increase in ship visits over the existing levels would be between 23 and 29.5% per year.

Although influenced on a daily basis by tidal cycles, commercial traffic patterns overall are generally stable, and show little seasonal variation, with the exception of fertilizer. Recreational and leisure sailing and boating are expected to increase with the enlargement of the Kilrush Marina.

3.5 Navigational Constraints

As a matter of policy, the developer has stated that no LNG carrier will enter port without having first embarked a Shannon pilot. In the event of bad weather, it is intended that the LNG carrier will remain at sea until conditions permit the safe embarkation of a pilot at the boarding station 2 miles to seaward of the Ballybunnion Buoy. Furthermore, a LNGC will not be permitted to pass the Ballybunnion buoy unless all of the following conditions are met:

- A Licensed Shannon Pilot has embarked;
- An Escort Tug is connected, and a second tug is in attendance;
- The LNG berth is vacant;
- The wind conditions at the berth are within defined parameters, and
- SFPC are able to enforce a “Control Zone” around the LNG carrier of 1 mile ahead, ½ mile astern, and 150 metres on either beam.

It is common LNG practise to remain at sea rather than anchor. Furthermore, in the context of the Shannon development, it is reported that the holding ground for anchorage to the west of the Ballybunnion Buoy is poor.

3.6 LNG Navigation

The approximate distance from the pilot station to berth is approximately 16 nautical miles.

From	To	Distance
Pilot Station	Ballybunnion Buoy	2
Ballybunnion Buoy	Tail of the Beal (Entrance)	4
Tail of the Beal (Entrance)	Doonaha Buoy	2
Doonaha Buoy	North Carrig	5.5
North Carrig	Berth	2.5

From the pilot station there is a minimum depth of 16.3m over the Ballybunnion Bar[6]. The LNG Carrier then has to make a turn to port of almost 20° from 065 ° onto the entrance channel leading lights bearing 047°. This channel has a minimum width of 400 metres 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 45° 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 650metres. The channel is marked by the Rineanna Port Buoy to the north and the North Carrig Buoy to the south. Minimum depth is 17.7 metres, 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 passed the North Carrig Buoy there are no further restrictions before the berth. There is approximately 1 mile (1852m) 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 1000 metres 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.

When conducting the swing to starboard onto the berth, account will need to be made for the significant tidal variations and back eddies, which can generate marked and sudden differences in flow at their interface This interface is reported to be less marked in the area of the proposed LNG jetty, than that observed during a similar manoeuvre off Tarbert Jetty.

Navigation for outbound carriers will be less complex in that they will be on the correct side of the channel when navigating adjacent to the port hand buoys. It was noted that some pilots do occasionally go North of Doonaha port hand buoy to get a better, and more controlled turn to port onto the Corlis leading marks. This practice is made possible by the depth of available water to the north of the buoy line, albeit care needs to be exercised in the region of the 14.6m wreck.

[6] As per survey 1969. The bar is a terminal moraine. A terminal moraine forms at the snout of the glacier. It marks the furthest extent of the ice, and forms across the valley floor and normally resembles a large mound of debris pushed ahead by the glacier. Depths over a terminal moraine are relatively stable as at Shannon.

Pilots board Money Point bulk carriers 2 hours 15 minutes before high water to berth on the start of the ebb. The time required for an LNG Carrier to complete a transit to the berth would be similar.

3.7 Weather Constraints

The jetty has been designed to align with the current flows in that location. It is also well positioned to accommodate the predominant south westerly winds in the estuary. It is, however, exposed to winds from the north. It is understood that the developers intend to set an upper wind speed limit for berthing. This is likely to be 25 knots in the first instance. During conditions when the wind is in excess of this speed, it is intended that the LNG carrier will remain at sea and will not enter port. As a consequence, it is likely that pilot embarkation can be achieved safely on almost all occasions that the wind is less than 25 knots at the berth.

3.8 Intended Berthing Arrangements

The developers have also indicated that it is their intention to source new line handling boats, built specifically for that purpose. Furthermore, it is their intention that mooring operatives will be formally trained and certificated, notwithstanding their general boat handling experience.

4 HAZARD IDENTIFICATION

4.1 Risk Assessment Areas

To facilitate the identification and assessment of risk, the Estuary was broken down into areas appropriate to the needs of the risk assessment. These are shown in the following table.

Area Description	Area Designation
Port Approaches up to Ballybunnion Buoy	A
Ballybunnion Buoy to Doonaha Buoy	B
Doonaha Buoy to North Carrig	C
North Carrig to Tarbert inc LNG jetty	D

Shannon Estuary - Risk Assessment Areas

4.1.1 Area A – Port Approaches to Ballybunnion Buoy

The approaches and entrance are exposed to the Atlantic; large swells and heavy seas are not uncommon which can make pilot boarding difficult, particularly in westerly or south-westerly gales. As a consequence, vessels have, on occasions, been "talked in" to calmer waters. This practice carries with it additional risk. It is not intended to be used with LNG carriers.

The approaches range in depth from 30 to 50 metres, but shallow towards the bar. The Bar, which is marked by a North Cardinal Racon Buoy has depths of 15.8m for a further ½ mile to the north and 15.0m for ½ mile to the south[7].

Whilst the water to the south can be used safely, the deeper water is better defined to the north by the Kilstiffen navigational mark.

Currents vary between 1.5 knots on the flood and 4.5 knots on the ebb but Pilots state that, from their experience, the strong currents are only encountered when approaching the Channel entrance.

4.1.2 Area B – Ballybunnion Buoy to Doonaha Buoy - 'The Entrance'

The entrance is nearly two miles wide but the Beal Bar and Spit reduce the navigable width to approximately 1 mile. The deep water channel is defined by buoys and the Corlis Point leading lights. The channel is approximately 350 metres in width with a minimum depth of 23m[8]. For vessels with draughts equivalent to a large LNG Carrier, safe water exists 300 metres to

[7] BA Chart 1819 Approaches to River Shannon, 19/06/2007.
[8] BA Chart 1547 River Shannon Kilcredaun Point to Ardmore Point, 11/07/2007.

the west of the port hand buoys. Whilst it is not proposed that a LNG Carrier should deliberately leave the channel, the existence of this water could be important in the context of an emergency situation. Currents within the entrance are up to 3.5 knots on the flood and 4 knots on the ebb.

The entrance is often affected by swell, especially when the wind is from the in SW and the ebb tide is at full strength. During, or after a SW gale, a heavy swell can often run straight into the entrance. However, it is reported that conditions are generally less daunting to the east of the Ballybunnion Bar.

The Corlis Point 047° leading lights were provided specifically to assist vessels transiting the Channel. In addition, the port side of the channel is marked by three lateral marks, whilst the starboard side is marked by three cardinal buoys.

At the Beal Bar buoy, the channel opens up into the main estuary. Sea swells sometimes extend as far as the Beal Bar Buoy and could thus affect a vessel turning onto an easterly heading at this buoy.

On completion of this turn, vessels generally leave the Doonaha Buoy to port, albeit there is sufficient water for 400 metres to the north of the buoy. As stated earlier, pilots sometimes leave this buoy to port when outbound as it gives a better turn into the channel.

4.1.3 Area C – Doonaha Buoy to North Carrig

Doonaha Buoy to North Carrig has a minimum charted depth of 17.7m[9] except for a small patch of 15.8m close to the Rineanna Buoy.

The deep water is marked by port hand buoys. The starboard side is unmarked. There is at least 400m safe water to the south of the buoy line.

Currents range from 3.5 to 4.5 knots for both ebb and flood.

The North Carrig Buoy marks the limit of the Carrig Shoals. Their western extremity, however, is unmarked, which necessitates vessels staying in the marked channel.

To the north of the Doonaha – North Carrig channel three anchorages have been designated. Anchorages 1 and 2 are deep enough for an LNG Carrier to anchor at all states of the tide. However, it has been noted that these anchorages can become busy, especially if there have been delays at the Aughinish Alumina berths.

[9] BA Chart 1547 River Shannon Kilcredaun Point to Ardmore Point, 11/07/2007.

4.1.4 Area D – North Carrig to Tarbert including the Proposed LNG Terminal

The water between North Carrig and Tarbert is mainly in excess of 30m. There are two exceptions: the “Bridge” which is only 17.0m and a 6.7m patch to the north west of Tarbert[10]. Although this patch is unmarked, it is unlikely to be a navigational risk to an LNG Carrier as it lies 1½ miles upstream and beyond the proposed LNG jetty and intended swinging area.

The third berthing tug is expected to join the LNG Carrier just after North Carrig Buoy.

As previously mentioned, inshore and to the east of the proposed site, there is a small ship anchorage at Glencloosagh Bay. This provides depths of 7.2m and could theoretically be a problem if the Carrier overshot the expected turn or was forced into the area due to malfunction or emergency. However, given the intention to use three tugs for the swing and subsequent berthing manoeuvre, two of which will have escorted the LNG carrier throughout its transit of the estuary, this scenario is considered highly unlikely.

Currents run up to 3 knots on the ebb. To the south of the proposed LNG jetty, back eddies regularly occur during the last four hours of the ebb.

The proposed jetty will have depths in excess of 20m.

4.2 Accident Categories

The process of assessing operational risks can be greatly aided by grouping the associated hazards into Accident Categories. Those identified as being relevant to this study are:

- Cargo Release
- Collision
- Contact – Berthing
- Contact – Navigation (Allision)
- Fire/Explosion
- Foundering
- Grounding
- Mooring Breakout
- Near Miss
- Personal Injury
- Port Security Incident

Within this Risk Assessment, pollution has been identified as a secondary accident category and only likely to occur as a result of one of the above incident categories. Due to their construction, LNG Carriers do not pose a significant pollution risk except from bunker tanks; however, these tanks are

[10] BA 1548 River Shannon Ardmore Point to Rinealon Point, 13/08/2007

normally well protected by the double hull construction of these vessels. The absence of pollution incidents involving LNG Carriers supports this view.

4.3 Draft Hazard List

Using the information gathered during the consultation phase, a draft Hazard List was prepared prior to the HAZID meeting. This was then used to facilitate discussion between the participants.

4.4 Incidents

When establishing the likelihood of an unwanted event occurring, it is important to take into consideration the historical record of incidents in the area.

As a result of discussions with SFPC and other stakeholders, it was established that the following marine incidents have occurred during the last 20 years:

Incident Type	Occurrence in 20 years	Incidence	Rate of Incident per Movement
Collision	0	0	0
Contact [with fixed object][11]	1	1 in 20 years	2.59E-05
Grounding	1	1 in 20 years	2.59E-05
Fire / Explosion	0	0	0
Hazardous Incident	0	0	0
Accident To Person	0	0	0
Capsize/Listing	1	1 in 20 years	2.59E-05
Flooding/Foundering	0	0	0
Mooring Breakout	1	1 in 20 years	2.59E-05
Pollution or Escape of Harmful Substance	1	1 in 20 years	2.59E-05
Person Overboard	2	1 in 10 years	5.19E-05
Machinery Failure	1	1 in 20 years	2.59E-05
Overall Total	8	1 in 2.5 years	2.07E-04

Unfortunately such small numbers, whilst welcome in themselves, are too few to generate meaningful statistics. That said, it was noted that records have not apparently been maintained consistently, nor have near misses been included. It is possible that this lack of formalised reporting and recording may have contributed to the apparent low rate of known incidents.

The International Group of P&I Clubs[12] has identified that an approximate incident rate of 1 in 100,000 pilot moves has occurred in the UK (for claims

[11] Incident also resulted in pollution due to hull being breached in way of a fuel tank

over $100,000) over a 5 year period. This Group also identified that the most claims were due to contact with a fixed object and that the most expensive claims were from grounding. Groundings and Contacts, in the Shannon, (2 in 20 years, i.e. 2 in 40,000 movements) give an approximate rate of 5 in 100,000 moves. However this is not to suggest that Shannon has a high incident rate as incidents in the Shannon estuary often involved smaller and sometimes unpiloted vessels transiting upstream to Foynes and Limerick. Any direct correlation with LNG movements is therefore inappropriate.

On balance, current records would indicate that the Shannon incident rate is probably within an acceptable range and considered normal for most ports.

4.5 HAZID Meeting

A structured HAZID meeting was held on 6th February 2008. A record of attendees is attached as Annex B. The draft Hazard List prepared by the Marico team, during Stage 1, was tabled at the meeting. All of those present participated fully in the ensuing discussions and helped to validate and/or amend the draft list. Marico Marine is greatly indebted to those attending.

By the end of the meeting, a total of 55 hazards had been validated from the draft hazard list, or alternatively, were identified during the meeting. They fell into the following categories:

Hazard Category	Identified Hazards
Contact - Navigation	14
Collision	12
Grounding	8
Personal Injury	6
Foundering	4
Fire\Explosion	3
Mooring Breakout	3
Near Miss	2
Contact - Berthing	1
Cargo Release	1
Port Security Incident	1

[12] International Group of P&I clubs; Pilotage Sub-committee Report on pilot error related claims over US$100,000 From 20.02.99 to 20.02.04

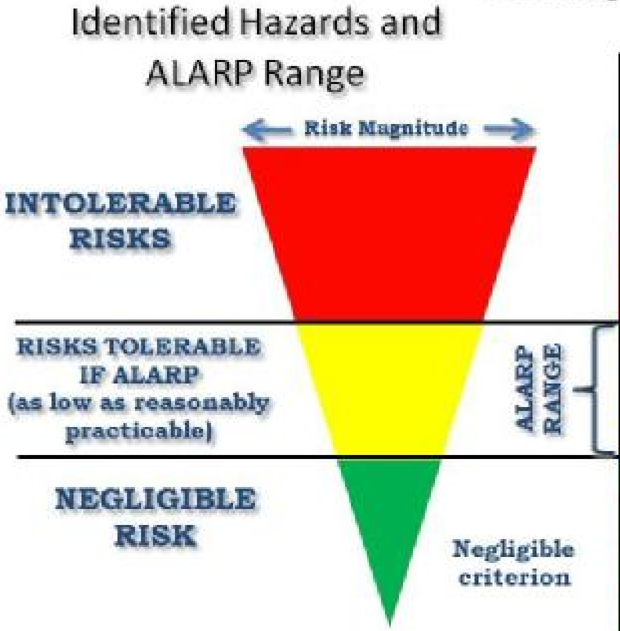
5 RISK ASSESSMENT

5.1 Overview of Hazards

The second objective of a HAZID meeting is the scoring of each confirmed hazard for Likelihood and Consequence. This then enables the HAZMAN software subsequently to establish a Risk Factor for each hazard on a linear scale of 0 to 10, which in turn facilitates the production of a Ranked Hazard List.

It is worthy of note that of the 55 confirmed hazards all the overall Risk Factors were within the ALARP range, thus suggesting that the risk controls currently in place are managing overall risk satisfactorily.

Pre Mitigations



Aggregate Risk Score	Risk Definition	No. of Hazards
10	Intolerable	0
9	High Risk	0
8	Significant Risk	0
7	Heightened Risk	0
6	Tolerable if ALARP	0
5	Tolerable Risk	7
4	Tolerable Risk	14
3	Low risk	20
2	Low risk	12
1	Negligable Risk	2
0	Negligable Risk	0

However, when the risks are scrutinised by individual consequence, both in the Most Likely and Worst Case scenarios, there are number which are scored at 6 or 7. Scores of 6 should only be considered tolerable if, with all available mitigations, the risk is as low as reasonably practicable. Scores of 7 fall into the Heightened Risk category, as a result of which, consideration needs to be given to reducing their risk factor further. (See diagram in Section 6.1.1 for breakdown).

The final Ranked Hazard List is shown in Annex C. It should be noted that the scorings in this list take into account existing mitigation measures. They do not, however, address the effects of the additional measures identified during the risk assessment process, and/or proposed by the developer. A commentary on each risk category, as discussed with stakeholders at the HAZID meeting follows:

5.2 Accident Categories

5.2.1 Contact - Navigation

Contact - Navigation includes all contacts that a vessel underway may have with a fixed object such as a navigation mark[13]. It also includes contact with vessels alongside or at anchor.

In total, fourteen hazards were identified, 7 involving the LNG carrier, or other large commercial vessels, and 7 involving recreational or small commercial/service craft, as illustrated in the following tables.

All fourteen hazards had overall risk factors well below the ALARP level. However, within these overall scores, six had individual consequence scores at the upper end of the ALARP range, and in the Heightened Risk category. These merit consideration of additional mitigation measures.

Given the width of the estuary off Ardmore Point (approximately 1 mile) and the distance between the proposed Ardmore Jetty and that at Tarbert (2 miles), the likelihood of contact between a LNG Carrier and a vessel alongside at these jetties, or vessel manoeuvring off these berths and a berthed LNG Carrier was considered so unlikely as to merit the lowest frequency score.

To the east of the proposed LNG Terminal, smaller commercial vessels often anchor in the Glencloosagh Bay charted anchorage. Some vessels also take advantage of the back-eddies when entering port at certain states of the tide, and consequently navigate close to the proposed location of the LNG jetty. When, however, a tanker is berthed at Tarbert Jetty, existing procedures prohibit such practice.

Two risks were identified involving a LNG Carrier in contact with an Aid to Navigation, the first in circumstances where weather precluded a pilot from embarking to seaward of Ballybunnion Buoy. Following discussion with the developers, this hazard has been discounted as it will be policy that no LNG carrier will ever enter port without an embarked pilot.

Of the hazards associated with commercial leisure, recreational or harbour service craft, those involving the Dolphin Watch vessels merit particular consideration. Whilst the likelihood of them hitting the LNG jetty, or a LNG carrier alongside could be mitigated by imposing a Control Zone, the associated consequences of heavy contact with could be serious given the large number of passengers usually embarked.

[13] Contact with a fixed object is also referred to as ‘allision’ by some authorities/countries

Rank No.	Hazard Detail	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall
Commercial Contact Navigation Hazards										
14	A Lead-In LNG Carrier in contacts channel mark	0	4	0	6	0	6	0	6	4.35
15	Other vessel comes into contact with unoccupied LNG Terminal jetty	2	4	0	2	3	6	3	5	4.28
16	LNG Carrier contacts vessel at anchor	0	5	0	5	3	6	0	6	4.26
17	Berthed LNG Carrier contacted by passing vessel	2	5	0	2	4	5	4	5	4.17
19	Large vessel such as a Capesize BC contacts jetty or vessel berthed alongside whilst swinging off Money Point	0	4	0	4	5	5	5	5	4.07
20	LNG Carrier comes into contact with berth or another vessel alongside during transit and swing	1	4	3	3	3	5	4	5	4.07
34	LNG Carrier in contact with channel mark	0	4	0	0	0	6	0	6	3.61
Service Craft Contact Navigation Hazards										
48	Escort tug contacts navigational mark	0	3	0	0	0	4	0	3	2.55
Commercial Leisure Contact Navigation Hazards										
32	Dolphin Watch involved in contact with LNG jetty	2	2	0	2	6	5	2	5	3.63
33	Dolphin Watch involved in contact with LNG carrier alongside	2	2	0	2	6	5	2	5	3.63
39	Commercial angling craft involved in contact with LNG Carrier jetty	0	2	0	2	5	5	2	5	3.15
40	Commercial angling craft involved in contact with LNG Carrier	0	2	0	2	5	5	2	5	3.15
Recreational Contact Navigation Hazards										
43	Leisure craft involved in contact with LNG Carrier alongside	0	2	0	0	5	5	2	3	2.91
44	Leisure craft involved in contact with LNG jetty structure	0	2	0	0	5	5	2	3	2.91

Contact – Navigation incidents are principally caused by a failure to control the vessel or a failure in the navigation of the vessel. The following origins of failure are typical:

Failure to Control the Vessel	Failure in the Navigation of the Vessel
Equipment Failure	Incorrect Action
Environmental Conditions	Failure in Command Structure (Bridge Team or Communications)
Ship Design/Hydrodynamics	Failure of External Intervention (VTS)
	Failure through an External Source

5.2.2 Collision

Collisions involving through traffic in a river or channel tend to result from interaction between vessels (either overtaking or passing close in the opposite direction). As a consequence, the angle of impact tends to be shallow, resultant damage is limited, and the risk of major pollution or injury is reduced. Although it is not unknown for a vessel involved in such an incident subsequently to ground, the benign nature of the Shannon seabed is such that catastrophic damage is unlikely. LNG Carriers are, anyway by their construction, less vulnerable to hull penetration in the event of a collision or grounding.

Vessels swinging to manoeuvre onto or off berths are potentially more vulnerable to collision, due to their reduced manoeuvrability and the likelihood that such collisions would involve broader angles of impact ("T-Bone"). However, it is considered unlikely that another vessel would be transiting the intended swinging during such a manoeuvre. Where such an occurrence might occur, it is open to the port authority to control navigation to mitigate this risk.

Twelve collision hazards were identified during the HAZID meeting. These can be sub-divided into three groups: large commercial vessels, small commercial leisure and recreational craft, and service craft.

Notwithstanding the risk of pollution may have been reduced by a shallow angle of impact and the nature of the seabed, any collision between an LNG carrier and a large commercial vessel can be expected to result in costly damage to property. As a consequence its scored risk factor puts it at the top of the Ranked Hazard List. The most likely areas in which such a collision might occur are at the two pinch points at the Beal Bar and Carrig Shoals. Options for mitigating this risk are discussed in Section 6.

A collision in the port approaches has been ranked as No. 8 in the Hazard List, due largely to the absence of an embarked Shannon pilot. However options for mitigating this risk are potentially available, and these are also discussed in the following Section.

Any small craft, such as leisure craft, fishing vessels, commercial anglers or Dolphin Watch boat, is likely to sustain serious damage and injury to personnel in the event of a collision with a LNG Carrier. This is particularly so for the latter category, where large numbers of passengers can be expected to be embarked. Whilst it is current practice for such craft to keep well clear of commercial vessels navigating in the deep water channel, the regular presence of dolphins close to these ships potentially increases the risk for the Dolphin Watch boats. Options for additional mitigation are therefore addressed.

Service craft, i.e. tugs and pilot cutters, require by the nature of their work to manoeuvre close to the LNG Carrier. However, mitigating the associated risk of collision is the competence of the associated crews, all of whom are both highly trained and experienced in such operations. It is recognised, however that the use of a tug in the active escort role, particularly in adverse environmental conditions, does increase risk, albeit the consequences are unlikely to be catastrophic, even in the Worst Case scenario.

Rank No.	Hazard Detail	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall
Commercial Collision Hazards										
1	LNG Carrier in collision at a navigation pinch point	4	7	0	7	6	6	6	6	5.86
8	LNG Carrier in collision with another vessel in port approaches	3	6	0	6	5	5	5	5	4.98
10	Cruise vessel in collision with LNG Carrier	4	5	0	5	5	5	5	5	4.71
26	LNG Carrier unable to manoeuvre onto berth and drifts down onto ferry	3	3	0	4	4	5	0	5	3.80
Service Craft Collision Hazards										
11	LNG Carrier damaged by contact with tug	2	6	0	2	2	6	0	6	4.49
21	Escort tug in collision with LNG Carrier during ship escort / connection	4	4	0	0	5	6	0	3	4.04
23	Tug in collision with LNG Carrier during maneouvring and/or connecting up operations	3	0	0	0	6	6	5	5	3.92
42	Pilot launch or harbour craft in collision with LNG Carrier	2	2	0	0	5	5	2	5	2.93

Commercial Leisure Collision Hazards										
9	Dolphin Watch collides with LNG Carrier in Port Approaches	5	2	0	5	6	6	5	6	4.83
35	Fishing vessel in collision with LNG Carrier whilst retrieving pots	3	2	0	3	5	3	2	5	3.58

Recreational Collision Hazards										
12	Leisure craft collides with LNG Carrier in Port Approaches	5	2	0	3	6	5	2	5	4.42
41	Leisure craft obstructs vessel manoeuvring on/off berth or swinging in the fairway or manoeuvring in an anchorage.	2	2	0	2	5	3	2	3	3.13

The typical origins of failure in the context of a collision incident are:

Failure to Control the Vessel	Failure in the Navigation of the Vessel
Equipment Failure	Incorrect Action
Environmental Conditions	Failure in Command Structure
Ship Design/Hydrodynamics	Failure of External Intervention (VTS)
Support Vessel Failure	Failure to Sight Other Vessel
	Failure with Navigation Equipment

5.2.3 Grounding

The nature of the seabed in the Shannon Estuary is generally such that any vessel grounding is unlikely to suffer a major breach of containment. More serious damage, however, could be sustained should a vessel ground on a wreck or other high spot, of if it takes the ground across a dredged box. Large vessels are particularly prone to structural failure of the hull in such circumstances. Whilst the Shannon Estuary is relatively deep throughout the intended route of the LNG Carriers, the risks inevitably increase in the vicinity of Ballybunnion Bar, the Beal Bar and the Carrig/Rinneanna Shoals. As the most effective measure for reducing a risk of grounding is competent navigation, particular attention should be paid of the Aids to Navigation available in these areas.

Relevant to any discussion on grounding is the fact that groundings, whilst accounting for only 3% of incidents worldwide, are often the most expensive. Evidence from P&I Clubs[14] indicates that the costs associated with groundings accounts for 35% of their total claims. The average cost of a single grounding is estimated to be US $7.8millon. This compares with the average cost of a pollution incident of US $1.8million.

Eight grounding hazards were identified at the HAZID meeting, with four lying in the top five of the Ranked Hazard List. However, the one involving a LNG Carrier with no pilot onboard being talked or “lead-in” to calmer water can effectively be discounted in view of the stated policy that no LNG Carrier will be allowed to enter port without an embarked pilot. That said, the procedure is currently used by Shannon pilots for other types of vessel, albeit rarely, and so the associated hazard has been retained in the Ranked Hazard List.

[14] International Group of P&I clubs; Pilotage Sub-committee Report

Rank No.	Hazard Detail	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall
Commercial Grounding Hazards										
2	A Lead-In LNG Carrier leaves fairway and grounds between Tail of Beal and Beal Bar Buoys	2	6	0	7	4	7	0	7	5.61
3	LNG Carrier grounds in the port approach prior to boarding pilot	2	6	0	6	4	7	0	7	5.27
4	LNG Carrier leaves channel between Doonaha Buoy and North Carrig and grounds	2	6	0	6	4	7	0	7	5.27
5	LNG Carrier leaves fairway and grounds between Tail of Beal and Beal Bar Buoys	2	6	0	6	4	7	0	7	5.27
13	Vessel misjudges turn in vicinity of Beal Bar/ Doonaha Buoy	2	5	0	5	3	6	0	6	4.38
24	LNG Carrier grounds near berth during swinging manoeuvre	0	5	0	5	3	5	0	5	3.91
28	LNG Carrier grounds during transit of Ballybunnion Bar inward or outward	1	4	0	4	3	5	0	5	3.71
Service Craft Grounding Hazards										
53	Pilot launch grounds whilst attending LNG Carrier	0	1	0	0	0	4	1	4	2.09

Faults leading to a grounding incident primarily fall into the same two categories as Contact and Collision, namely:

Failure to Control the Vessel	Failure in the Navigation of the Vessel
Equipment Failure	Incorrect Action (Ship-handling, Monitoring, Knowledge)
Environmental Conditions	Failure in Command Structure (Bridge Team or Communications)
Ship Design/Hydrodynamics	

These may be expanded as follows

1) A miscalculation or misjudgement by the ship handler (normally the pilot) during the transit.
2) A strong tidal set across the entrance at certain states of the tide. This can be exacerbated by late pilot boarding, vessels standing in too close.
3) A strong cross-wind generating excessive leeway and the vessel not able to maintain her track.
4) Lack of support from the bridge team and inadequate master/pilot exchange with poor monitoring of vessels track.

5) The failure of equipment on the LNG Carrier whilst being passively escorted. The failure could be either due to an engine failure, steering failure or both.

The Most Likely case is considered to involve a minor/moderate grounding with possible breaching of the hull. The Worst Case scenario would involve a major breach of the hull, pollution, and a declaration of a major port emergency. However, the consequences of grounding depend , a grounding in the entrance where the bottom is unforgiving, is likely to lead to more extensive damage than if an incident were to take place in a less critical location. As the proposed LNG carriers do not store fuel in the double bottoms, little, if any, pollution is envisaged. Conversely, if the hull of a double skinned vessel is breached, it is likely that draught will increase due to loss of buoyancy, with subsequent complications when refloating the vessel.

As stated above, competent navigation is the key to mitigating the risk of grounding. Up to date charts are therefore essential. Given the increasing use being made of electronic charts in modern ships, it will be critical that the charts of the Shannon Estuary are accurate and that the electronic versions are based on the WGS 84 datum. This is not currently the case.

Although the expected draught of LNG Carriers trading into the Shannon Estuary is not expected to exceed 12.5 metre, thus providing them with unrestricted access throughout the tidal cycle, careful consideration will need to be given to the reduction in Under Keel Clearance (UKC) induced by heel. A vessel of 50 metres beam can expect to increase draught by 1 metre for every degree of heel or roll.

The risk of grounding as a result of a failure of propulsion or steering, whilst ever present, occurs most often when a vessel changes its machinery state, i.e. just before conducting its final berthing manoeuvres. The intended use of tugs in the active escort role for the LNG Carriers will largely negate this risk.

5.2.4 Fire/Explosion and Port Security Incident

Due to the way LNG is stored onboard, an explosion on an LNG Carrier is considered to be extremely remote. This assumption is supported by the fact that LNG is transported at -160°C and is not pressurised[15]; furthermore, the accident statistics of the LNG industry worldwide endorse this view. The most likely source of a fire, therefore, is either from an engine room or accommodation fire. Even then, LNG will only ignite if it has leaked and has returned to a fully gaseous state. Given the fact that such a process involves the rapid dissipation of the gas, contact with a fire source, whilst not

[15] There is a slight positive pressure through boil off; this positive pressure is maintained throughout, whether loaded or empty. The advantage of positive pressure is that air cannot enter the cargo space thereby a flammable atmosphere cannot develop.

impossible, is much reduced. Again, the safety performance of the LNG industry stands testament to the unlikelihood of such an event occurring.

LNG Carrier fire fighting and detection systems are stringently regulated and are amongst the most sophisticated systems in the marine industry[16]. These regulations are the primary reason why LNG Carriers have had an excellent safety record. Both vessels and terminals are subject to regulations and standard operating procedures (ISGOTT)[17], which require them to meet a minimum fire fighting capability and utilise internationally recognised procedures to reduce the risk during the transfer of cargo. All ships have to comply with the International Safety Management (ISM)[18] Code which is designed to ensure that the vessel is operated in a safe and reliable manner; this is monitored by port state control personnel, classification societies and, of significance to the tanker industry, by vetting inspectors.

Catastrophic failure of the cargo containment tanks could only conceivably occur as a result of major external impact; i.e. another vessel at speed in collision with an LNG Carrier. The construction of the tanks, however, is such that it would require extraordinary impact to penetrate a tank and to date no such penetration has occurred within the industry. As indicated above, due to the temperature of the gas in the tanks, any escaping cargo would 'boil off' and dissipate very rapidly. If an ignition source is present and the cargo does ignite, often the most appropriate strategy is to let the fire burn itself out, whilst protecting surroundings[19]. Catastrophic failure and subsequent fire rarely results in an explosion. Moreover, the possibility of a Boiling Liquid Expanding Vapour Explosion (BLEVE) on a gas carrier can almost be excluded as the Gas Codes require pressure relief valves which avoids any pressure build up[20].

Notwithstanding the above, fire is always recognised as a major risk and three hazards were identified at the HAZID meeting. The cost of a fire, however small, can be considerable. Moreover, given the public perceptions concerning LNG, a fire onboard a LNG carrier in the Shannon Estuary could have far reaching PR and business consequences.

The risk of a terrorist incident in the context of LNG is reflected by the high standards of physical security planned by the developers throughout the terminal, including the jetty and any vessel alongside. Furthermore, the requirements of the ISPS Code will apply equally to LNG Carriers when underway or when secured to its berth.

[16] International Maritimes Organisation's Gas Codes. International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk – better know at the **IGC Code**.
[17] ISGOTT – International Safety Guide for Oil Tankers and Terminals (5th Edition 2006)
[18] http://www.imo.org/HumanElement/mainframe.asp?topic_id=287
[19] Liquified Gas Handling Principles,(LGHP) Sigtto 2000, 3rd ed. p137
[20] LGHP Sigtto 2000, 3rd ed. p49

Rank No.	Hazard Detail	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall
Commercial Fire/Explosion and Port Security Incident Hazards										
6	Fire on LNG Carrier whilst alongside	4	4	0	2	7	7	2	7	5.03
7	Fire on LNG Carrier while underway in harbour areas	4	4	0	2	7	7	2	7	5.03
36	Terrorist Incidents which can impinge on all/any activities and operations in the port.	0	0	0	3	5	5	4	5	3.57
Service Craft Fire/Explosion and Port Security Incident Hazards										
25	Fire on Service Craft in attendance at LNG terminal	4	0	0	2	5	5	3	5	3.88

A port security incident is often unpredictable. The most likely scenario is a civil disturbance of some kind, albeit it has to be recognised that a full blown terrorist attack on a vessel could lead to the same worst case outcome as a fire.

The failures associated with incidents in this category are as follows.

Fire Initiation	Port Security Incident
External Causes	Internal Incident
Shipborne Causes (Fuel Sources / Ignition Sources)	External Incident
	Terrorism
Fire Protection Failure	

5.2.5 Contact – Berthing

Every vessel faces the risk of contact damage every time it berths and, to a lesser extent, departs. There is also a slight possibility of damage whilst alongside but this is considered unlikely in the context of the LNG berth in the Shannon Estuary.

In particular, the intended use of at least three tugs when berthing is designed to reduce significantly the risk of serious damage to minimal proportions, as is the application of a maximum wind speed limit for berthing.

Added to this, LNG Carriers are primarily longitudinally framed which reduces side impact damage that often occurs on bulk carriers of the same dimensions. This is because the loadings, from a fender, are transferred more readily to the ship longitudinal structure. Fenders have design loadings which will stipulate a maximum berthing speed and vessel deadweight size.

Taking the above into consideration, one hazard was identified at the HAZID meeting. The associated risk however, was assessed to be mitigated satisfactorily by the intended design of the berth and its fender system, the use of powerful tugs, and the provision of visual readouts at the jetty of approach speeds, current and wind strength and direction.

Commercial Contact Berthing Hazards										
Rank No.	**Hazard Detail**	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	**Risk Overall**
27	LNG Carrier contacts berth heavily	2	4	0	2	2	5	2	5	3.74

The principal causes for this hazard are misjudgement and adverse weather conditions. The most likely scenario would result in minor damage to the ships plating and/or slight damage to the fendering system – a low energy impact. In the worst case, this could be moderate, possibly with pollution if a bunker tank is damaged; damage to the berth could require it to be closed for repairs leading to delays to other vessels. Swinging off the berth has been primarily categorised as a contact navigation hazard, but it would fall into this category if the swing was part of the berthing/sailing manoeuvre.

Analysed failures showed two primary areas where faults could occur, with a third area concerning the mooring operation:

Failure to Control the Vessel	Failure in the Navigation of the Vessel
Equipment Failure	Incorrect Action
Environmental Conditions	Failure in Command Structure
Ship Design/Hydrodynamics	Failure through an External Source
Support Vessel Failure	
Failure during Mooring Operations	

5.2.6 Mooring Breakout

Opposite to the LNG jetty at Ardmore Point, but one mile distant on the northern shore of the Estuary, is the Moneypoint Power Station Jetty. Tarbert Oil Jetty lies two miles upstream. There is therefore a theoretical risk of another vessel causing a berthed LNG Carrier to break its moorings, or conversely, a LNG Carrier causing a vessel at either of these two jetties to break out. However, when examining in detail the associated passage routes and berthing manoeuvres, the risk of this occurring was considered to be extremely remote, in view of the distances involved and the likely speed of vessels in transit. As a result, the resultant risk factors were assessed to be low.

Of greater possible concern, is the possibility of breakout, following a failure of a vessel mooring systems. In the case of this happening to a LNG Carrier, the intended stand-by tug would be immediately available to stabilise the situation. Moreover, the manifold auto-shut down system would contain any loss of LNG liquids to less than 3 litres. Again the risks of a vessel at Moneypoint or Tarbert Jetty breaking its moorings and drifting onto the LNG berth before it could release an anchor, or otherwise control the situation is considered to be extremely remote.

Commercial Mooring Breakout Hazards										
Rank No.	**Hazard Detail**	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	**Risk Overall**
47	LNG Carrier passing other jetties causes vessels alongside to part moorings.	0	1	0	1	1	5	1	5	2.65
50	Mooring breakout at another berth drifting near LNG Terminal	0	0	0	0	3	6	0	6	2.44
51	Mooring breakout of LNG Carrier during cargo transfer alongside jetty	0	0	0	0	3	6	0	6	2.44

5.2.7 Personal Injury

Six personal injury hazards were identified. Personal injuries are always inherent in marine operations due to the dynamic environment in which personnel habitually work. Those identified fall into three categories: connecting up the tug to the LNG Carrier, mooring the LNG Carrier and the transfer of pilot to/from the Carrier.

The greatest hazards are associated with the use of mooring and tow ropes and the inherent possible entrapment of hands, feet and limbs. There are also slip hazards from wet surfaces, which can lead to falls especially if a service craft comes into contact with the Carrier.

Design of work spaces, training, procedures, operational parameters, and the use of personal protection equipment are the primary controls to reduce personal injury. Notwithstanding these measures, an accident can never be discounted, even to the best trained employee. Injury during towing and/or mooring are considered the most hazardous scenarios, followed by the risks inherent in pilot embarkation/disembarkation in adverse weather.

Rank No.	Hazard Detail	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall
Commercial Personal Injury Hazards										
31	Personal injury to LNG carrier crew during towage and/or connecting up	4	0	0	0	6	2	0	4	3.67
Service Craft Personal Injury Hazards										
18	Personal injury to tug crew during towage and/or connecting up	4	2	0	2	6	4	0	4	4.09
29	Line boat crew suffer personal injury during berthing operations	6	0	0	0	5	2	0	3	3.70
30	Mooring gang sustain injuries during mooring (or unmooring) operations on dolphins	4	0	0	0	6	2	0	4	3.67
45	Personal injury to launch crew during pilot transfer or operation in exposed areas of Estuary or outside entrance	2	0	0	2	5	0	0	5	2.73
46	Pilot suffers personal injury during transfer to or from an LNG Carrier	2	0	0	2	5	0	0	5	2.73

The two primary categories of cause are:

Human Factors	Working Environment
Experience / Training	Working Conditions (Equipment/Operations/Conditions)
Manning Levels	Movement of Vessel
Inattention / Complacency	Environmental Conditions

5.2.8 Foundering

Four foundering hazards were identified although the risk factors in all four cases were scored as “Low”. The historical hazard of a tug being girted during berthing manoeuvres, especially in poor visibility, has been greatly reduced by modern tug design and better operational safety procedures, including those associated with maintaining watertight integrity.

Pilot launches are specifically designed and certificated to operate in challenging conditions. Most operational situations that a cutter could be expected to encounter are thus mitigated by its inherent design. The most realistic scenario wherein a pilot cutter could conceivably flounder was considered to arise should a cutter lose its engines or steering. Reliability of these systems thus plays a key factor in managing this risk.

Line boats operate at or near the berth so are not normally subjected to excessive weather. The primary cause of a line boat capsizing is likely to occur in circumstances where it is unable to release a mooring line under tension. Exceptionally, anchors have been known to be dropped onto a line boat causing it to sink. There is also a remote chance that a disabled mooring boat could capsize if forced either under a vessel's bow or stern or pinned under the jetty structure by the tide.

Service Craft Foundering Hazards										
Rank No.	**Hazard Detail**	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	**Risk Overall**
22	Pilot launch floods in adverse weather/sea conditions during LNGC pilot operations	0	2	0	5	5	5	3	4	3.97
37	Tug floods or is capsized during ship assist	0	2	0	0	6	6	5	6	3.47
38	Escort tug floods whilst assisting LNG Carrier	0	2	0	0	6	6	5	6	3.47
49	Line boat capsizes during mooring operations.	2	0	0	0	4	4	1	4	2.45

5.2.9 Others

Three additional marine related hazards were identified within the risk assessment. LNG cargo release hazards are not strictly marine related but could occur alongside, due to vessel movement or due to malfunction of onboard or jetty systems. Again the fail safe auto shutdown mechanism in conjunction with the jetty and stand-by tug safety and fire-fighting equipment can be expected to reduce this risk to very low proportions.

Two near miss scenarios were also identified. The first involving a tug towline parting; the second arising through a close quarter situation between a LNG Carrier and another vessel whilst underway. Neither, however, was considered to merit additional mitigation over and above that being considered for other greater hazards.

Rank No.	Hazard Detail	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall
Commercial Cargo Release Hazards										
52	Uncontrolled LNG gas released from vessel. Failure of cargo containment system on board.	0	0	0	3	3	2	0	2	2.42
Commercial Near Miss Hazards										
55	LNG Carrier in close quarters situation with another vessel	0	0	0	0	0	0	0	4	1.39
Service Craft Near Miss Hazards										
54	Towline parts during approach, transit and/or berthing	0	2	0	0	0	2	0	2	1.67

6 RISK CONTROL MEASURES AND OPTIONS

The Ranked Hazard List was further reviewed by the study team and the hazards were mapped to the existing risk control measures identified during the data gathering exercises. Possible additional risk control measures were determined at a mitigation meeting held on 25th February 2008, and attended by Marico Marine, SFPC, Shannon pilots and CIL. The reduction to risk, potentially achieved by these measures was also assessed.

A spread sheet showing the risk factors before and after the application of possible further mitigation measures is tabled at Annex D. It should be noted that only those hazards where an individual consequence score has been assessed as 6 or higher have been considered in respect of further mitigation.

6.1 Additional Mitigation

6.1.1 Assessment of Need

As previously indicated, all hazards were assessed as having an aggregate score well within the ALARP range (i.e less than 6), both for the Most Likely and Worst Case scenarios, as illustrated in the diagram in Section 5.1.

Some hazards, however, were scored at 7 in respect of an individual consequence, (i.e. just above the ALARP range). See Annex D for further details. This scoring takes into effect the risk control measures that are already in existence. In overall terms this outcome is not untypical of a responsible and well run port.

Pre-Mitigations

Individual Consequences and ALARP Range

ALARP RANGE

Consequence Scores	Risk Definition	Number of Consequences Scores: M L – No. of Individual Hazards (top score)	M L – People	M L – Property	M L – Environment	M L – Stakeholders	W C – No. of Individual Hazards (top score)	W C – People	W C – Property	W C – Environment	W C – Stakeholders	Total Hazards (top scores)
10	Intolerable	0	0	0	0	0	0	0	0	0	0	0
9	High Risk	0	0	0	0	0	0	0	0	0	0	0
8	Significant Risk	0	0	0	0	0	0	0	0	0	0	0
7	Heightened Risk	2	0	1	0	2	6	2	6	0	6	7
6	Tolerable if ALARP	7	1	6	0	5	20	11	14	1	11	21
5	Tolerable	8	2	5	0	6	23	17	21	7	23	21
4	Tolerable	14	9	10	0	3	4	7	4	3	7	4
3	Low risk	5	4	2	1	5	1	9	2	3	6	1
2	Low risk	14	16	16	0	15	1	2	5	13	2	1
1	Negligable Risk	2	2	2	0	1	0	1	0	3	0	0
0	Negligable Risk	3	21	13	54	18	0	6	3	25	0	0

As shown in the above table, seven hazards had eight individual scores of 7 for one or more of their consequences. Two of the hazards occurred in the Most Likely scenario, and six in the Worst Case scenarios. Of the 21 hazards with one or more of their individual consequence assessed as 6, seven occurred in the Most Likely scenario and twenty in the Worst Case scenario.

Following discussion with stakeholders at the meeting on 23 February, it was agreed that additional mitigation must be considered for those hazards showing an individual consequence score of 7 or higher.

However, it was also agreed that any individual consequence score of 6 should be scrutinised with view to confirming that the associated risk level was as low as could reasonably be achieved, and if not that additional mitigation should be considered. In many cases additional mitigation was considered both feasible and merited.

6.1.1 Discussion of Options

As indicated in paragraph 1.5, possible additional mitigation measures are addressed under three main headings, namely:

- Documentary (Procedural Controls)
- Hardware (Engineered Controls)
- Personnel Competence (Experience and Training Controls)

Noting, however that such measures often apply to many of the hazards within an accident category, the measures have been further grouped within these headings. The discussion about each of the individual mitigation measures, as shown in Annex D undertaken at the meeting on 23 February, is reflected in the following tables. Where it was considered that the implementation of a measure is necessary in order to reduce risk to acceptable proportions, an appropriate recommendation has been made.
Many of the measures discussed are also to be found in the publication SIGTTO LNG Operations in Port Areas, Essential Best Practices for the Industry, 2003. Those included are shown with a SIGTTO tag.

6.2 Documentary/Procedural Mitigation

Some of the procedures identified already exist, but have been included so that they can be scrutinised with view to identifying whether scope exists to develop or enhance them. It is relevant that some existing "operational routines" take the form of "custom and practice" and are not documented formally.

6.2.1 Pilotage and Navigation Measures

Measure	Discussion/Recommendation
• Embark pilot to seaward of Ballybunnion Buoy	LNGC's could, in theory, be boarded at Kilstiffen Buoy under present procedures. However, this would be unacceptable to the Port Authority. Moreover it is the opinion of Marico that notwithstanding its commercial merits, this practice can introduce an element of added risk for existing vessels, and particularly those carrying hazardous cargoes. It is recommended therefore that consideration be given to moving the boarding area for LNG Carriers to the position used by deep-draught vessels, irrespective of size. LNG Carriers would thereby by under the control of an experienced pilot prior to entering restricted waters.
• Environmental operating limits (SIGTTO)	Setting maximum environmental operating limits would ensure that pilot embarkation could be achieved in the majority of circumstances and that the transit and subsequent berthing operation could be undertaken safely (part of passage planning). It is recommended that SFPC endorse the limits intended by Shannon LNG.
• Develop generic LNG Carrier optimum track and Passage Plan (SIGTTO)	Development of an optimum track for LNGC transits will enhance navigational safety. These tracks should be incorporated into a generic LNG Passage Plans. Use of such plans would standardise the conduct of the Master/Pilot information exchange, which itself is critical to achieving navigational safety. Comprehensive written and oral Master/Pilot exchanges, including discussion of the agreed Passage Plan would additionally enhance the quality of service delivered by SFPC and its pilots. It is recommended that consideration be given to developing generic LNGC passage plans and to standardising the conduct of the Master/Pilot exchanges.

• Designated channel (SIGTTO)	Development of a charted deep-water channel would help other port users anticipate the likely movements of LNG carriers and other large vessels constrained by draught. Such measures are recommended.
• Define 'narrow channel'	Having designated a deep water channel, consideration should be given to using a byelaw to classify it as a 'narrow channel', as defined by the Colregs. This would reduce the risk of vessels less than 20m impeding the navigation of large commercial vessels in transit. Again appropriate action is recommended.
• Mobile Control Zone (SIGTTO)	The use of a Mobile Control Zone around a LNGC underway would reduce the risk of it being hampered during its passage or subsequent manoeuvres. It is current industry practice to impose a Control Zone of 1 mile ahead, ½ mile astern, and 150 metres on either beam. It is recommended that consideration be given to creating a byelaw to this effect and employing a berthing tug, or other service craft to enforce compliance. The effect of such a measure would be to negate two-way traffic at critical locations in the designated channel.
• Review of Limits	Environmental limits and operating procedures should be kept under review as experience of operating LNGC is gained, and particularly once the details of further simulator modelling are available. .
• Dolphin Watch procedures	It is recommended that consideration be given to developing written procedures/guidance to minimise the risk of a Dolphin Watch craft hampering a LNGC underway
• Effective Communications	It is recommended that SFPC ensure that effective and reliable communications exist between all parties (Pilot, Cutter, Tugs, Mooring Gangs/Boats and Terminal). This may involve the enhancement of associated hardware See paragraph 7.2.4.
• Existing Byelaws/rules	It is recommended that the existing rules concerning the use of the Glendoosagh Bay anchorage, and not passing close to the southerly shore when vessels are berthed at Tarbert Jetty should be revised/extended to accommodate operations at the LNG berth
• Reporting Incidents and Near Misses	It is recommended that consideration be given to encouraging port users to report incidents and near misses, thereby providing SFPC with a more detailed appreciation of safety standards within the port. Use of a byelaw to this effect should also be considered

6.2.2 Tug Measures

Measure	Discussion/Recommendation
• Tug procedures (SFPC)	Tug procedures will in part be determined by the new tug fleet and final berth design. The use of simulators to assess minimum tug requirements and to practise emergency scenarios is strongly recommended. Procedures should cover the following issues: • The number of tugs required for active and passive escort, berthing/unberthing. • Where and when tugs are to be made fast. What connecting up procedures are to be used • Communications • Actions in the event of an emergency • Action in the event of a Control Zone infringement.
• Guidelines for handling LNG Carrier - towage	Development of Guidelines for handling LNG Carriers at Shannon is strongly recommended. These guidelines should be designed to ensure that sufficient tugs are used at all times, taking into account the size of the vessel, its fitted manoeuvring aids and the forecast environmental conditions.
• Standby tugs	It is a requirement of the developer that a Stand-by tug should be underway and in close proximity to the LNG jetty whenever a LNGC is alongside. This tug is to ensure that immediate assistance is to hand in the event of an emergency. It will also be required to enforce a Control Zone around the jetty and vessel. This measure is fully endorsed. It is also recommended that guidelines be developed to address the circumstances when a second Stand-by tug is required, e.g. during periods of extreme weather.
• Tug Operating procedures (Towing Company)	The Towing Company should develop detailed operating procedures which embrace the requirements of SFPC and the LNG Terminal operator. Such procedures should include water-tight integrity requirements, and stipulate what vents and doors are required to be closed when operating.

6.2.3 Other Measures

Measure	Discussion/Recommendation
• Introduction of a 150m control zone around a berthed LNGC (SIGTTO)	It is recommended that a 150m Control Zone be introduced whenever a LNGC is berthed at the Ardmore Point jetty. Enforcement using the Stand-by tug would ensure that commercial and other leisure craft keep clear of a berthed LNGC thereby eliminating the risk of contact. It would also help to reduce the risk of interaction from passing vessels.
• Maintain safe distance from structures	Consideration should be given to requiring a commercial leisure operator to show evidence of his own procedures, and particularly that which requires his own craft to maintain a safe distance of the LNGC terminal.
• Vetting Procedures (SIGTTO)	It is strongly recommended that LNG Carriers be vetted by the LNG Terminal operator (or other appointed body) prior to arrival to ensure that operating procedures and the condition and layout of onboard equipment, including mooring ropes is satisfactory.
• Develop joint emergency plan (SIGTTO)	It is recommended that SFPC and the LNG Terminal operator, together with shore fire and other emergency services and tug operators, develop a joint emergency plan, which incorporates training and exercises.
• ISPS Code	Implementation of the port ISPS Code should be updated to reflect LNG operations.
• Ship/Shore Interface (ISGOTT & SIGTTO)	ISGOTT guidance concerning ship shore interface should be implemented prior to the commencement of any cargo operations. It is recommended that SFPC ensures that its requirement for pre-arrival information covers all aspects of LNG operations, including the reporting of any onboard defects.

6.3 Hardware/Engineering Mitigation

Hardware/Engineering controls are often costly in terms of initial outlay. They are often, however, the only way to mitigate risk satisfactorily.

6.3.1 Vessel Traffic Services (VTS)

Measure	Discussion/Recommendation
• Enhancement of VTS functionality (SIGTTO)	Throughout the Risk Assessment process, VTS has repeatedly been identified as a powerful mitigation measure capable of reducing risk across a wide range of accident categories. For SFPC to utilise VTS as a formal risk control measure, and to be formally classified as a VTS Authority, its equipment and personnel will need to brought up to the standards defined by IALA and endorsed by IMO. Such action is strongly recommended.
• Provision of Services (SIGTTO)	VTS comprises three different types of service, namely: • Information Service (INS) • Traffic Organisation Service (TOS) • Navigational Assistance Service (NAS) For SFPC to benefit from the full risk reduction potential of VTS, all three services will be required. Such provision is strongly recommended before and for the duration a LNGC is in port.
• Equipment enhancement	SFPC has many of the basic equipment necessary to operate a VTS. The following technical development options are recommended: • Reliable reception of AIS signals throughout port limits and at least 15 miles to seaward of the westerly limit • Enhanced radar detection and tracking , including that of small craft • Full integration of AIS and radar tracks to facilitate an accurate and comprehensive vessel traffic image • Presentation of full AIS data, including dynamic information • Facilities for recording/playback of the traffic image
• Computerised Incident Database	Although not necessarily an integral part of a VTS system per se, it is strongly recommended that SFPC consider installing a computerised database on which all incidents and near misses can be recorded. Such systems can usefully be integrated into an overall VTS system. An ability to review safety performance and incident trends lies at the core of a good safety management system.

6.3.2 Aids to Navigation

• Measure	Discussion/Recommendation
• Hydrographic Surveys	The last Main survey of the Shannon Estuary and its approaches was conducted in 1842. The main navigational channels were re-surveyed between 1969 and 1979. The typical periodicity of port Main Surveys is 12 years. SFPC is recommended to liaise with CIL with view to updating existing survey data, and particularly that likely to be critical to LNG operations.
• Chart and VTS Datum	Existing charts of the Shannon Estuary are based on an Irish Ordnance Survey Datum. All GPS based systems, including ship borne Electronic Navigation Systems, eg ECDIS use the WGS 84 datum. Most port VTS systems utilise an electronic chart based on WGS84. The carriage and use of paper charts based on a different Ordnance Survey datum, particularly in confined waters, risks navigational discrepancy with possible serious consequence SFPC is strongly recommended to liaise with CIL and Geological Survey of Ireland with view to transposing the charts of the Shannon Estuary and its environs to WGS84.
• Increase clearance over Doonaha wreck - remove buoy	The Doonaha Buoy currently impedes the turn of many large vessels entering or leaving the port. It marks the existence of a 14.3m wreck close to the track taken by vessels with draughts up to 17.5m. Significant safety and traffic management benefits would accrue if the Doonaha wreck could be cleared to a greater depth, allowing for safe transit (including squat and roll), and the buoy removed. SFPC is recommended to investigate the scope for such action and for removing the buoy.
• Reposition Beal Bar Buoy	The Beal Bar Buoy currently restricts the manoeuvring room available to vessels entering the estuary and turning off the Corlis leading lights into the main estuary channel. Repositioning this buoy by approximately 1 cable to the south east and close to the 20m contour would significantly widen the available water when turning and enhance safety. It is understood that this buoy had previously been positioned in this location. Such action is recommended.

• Reposition Carrigaholt Buoy	Consideration is recommended to repositioning the Carrigaholt Buoy onto the 14.9m patch to the west of Doonaha Buoy. This would provide an unambiguous port hand buoy on, and at the safe limit of, the Corlis transit. It would also facilitate the removal of the Doonaha buoy should it prove feasible to remove or reduce the associated wreck.
• Improved existing navigational marks	Currently the North Carrig Buoy light is reported to be difficult to detect in certain conditions. Its role is however important in marking the Carrig Shoals. It was reportedly changed to a North cardinal Light to improve detection iin daylight. It is recommended that the effectiveness of the light be improved.
• Remove/reposition small ship anchorage at Glencloosagh Bay	This anchorage lies close to the manoeuvring area off the proposed LNG Jetty. Any vessels so anchored could impede the manoeuvres of a LNGC. Likewise vessels arriving at or leaving the anchorage could come close to a LNGC moored at the new jetty. It is recommended that this anchorage be removed or re-positioned.
• Marking the Glencloosagh Bay shallows	It is recommended that consideration be given to marking the limits of the Glencloosagh shallows, these being the nearest navigational hazard to LNG carriers manoeuvring onto and off the berth. The exact position of such a buoy will depend on the final design of the LNG Jetty.

6.3.3 Tugs

It was noted that the existing fleet of tugs have the theoretical capability of handling an LNGC in winds up to 20 knots, but that they are not designed for escort towing and may have high point loadings. Their use is also contracted to existing berth operators.

It was also noted that the developer is considering the provision of 4 new tugs with a reserve bollard pull of 25% of that needed for normal operations.

SFPC is recommended to monitor developments in the provision of these tugs and to keep in mind the following points.

Measure	Discussion/Recommendation
• Tug Design	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. Dual redundancy of tug systems will reduce significantly the likelihood of tug failure.
• Escort Duties	It is recommended that an escort tug in the active role is attached to the LNGC well to seaward of the approach narrows. It is further recommended that a second tug, or harbour service craft is used to police the Control Zone around the LNGC throughout its transit. The provision of an active escort tug greatly reduces the risk of collision, contact, or grounding in the event of a steering or propulsion failure onboard the LNGC.
• FiFi 1 escort tug	All tugs should be fitted with FiFi 1 equipment to assist the Carrier in the event of fire.
• Towline configuration	The towline configuration can increase safety and should be assessed during the design phase. The use of quick connection units (Foslink), and LNGC dedicated towing points should be considered
• Freewheel/quick release facilities for winches	Freewheel and quick release facilities 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.

6.3.4 LNG Jetty - Safety Features

• Measure	Discussion/Recommendation
• Effective design (SIGTTO)	It is clear from discussions with the developers that best practice will be incorporated into the LNG Jetty design. SFPC is recommended to continue monitoring progress in this area and in particularly to ensure that fender systems and mooring points are optimised for

	Shannon environmental conditions. Specialist software is used by some ports to verify safe environmental limits and to optimise mooring retention of large vessels.
• Environmental Monitoring Equipment and Display	The proposal by the developers to fit real-time electronic displays of the immediate environmental conditions at the berth is fully supported. By making this data clearly visible to a LNGC, the pilots will be greatly aided when berthing and unberthing.
• Doppler docking system	Integrated with the above environmental data displays, the developers have indicated they intend to fit a Doppler docking system which will indicate real time approach data to the pilot. This is also fully supported.
• Load cells on Mooring Equipment	Consideration should be given to utilising load cells on the jetty mooring systems. It is not known whether the developers intend fitting such equipment. SFPC is recommended to encourage its provision, given LNGC susceptibility to wind and likely conditions in the Shannon estuary.
• Jetty fire fighting equipment (SIGTTO)	Again, it is understood that the developers intend providing extensive fire detection and suppression equipment on the jetty. This is strongly supported. SFPC attention is drawn to the guidance provided by SIGTTO in the matter of fire fighting equipment and terminal fire fighting standards.
• Berthing Master or Mooring Supervisor	It is the intention of SFPC to have Marine Operations Staff, attend all movements to control arrivals and departures as well as to ensure proper securing arrangements." The presence of such an individual will ensure compliance with required procedures both on the jetty and by the contracted mooring crews.
• Jetty Security	It is recognised that the safety requirements of LNG operation will provide a high level of physical security at and around the jetty. Nevertheless, it is likely the SFPC Security Plan as required by the ISPS Code will require review and updating to reflect the security aspects of the LNG Terminal and Jetty.

6.4 Personnel Competence (Experience and Training Controls)

• Measure	Discussion/Recommendation
• VTS Staff training and certification	It is strongly recommended that SFPC train appropriate personnel in order that they achieve IALA V-103/3 VTS Operator standards and accreditation. By so doing,

	SFPC will be less exposed to claims of operator incompetence in the event of an incident involving VTS advice or direction. Staff manning levels will be dictated in part by vessel traffic patterns and densities. It is recognised that LNG traffic levels alone are unlikely to necessitate 24/7 VTS provision. In deciding what manning levels are appropriate and cost-effective, SFPC is recommended to take into consideration the following: • VTS coverage is likely to be required for approx 3 hours before arrival of a LNGC, in order to generate a comprehensive traffic image throughout the port. • A failure to apply the risk reduction benefits of its accredited VTS before and during the passage of any vessel carrying potentially hazardous cargo, e.g. Oil and chemical tankers, is likely to leave company exposed in the event of an incident • VTS is particularly useful when monitoring widely dispersed anchorages during adverse weather • The introduction of an incident or near miss reporting regime is greatly enhanced and encouraged by the existence of VTS surveillance • Port users of all categories are less likely to rely on the information and advice provided by a VTS in its information service role if that role is intermittent and unpredictable. Some form of reduced VTS service should be considered when TOS and NAS are not warranted, if overall compliance and acceptance of VTS is to be achieved.
• Bridge team management training (SIGTTO)	It is recommended that pilots and tug masters attend Bridge Team Management courses so that they are fully conversant with, and understand, bridge team management techniques and associated communication. Bridge team management has been identified as an important component in the overall quality delivery of port marine services.
• Training and HSE	SFPC is recommended to ensure that H & S training programmes are in place for all SFPC operational personnel and that Health and Safety principles are well understood by all.
• Joint bridge simulation (SIGTTO)	SFPC is recommended to include tug masters when conducting pilot simulation training. Such joint training greatly aids effective communication. It also allows different manoeuvres to be trialled as well as exercising actions in the event of an emergency.
• Trained Mooring	SFPC is recommended to ensure that only trained

Personnel	mooring personnel are employed in mooring operations
• Trained jetty supervisors	SFPC is recommended to ensure that Berthing Masters/Jetty Supervisors are appropriately trained.
• Shore services fire fighting training	SFPC is recommended to liaise with the shore fire fighting services with view to their training in LNG procedures

7 CONCLUSIONS

The following conclusions were formed during the review by Marico Marine Ltd:

1. The Risk Assessment undertaken in the context of potential LNG operations has demonstrated that the existing aggregated risk levels within the port are broadly within or below the level to be expected in an established and effectively managed port. That is to say, that aggregated risk levels are within, or below, the ALARP range (As Low As Reasonably Practicable). There are, however, a few areas where the risk level for an individual consequence within the aggregated score, is in the “Heightened Risk” category. These merit further mitigation.

2. There are also some fourteen hazards where the level of risk associated with an individual consequence is at the upper limit of the ALARP range. These also warrant scrutiny with view to reducing risk where both practicable and reasonable. Details of all the hazard scores are to be found on the Ranked Hazard List tabled at Annex D.

3. This relatively low risk level is due in large measure to the absence of high densities of shipping and the relative spacious characteristics of the Shannon Estuary. With the exception of two pinch points the route taken by future LNG carriers within port limits is wide, deep and offers a variety of abort locations and anchorages. From a navigational perspective, the Shannon Estuary may be considered to be a very suitable location.

4. Given the difficulty of embarking pilots to seaward of the Ballybunnion Buoy in extreme weather, the Shannon LNG policy that no LNG Carrier will enter port when the wind at the berth exceeds the defined berthing parameters, and that in such circumstances LNG Carriers will remain at sea until the has weather abated, will greatly reduce the associated risks to both personnel and navigation. These decisions complement the findings of the risk assessment and are fully endorsed by Marico Marine.

5. Also bearing on the ability of SFPC to service a pilot is the reliability and suitability of its pilot cutter(s). As SFPC records show, the operability of a single cutter is hard to maintain, given the inevitable breakdowns and need to take it out of service for maintenance. It is recommended that serious consideration be given to pilot cutter provision in an era of enhanced traffic volumes and LNG operations.

6. The use of VTS in monitoring and organising vessel traffic is recognised best practice for all LNG ports worldwide. As currently configured and used, the SFPC system does not meet international standards, and is thus not utilising its full risk mitigation potential. SFPC should therefore give serious consideration to enhancing the technical capability of the present system, and importantly, to introducing properly accredited VTS operators. As is discussed in the body of the report, it will be for SFPC to decide when and how an enhanced VTS should be used. Section 6 discusses some of the issues which bear on that decision. In sum, the risk assessment process cannot demonstrate that LNG Carrier operations may be conducted safely without a comprehensive and effective VTS in operation during the period leading up to and whilst a LNG Carrier is in port.

7. Finally, Marico Marine, have concluded that subject to the mitigation measures recommended in Section 6 being addressed, the level of risk associated with LNG operations in the Shannon Estuary is acceptable and that such operations may be conducted in safety.

ANNEX A

RISK CRITERIA

1 RISK ASSESSMENT

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 estimated (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:-

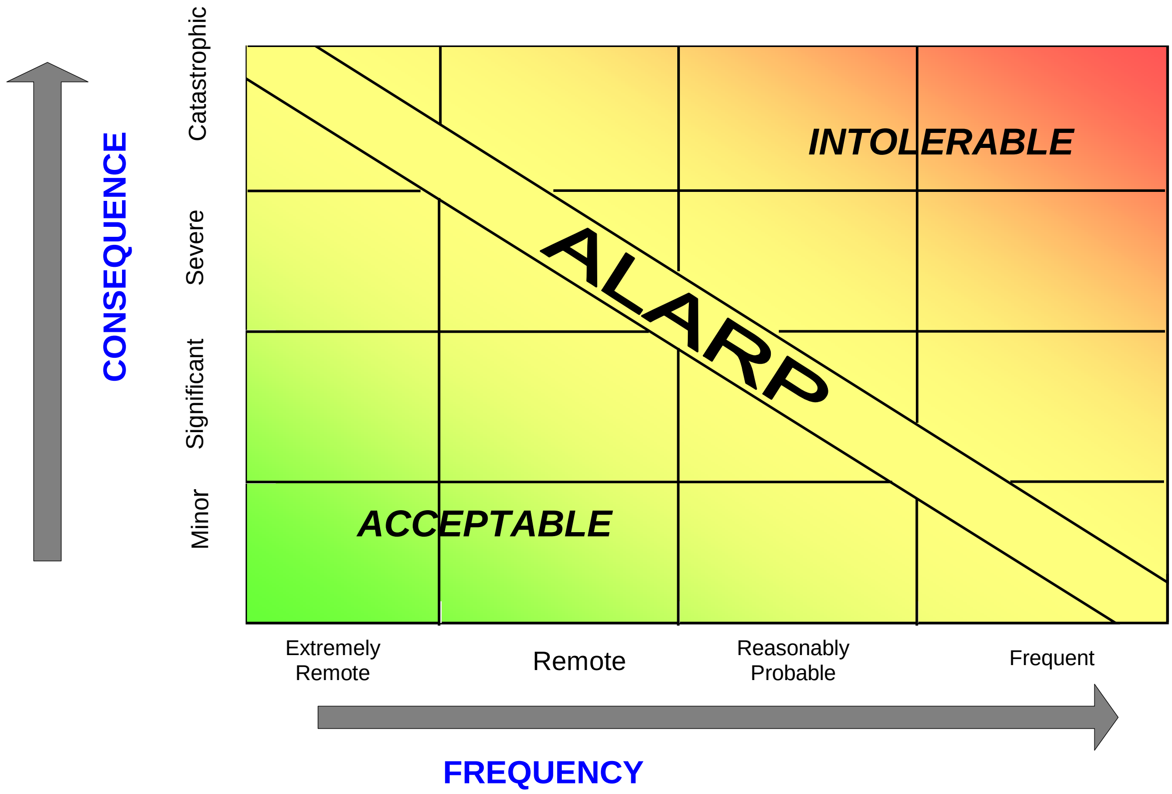


Figure 1 Example Risk Matrix

At the low end of the scale, frequency is extremely remote and consequence insignificant; 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 is an area, which is defined as ALARP, or "As Low As Reasonably Practicable". ALARP corresponds to the point where further reduction of risk is impracticable, or where the cost of such reduction would obviously be highly disproportionate to the improvement.

For this study risk is applied in a partly qualitative way by using expert judgement. The risk assessment is also comparative, allowing the importance of hazards in relation to each other to be identified in terms of overall risk.

1.1 Criteria for Assessment

1.1.1 Risk Matrix Criteria

In this study, each hazard was reviewed with respect to cause and effect. Frequencies were derived for notional 'most likely' and 'worst credible' hazard events in each case, using the following frequency bands:-

Category	Description	Definition	Operational Interpretation
F1	Frequent	An event occurring in the range once a week to once a month.	Monthly
F2	Likely	An event occurring at least once per annum.	Annually
F3	Possible	An event occurring in the range once a year to once every 10 operating years.	1 – 9 years
F4	Unlikely	An event occurring in the range once every 10 operating years to once in 100 operating years.	10 – 99 years
F5	Improbable	An event occurring in the range less than once in 100 operating years.	>100 years

Table A1 – Frequency Criteria for the Risk Assessment

The Frequency table for the risk assessment were defined as show in Table A1.

The first three frequency categories are perhaps self-explanatory. Category F4 represents a frequency suggesting an event that could occur in the region of 10-99 operating years, this would reflect major events in the operating history of the Port. Category F5 is an event, which is *currently* considered to pose a very low probability, but where the consequential outcome is major/serious and thus needs to be included to take account of possible future changes in risk.

Using the assessed notional frequencies for the 'most likely' and 'worst credible' events for each hazard, the probable consequences associated with each event were assessed in terms of damage to:-

- Life (e.g. personal injury, fatality, etc.)
- Property, especially to Third party (i.e. not belonging to the port or terminal or their subcontractors)
- The Environment (oil pollution, etc.)
- Stakeholders (Reputation/Publicity/Loss of revenue streams)

1.1.2 Probable Consequences

Scale	People	Property	Environment	Stakeholders (Business)
C0	None	< €2,000	No effect of note	< €2,000
C1	**Negligible** (single slight injury)	**Negligible** (> €2 K)	Tier 1 response (small operational) oil spill with no affect on environmental amenity (>€2 K)	**Negligible** (>€2 K)
C2	**Slight** (multiple minor or single major injury)	**Minor** (> €20K)	**Minor** Tier 2 spill declared but capable of being limited to immediate area within harbour enclosure. (> €20 K)	**Minor** Bad local publicity or short-term loss of dues, revenue, etc (> €20 K)
C3	**Moderate** (multiple major injuries or single fatality)	**Moderate - Major** (> €200 K)	**Moderate** Tier 2 response required, with pollution outside harbour enclosure expected. Loss of environmental amenity. Chemical spillage or small gas release (> €200 K)	**Moderate** Bad widespread publicity, temporary port closure or prolonged restriction of navigation (> €200 K)
C4	**Major** (More than one Fatality)	**Major** (>€2 M)	**Major** Tier 3 oil spill, widespread beach contamination or extensive damage to amenities. Serious chemical or gas release. (>€2 M)	**Major** Port closes, navigation seriously disrupted for more than 1-2 days. Ensuing loss of trade. (>€2 M)

Table A2 – Consequence Criteria for the Risk Assessment

In Table A2, consequence is assessed for each category and the possible impact for each.

1.1.3 Review and Verification Process

During the HAZID meeting, details of each hazard were recorded in a structured hazard list, together with the relevant causes in both most likely and worst credible scenarios.

Frequency and consequence data was then generated for each hazard in the structured hazard list in terms of “most likely” and “worst credible” scenarios, by a process of expert review. This was undertaken at a Hazard Scoring

Workshop where representatives from the relevant stakeholder groups were invited to attend.

During the workshop, each hazard was considered in turn and scored on the basis of the consequence in terms of human life, the environment, third party property and business for both the most likely and the worst credible scenarios. On completion of the workshop, the scoring data was entered into the hazard database and a ranked hazard list produced to show the risk profile.

The frequency and consequence data thus obtained was then reviewed by the study team to ensure internal consistency. The reviewed hazard list is reproduced in full in a subsequent Annex.

1.2 Risk Assessment

1.2.1 Risk Analysis

From the individual frequency and consequence ratings for each hazard, individual risk factors were derived on a scale of 0 (low risk) to 10 (high risk) as follows:

Consequence	Cat 4	5	6	7	8	10
	Cat 3	4	5	6	7	9
	Cat 2	3	3	4	6	8
	Cat 1	1	2	2	3	6
	Cat 0	0	0	0	0	0
	Frequency	Less than once per 100 years	10 to 100 years	1 to 10 years	More than once per year	More than once per month

Where:-

0 & 1	Negligible Risk
2 & 3	Low risk
4 & 5	Tolerable Risk (ALARP)
6 & 7	Heightened Risk
8 & 9	Significant Risk
10	High Risk

The risk data obtained from this process was then tabulated (in terms of the 'most likely' and 'worst credible' scenarios (i.e. providing eight risk scores per hazard). The scoring of hazards was undertaken using both the incident data profile for the port company and the local knowledge of users.

It should be noted that occasionally, most likely scenarios can generate higher individual risk levels than worst credible; this is due to the increased frequency naturally associated with the most likely event. In effect, the assessment is scoring the risk associated with two different outcomes from the same initiating event. This tends to occur particularly where consequence levels are similar between most likely and worst case and/or where the frequency of the worst credible is very much less than that of the most likely.

1.2.2 Hazard Ranking

The risk data obtained from the above process was then analysed to obtain four indices for each hazard as follows:

A) the average risk value of the four categories in the ‘most likely’ set

B) the average risk value of the four categories in the ‘worst credible’ set

C) the maximum risk value of the four categories in the ‘most likely’ set

D) the maximum risk value of the four categories in the ‘worst credible’ set

Average risk values are sensitive towards hazards, which score moderately or highly over a number of categories, whilst the maximum risk values are sensitive towards hazards, which score particularly high in any category.

These values were then aggregated to produce a numeric value representing the average of the four indices.

The hazard list was then sorted in order of the aggregate of the four indices to produce a Ranked Hazard List, in descending order, with the highest risk hazards at the top. This list is produced in full in a subsequent Annex to this report.

ANNEX B

HAZID MEETINGS
RECORD OF ATTENDEES

HAZID MEETING

6th February 2008

Meeting attendees:-

Person	Expertise	Organisation
Jonathon Pearce	Recorder	Marico Marine
Bruce Richardson	HAZID Chairman	Marico Marine
Dennis Barber	Facilitator	Marico Marine
Willie Nolan		E.S.B. Tarbert
Michael Kelly		E.S.B. Moneypoint
Kevin Cribbin	Shipping Facilitator	Aughinish Alumina
Brian Sheridan	Harbourmaster	Galway
Darin Mc Gibney	Dolphin Watch, Launch-hand, Mooring Crew	Dolphin Discovery, Kilrush
Hugh Conlon	Deputy Harbourmaster	S.F.P.C.
Peter Burke	Pilot (Inbound)	Shannon Pilots
Robert Mc Cabe		C.I.L.
Noel Lynch		Ballylongford
Eugene Maher	Manager	Shannon Ferry Group Ltd
James Behan	Pilot	Shannon Pilots
Brian Dolan	Pilot (Outbound)	Shannon Pilot
Paul Griffin	Coxswain	Shannon Pilot Boat

ANNEX C

HAZID LIST

SUMMARY OF IDENTIFIED HAZARDS
(Ranked in Order of Risk Level)

Ranked Hazard List

MARICO MARINE

Rank No.	Hazard Ref	Affected Areas	Accident Category	Hazard Title	Hazard Detail	Affected Vessel Types	Affected Stakeholders	Possible Causes	Consequence Descriptions: Most Likely (ML)	Consequence Descriptions: Worst Credible (WC)	Risk By Consequence Category: M L People	M L Property	M L Environment	M L Stakeholders	W C People	W C Property	W C Environment	W C Stakeholders	Risk Overall	Remarks
1	4	Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig	Collision	LNG Carrier and large vessel in collision	LNG Carrier in collision at a navigation pinch point	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Channel usage conflict No management of vessel traffic Attempted passing in channel Misjudgement or miscommunication by either/both vessels Low powered vessel has difficulty in clearing path of larger vessel committed to channel in heavy weather.	Minor contact/glancing blow with some minor structural damage	Severe damage to one or both vessels Pollution and / or loss of cargo containment on LNG carrier Possible fire Loss of life Sinking of one or both vessels Port or channel closure	4	7	0	7	6	6	6	6	5.86	
2	44	Ballybunnion Buoy to Doonaha Buoy	Grounding	Lead-In LNG Carrier Grounding - Channel	A Lead-In LNG Carrier leaves fairway and grounds between Tail of Beal and Beal Bar Buoys	LNG Carrier, All	Pilot, Pilot Launch, Shannon Foynes Port Company, Shannon LNG	Misjudgement by Master of manoeuvre in tidal stream/wind Lack of Local Knowledge Misinterpretation of/Ignoring External Advice/Orders Adverse weather / tidal conditions Loss of directional stability in heavy swell Lack of Bridge Team support (manning levels) and poor or No BRM principles being utilised Failure to monitor position in channel Poor passage planning and monitoring including over-reliance on channel buoys for position reference (poor visibility) Vessel not on leads on approach Miscalculation of UKC in heavy swell and state of tide Shore based Aids to Navigation inoperative or obscured in restricted visibility Inadequate aids to navigation Other craft obstructs manoeuvre on approach, or impedes assisting vessels Traffic conflict with vessels navigating near limits of fairway Lack of vessel traffic management Lack of formal vessel traffic management	Glancing grounding at margins of the deep water channel Damage to hull plating	Vessel grounds with moderate damage to double bottom plating and propeller/rudder Delay until Refloated, main channel closed to large movements	2	6	0	7	4	7	0	7	5.61	
3	36	Port Approaches up to Ballybunnion Buoy	Grounding	LNG Carrier grounds in the port approach	LNG Carrier grounds in the port approach prior to boarding pilot	LNG Carrier, All	Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Vessel subjected to excessive leeway and/or current and unable to maintain track Late pilot boarding - e.g. difficulties in boarding (weather, access arrangements, etc) Vessel stands in too close prior to pilot boarding Lack of support from Bridge Team (manning levels) Poor or No BRM principles being utilised Poor/Inadequate Passage Planning Poor passage planning and monitoring including over-reliance on channel buoys for position reference (poor visibility) Failure to monitor position Inadequate Master/pilot information exchange Inadequate aids to navigation Miscalculation of UKC in heavy swell and state of tide Other craft obstructs manoeuvre on approach, or impedes assisting vessel Movement attempted in restricted visibility/night, lack of visual cues (disorientation) Propulsion/steering or bow thrust failure at critical stage Inadequate aids to navigation Inexperience or Master not trained in emergency response aboard vessel No risk assessment prior to movement Lack of vessel traffic management	Refloated with minor damage to external hull Refloated by attending tugs	Major port emergency declared Partial flooding and increase in draught Major damage to vessel Stranding Theoretical escape of cargo through tank displacement Port closure during salvage operations	2	6	0	6	4	7	0	7	5.27	
4	42	Doonaha Buoy to North Carrig	Grounding	LNG Carrier grounding - Channel	LNG Carrier leaves channel between Doonaha Buoy and North Carrig and grounds	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Adverse weather / tidal conditions Movement attempted in restricted visibility, lack of visual cues Poor assessment of set and leeway; Other craft obstructs manoeuvre on approach, or impedes assisting vessels Inadequate aids to navigation Propulsion/steering/control systems or bow thrust failure at critical stage Miscalculation of UKC in respects to stage of tide and conditions Poor passage planning and monitoring including over-reliance on channel buoys for position reference (poor visibility) Traffic conflict with other large movement Lack of vessel traffic management Tug operational failure or miscommunications between ship handler/pilot & Tugmaster	Prompt refloating Minor damage to vessel Hull not breached Delays during investigation/surveys	Vessel grounds with moderate damage to double bottom plating and propeller/rudder Delay until Refloated, main channel closed to large movements	2	6	0	6	4	7	0	7	5.27	
5	40	Ballybunnion Buoy to Doonaha Buoy	Grounding	LNG Carrier Grounding - Entrance	LNG Carrier leaves fairway and grounds between Tail of Beal and Beal Bar Buoys	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Loss of directional stability in heavy swell Lack of Bridge Team support (manning levels) and poor or No BRM principles being utilised Failure to monitor position in channel Poor passage planning and monitoring including over-reliance on channel buoys for position reference (poor visibility) Vessel not on leads on approach Miscalculation of UKC in heavy swell and state of tide Shore based Aids to Navigation inoperative or obscured in restricted visibility Inadequate aids to navigation Other craft obstructs manoeuvre on approach, or impedes assisting vessels Traffic conflict with vessels navigating near limits of fairway Lack of vessel traffic management Tug operational failure or miscommunications between ship handler/pilot & Tugmaster	Glancing grounding at margins of the deep water channel Damage to hull plating	Vessel grounds with moderate damage to double bottom plating and propeller/rudder Delay until Refloated, main channel closed to large movements	2	6	0	6	4	7	0	7	5.27	

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6	29	North Carrig to Tarbert inc LNG jetty	Fire/Explosion	LNG Carrier Fire	Fire on LNG Carrier whilst alongside	LNG Carrier, All	Shannon Foynes Port Company, Shannon LNG	Accommodation and machinery space fires Gas leak from cargo pipes, glands, safety valve ignited by any source Accommodation and machinery space fires Other vessel or small leisure craft that is disabled and on fire and drifts down onto terminal	Fire brought under control and extinguished by ships staff, possibly with assistance from shore fire and rescue service Major port emergency declared Shutdown of LNG Terminal and activation of Emergency Plans	Fire on LNG carrier not immediately contained or extinguished Failure of jetty fire fighting equipment Delay in arrival of Fire Service appliances Tug unable to assist fire fighting Possible multiple fatalities Reduction in port trade	4	4	0	2	7	7	2	7	5.03	Major port emergency declared
7	31	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig, North Carrig to Tarbert inc LNG jetty	Fire/Explosion	Fire on LNG Carrier whilst underway	Fire on LNG Carrier while underway in harbour areas	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Accommodation or machinery space fires or electrical failure Gas leak from cargo pipes, glands, safety valve ignited by any source	Fire brought under control and extinguished by ships staff, possibly with assistance from tugs	Fire on LNG carrier not immediately contained or extinguished Tug fire fighting ability slow to deploy Possible multiple fatalities	4	4	0	2	7	7	2	7	5.03	Unlikley to have major gas leak without detection during transit Major port emergency declared Possible increased likelihood of hazard over sea passage due to preparations for commencement of discharge during which erriors could be made in operation of
8	3	Port Approaches up to Ballybunnion Buoy	Collision	LNG Carrier in collision in port approach	LNG Carrier in collision with another vessel in port approaches	LNG Carrier, All	Shannon Foynes Port Company, Shannon LNG	Misjudgement by either vessel Coastal traffic bound passed the Shannon Estuary conflicting offshore Bridge team focussed manoeuvring to embark pilot Difficulty in boarding pilot (weather conditions, ship rolling, access arrangements, etc) Port traffic conflicting in final approach area - e.g. outbound vessel impedes manoeuvre	Minor contact/glancing blow with some minor structural damage	Severe damage to one or both vessels Pollution and / or loss of cargo containment on LNG carrier Possible fire Loss of life Sinking of one or both vessels	3	6	0	6	5	5	5	5	4.98	
9	12	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy	Collision	Dolphin Watch collides with LNG Carrier in Port Approaches	Dolphin Watch collides with LNG Carrier in Port Approaches	Passenger, LNG Carrier	Dolphin Watch, Shannon Foynes Port Company, Shannon LNG	Dolphin Watch obstructs LNG Carrier due to lack of knowledge of Bye-Laws Misjudgement of closest point of approach, lack of appreciation of manoeuvring characteristics or blind sector under and ahead of bow of vessel Dolphin Watch appears without warning ilure (reliquification plant)	Minor contact/glancing blow Possible injuries/man overboard on Dolphin Watch from wash of larger vessel Secondary hazard: Larger vessel's margin of safety reduced when taking avoiding actions in entrance channel	Dolphin Watch run down by LNG Carrier. Vessel lost. Possible multiple fatalities.	5	2	0	5	6	6	5	6	4.83	Dolphin Watch generally keep out of main channels used by commercial shipping and are aware of all shipping operations
10	6	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig, North Carrig to Tarbert inc LNG jetty	Collision	Cruise ship and LNG Carrier in collision	Cruise vessel in collision with LNG Carrier	LNG Carrier, Passenger	Pilot, Shannon Foynes Port Company, Shannon LNG	Misjudgement of Bridge Team on either vessel Conflicting traffic movement including congestion at Pilot Boarding Area Lack of traffic management (e.g. allowing vessel to be underway at same time)	Minor contact/glancing blow with some minor structural damage	Moderate or major damage to one or both vessels Potential for fire/explosion Potential for fatalities Possible loss of one or both vessels	4	5	0	5	5	5	5	5	4.71	
11	10	North Carrig to Tarbert inc LNG jetty	Collision	LNG Carrier damaged by contact with tug	LNG Carrier damaged by contact with tug	LNG Carrier, Port Service Craft	Pilot, Shannon LNG, Tugs and Towing Company	Misjudgement by tugmaster Mechanical failure on board tug	Minor damage to vessel.	Shell plating damaged with possible water ingress to ballast / void spaces. Progressive (slow) increase of draught / list	2	6	0	2	2	6	0	6	4.49	VTS controls
12	2	Port Approaches up to Ballybunnion Buoy	Collision	Leisure craft collision with LNG Carrier	Leisure craft collides with LNG Carrier in Port Approaches	Leisure, LNG Carrier	Leisure Users, Shannon Foynes Port Company, Shannon LNG	Leisure craft obstructs LNG Carrier due to lack of knowledge of Bye-Laws Misjudgement of closest point of approach, lack of appreciation of manoeuvring characteristics or blind sector under and ahead of bow of vessel Sailing craft becalmed or capsized in path of larger vessel Leisure craft appears without warning at speed from radar shadow area Consumption of alcohol impairs judgement of leisure craft operator	Minor contact/glancing blow Possible injuries/man overboard on leisure craft from wash of larger vessel Secondary hazard: Larger vessel's margin of safety reduced when taking avoiding actions in entrance channel	Leisure craft run down by large vessel Possible multiple fatalities	5	2	0	3	6	5	2	5	4.42	Leisure craft generally keep out of main channels used by commercial shipping
13	41	Ballybunnion Buoy to Doonaha Buoy	Grounding	LNG Carrier Grounding - During turn	Vessel misjudges turn in vicinity of Beal Bar/ Doonaha Buoy	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Lack of support from Bridge Team or poor or No BRM principles being utilised Failure to monitor position in channel Poor assessment of set and leeway; Poor passage planning and monitoring including over-reliance on channel buoys for position reference (poor visibility) Complacency of bridge team once Pilot embarked Inadequate Master/pilot information exchange Other craft obstructs manoeuvre on approach, or impedes assisting vessels Inadequate aids to navigation Relatively tight bend / narrow channel Failure of Buoy lights at night Traffic conflict results in vessel turning late Lack of vessel traffic management Tug operational failure or miscommunications between ship handler/pilot & Tugmaster during turn	Glancing grounding at margins of the deep water channel Minor damage to hull plating	Vessel grounds with moderate damage to double bottom plating and propeller/rudder Delay until Refloated, main channel closed to large movements	2	5	0	5	3	6	0	6	4.38	At 12.5 metres draft, there is sufficient water to pass to the north of Doonaha Buoy

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14	28	Ballybunnion Buoy to Doonaha Buoy	Contact - Navigation	Lead-In LNG Carrier in contact with Aid to Navigation	A Lead-In LNG Carrier in contacts channel mark	LNG Carrier, All	Pilot, Pilot Launch, Shannon Foynes Port Company, Shannon LNG	Misjudgement by Master of manoeuvre in tidal stream/wind Lack of Local Knowledge Misinterpretation of/Ignoring External Advice/Orders Adverse weather / tidal conditions Movement attempted in restricted visibility, lack of visual cues Propulsion/steering or bow thrust failure at critical stage Transit impeded by another vessel at critical time Poor or No BRM principles being utilised Failure to monitor position in channel Escort Tug unable to assist in time Lack of formal vessel traffic management	Minor contact with buoy with superficial damage, scraped paintwork.	Navigation mark put out of commission by heavy contact Possible steering gear damage	0	4	0	6	0	6	0	6	4.35	
15	14	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Other Vessel Contacts LNG Terminal jetty	Other vessel comes into contact with unoccupied LNG Terminal jetty	All, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Passing vessel using eddies Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions. Propulsion or steering failure at critical stage	Glancing blow with superficial damage to berth	Vessel contacts berth with penetration of shell plating Possible loss of cargo (single hull) or fuel oil / pollution Damage to LNG jetty / dolphins LNG jetty out of commission until repaired	2	4	0	2	3	6	3	5	4.28	
16	27	Doonaha Buoy to North Carrig	Contact - Navigation	LNG Carrier in contact with vessel at anchor	LNG Carrier contacts vessel at anchor	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Movement attempted in restricted visibility, lack of visual cues Propulsion/steering or bow thrust failure at critical stage Anchored vessel in incorrect position or drags anchor into channel Poor or No BRM principles being utilised Failure to monitor position in channel Escort Tug unable to assist in time	Glancing blow with minor damage to both vessels.	Major damage to both vessels.	0	5	0	5	3	6	0	6	4.26	
17	16	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Berthed LNG Carrier contacted by passing vessel	Berthed LNG Carrier contacted by passing vessel	All, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Propulsion/steering or bow thrust failure at critical stage on passing vessel Misjudgement of manoeuvre in tidal stream/wind on other vessel Adverse weather / tidal conditions Transit impeded by another vessel at critical time Vessels passing too close (Interaction) Poor or No bridge team management principles being utilised Failure to monitor position in channel	Glancing blow Damage to plating on both vessels No loss of cargo containment	Penetration of LNG hull resulting flooding and consequent loss of power.	2	5	0	2	4	5	4	5	4.17	Proposed jetty is clear of main channel Proposed to have a standby tug in vicinity Pilot on board commerical passing vessels Vessels have space to anchor in the event of a systems failure Pilots only use 'eddies when no vessel is alongside Tarbet; this would apply to LNG
18	53	Ballybunnion Buoy to Doonaha Buoy, North Carrig to Tarbert inc LNG jetty	Personal Injury	Personal injury to tug crew	Personal injury to tug crew during towage and/or connecting up	Port Service Craft, All	Shannon Foynes Port Company, Tugs and Towing Company	Heavy weather resulting in violent motion Shipping water on deck Towline parts Error or inexperience of crew handling winch or towline Contact with weighted heaving lines passed between tug and ship Incorrect PPE Inexperience of Tugmaster in conditions Crew unbalanced from heavy landing on vessel Having to connect up under expediency Towing equipment not fit for purpose	Minor injury resulting from fall or slip on tug; Minor injury to hands or fingers while connecting ropes;	Tug crew fatality from parting towline Tug crew washed from deck in heavy weather outside entrance	4	2	0	2	6	4	0	4	4.09	Likelihood of hazard may be higher if untrained personnel are used to relieve normal crew;
19	20	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Large vessel swinging onto Money Point contacts jetty or LNG Carrier	Large vessel such as a Capesize BC contacts jetty or vessel berthed alongside whilst swinging off Money Point	Bulk Carrier, All	ESB, Pilot, Shannon Foynes Port Company, Shannon LNG	Catastophic failure of propulsion/steering and tug control at critical stage Excessive speed on commencing swing Adverse weather eg squally wind from North or wind speed increases after vessel committed to manoeuvre Not monitoring weather forecasts/warnings Movement attempted in restricted visibility, lack of visual cues Other craft obstructs manoeuvre on approach, or impedes assisting vessels	Contact damage to both vessels (or vessel and berth) Delay to berthing and during investigation and survey	Major damage to both vessels or vessel/jetty Possible pollution from bulk carrier Potential for loss of life Damage to Jetty Mooring breakout on LNG Carrier.	0	4	0	4	5	5	5	5	4.07	Money Point is on the north bank and to the east of the proposed LNG jetty There is plenty of sea room for berthing and swinging vessels bound to or from Money Point
20	22	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	LNG carrier contacts jetty / vessel during transit/swing	LNG Carrier comes into contact with berth or another vessel alongside during transit and swing	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Vessels passing too close / interaction Misjudgment Strong cross winds causing leeway / requiring set especially in squally conditions Reduction of speed may be required if vessels alongside jetties Steering failure. Power failure. Vessel unable to get all tugs fast.	Glancing blow - minor or moderate damage to one or both vessels Damage to moorings Pollution (from damage to cargo connections Damage to gangways	Glancing blow - moderate or major damage to one or both vessels Mooring breakout Pollution (from damage to cargo connections Damage to gangways	1	4	3	3	3	5	4	5	4.07	
21	7	Ballybunnion Buoy to Doonaha Buoy	Collision	Escort tug and LNG Carrier collision	Escort tug in collision with LNG Carrier during ship escort / connection	Port Service Craft, LNG Carrier	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Misjudgement during connecting for active escort in adverse weather Poor communication between tug and ship's crew Control systems failure on tug or misjudgement Sudden illness/incapacitation of Tugmaster with no trained person immediately available to take controls	Glancing blow with minor damage to tug bulwarks and fendering Possibility for minor injuries to tug crew on deck (unable to keep balance and falls to deck or against winch)	Tug goes under counter of LNG Carrier Major damage to tug Possible puncture of after peak plating of LNG Carrier Potential for fatality on tug	4	4	0	0	5	6	0	3	4.04	Escort tugs normally have a significant wave height restriction for safe connecting up Tug masters are well trained & experienced
22	35	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy	Foundering	Pilot launch swamped/capsize	Pilot launch floods in adverse weather/sea conditions during LNGC pilot operations	Port Service Craft, All	Pilot, Pilot Launch, Shannon Foynes Port Company	Adverse operating conditions. Deck openings not secured. Wheelhouse window broken by heavy seas. Propulsive or steering system failure, inability to maintain safe heading in seaway. Damage to vessel during transfer operations. Inadequate lee made by vessel.	Water ingress controlled by bilge pumps, launch returns to sheltered waters with minor water logging to lower spaces or wheelhouse.	Water ingress through structural failure in heavy weather with loss of pilot launch and possibility of fatalities.	0	2	0	5	5	5	3	4	3.97	Engine reliability questionable. Use of Foynes pilot cutter (Kerry Head) at Killrush if transfer inside heads

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23	8	North Carrig to Tarbert inc LNG jetty	Collision	Tug and LNG Carrier collision	Tug in collision with LNG Carrier during maneouvring and/or connecting up operations	Port Service Craft, LNG Carrier	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Attempting connection at relatively high speed for tug Misjudged approach by tug Loss of tug control systems, engine power or engine/s at critical stage Pilot or Master not monitoring tug position, moves ahead or astern when tug not clear Tug use plan not provided or discussed Loss of communications Winch does not release under emergency conditions Tugmaster temporarily incapacitated and control lost before another crew member can take over Poor forward visibility on LNG carrier.	Tug has glancing blow with hull and pushed off before regaining control with nil or minimal damage	Tug over-run or caught under bow flare doing considerable damage to mast and wheelhouse structure Injuries to tug crew Tug holed and disabled Possibility of tug sinking; Fatalities; Salvage operations;	3	0	0	0	6	6	5	5	3.92	Connecting speed is generally 4 knots or less and procedure is for tugs to avoid crossing ahead of ships proceeding at more than 5 knots Tug pushing outside the designated area of the shipside
24	37	North Carrig to Tarbert inc LNG jetty	Grounding	LNG Carrier grounds near berth	LNG Carrier grounds near berth during swinging manoeuvre	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Initial lack of familiarity with LNG vessel type - handling characteristics Misjudgement of manoeuvre in tidal stream/wind allowing vessel to travel outside manoeuvring area Adverse weather / tidal conditions Movement attempted in restricted visibility/night, lack of (or obscured) visual cues. Miscalculation of UKC Poor assessment of set and leeway; Poor passage planning and monitoring including over-reliance on channel buoys for position reference (poor visibility) Excessive headway on commencement of turn Tug operational failure or miscommunications between ship handler/pilot & Tugmaster Incorrect tug usage and power for manoeuvre Other craft obstructs manoeuvre on approach, or impedes assisting vessels Poor or No BRM principles being utilised Failure to monitor position in channel Pilot judgement impaired due to fatigue	Low energy grounding Refloated promptly Minor damage to shell plating Possible damage to rudder / propeller	Vessel grounds with force Unable to refloat on remainder of flood Possible vapour release in the event of prolonged stranding Port closure during refloating operations	0	5	0	5	3	5	0	5	3.91	Pilots have a portable berthing coputer aid that bis independant of the ships systems.
25	30	North Carrig to Tarbert inc LNG jetty	Fire/Explosion	Fire on Service Craft	Fire on Service Craft in attendance at LNG terminal	Port Service Craft, All	Mooring Crews and Boats, Pilot Launch, Shannon Foynes Port Company, Tugs and Towing Company	Poor maintenance Mechanical or electrical fault Inadequate training of crew or maintenance staff	Source of ignition detected early with fire quickly extinguished with minimal damage	Engine room or electrical fire causes major damage Possible loss of craft Possible fatality Reduction in port facilities Secondary hazard: Fire threatens LNG Carrier	4	0	0	2	5	5	3	5	3.88	Assistance can be given by other craft/LNG Carrier Harbour Emergency Plans Harbour maintenance procedures Crew training
26	15	North Carrig to Tarbert inc LNG jetty	Collision	LNGC in contact with Ferry	LNG Carrier unable to maneouvre onto berth and drifts down onto ferry	LNG Carrier, Passenger	Pilot, Shannon Ferries, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Control system failures on LNGC and/or tugs	Superficial damage to LNGC and/or ferry plating/paintwork	Heavy impact with possibility of some passengers being injured and damage to vehicles. Punctured shell plating above waterline requiring repair and inspection before ferry resumes sailing Negative publicity	3	3	0	4	4	5	0	5	3.8	Ferry route runs across the Shannon Estuary and is 2 miles east of proposed LNG Terminal; therefore the LNGC would not normally come within proximity of the ferry under exceptional circumstances
27	13	North Carrig to Tarbert inc LNG jetty	Contact - Berthing	Contact Berthing LNG Carrier	LNG Carrier contacts berth heavily	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Wind limits for berthing exceeded Misjudgement of manoeuvre in tidal stream/wind or adverse weather / tidal conditions Movement attempted in restricted visibility, lack of visual cues Tug operational failure or miscommunications between ship handler/pilot & Tugmaster Ship handler not used to manoeuvring vessel (lacks currency) with tug assistance Other craft obstructs manoeuvre on approach, or impedes assisting vessels Propulsion/steering or bow thrust failure at critical stage Approach/departure not planned sufficiently for conditions Fatigue impairs judgement of master or pilot Initial lack of familiarity with LNG vessel type as trade starts (handling characteristics)	Heavier landing than anticipated with minor damage to berth facing and plating of vessel	LNG Carrier set down onto jetty or dolphins Damage to fender system Damage to vessel and possible penetration of hull	2	4	0	2	2	5	2	5	3.74	Pilots may be using a carry aboard system for position fixing independent of the ships navigation system Approach speed is likely to be low, due to pilot caution Area subject to changeable weather Beam wind forces can be considerable.
28	39	Port Approaches up to Ballybunnion Buoy	Grounding	LNG Carrier grounds during transit of Bar	LNG Carrier grounds during transit of Ballybunnion Bar inward or outward	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Loss of directional stability in heavy swell Poor assessment of set and leeway; Poor passage planning and monitoring including over-reliance on channel buoys for position reference (poor visibility) Lack of support from Bridge Team or poor or No BRM principles being utilised Failure to monitor position Miscalculation of UKC in respects to state of tide and weather conditions Traffic conflict resulting in LNGC being impeded and taking avoiding action into shallow water Lack of vessel traffic management Tug operational failure or miscommunications between ship handler/pilot & Tugmaster	Damage to shell plating Prompt refloating Possible slight berthing delay Possible delays to other vessels during stabilisation of situation	Major hull damage Restriction of port operations Possible loss of cargo if machinery disabled or vessel stranded	1	4	0	4	3	5	0	5	3.71	Arrival draft expected to be about 12.5 metres and depth over Bar is 16.4 metres

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29	50	North Carrig to Tarbert inc LNG jetty	Personal Injury	Personal Injury to Line Boat Crew	Line boat crew suffer personal injury during berthing operations	Port Service Craft, All	Mooring Crews and Boats, Pilot, Shannon Foynes Port Company, Shannon LNG	Poor communications between Pilot / tugs / line boat Line boat operating in rough conditions Propulsion/steering/control systems failure at critical stage Crossing springs (line boat passing over the top of) Line boat caught between berth face and ship Anchor dropped while line boat underneath Uncontrolled dropping of mooring lines or wires onto Line Boat Line boat underpowered for lines being passed Lack of training and.or procedures	Minor injury to line boat crew through trip/slip/fall	Possible fatality Damage to boat Delay to vessels if no line boat available	6	0	0	0	5	2	0	3	3.7	
30	55	North Carrig to Tarbert inc LNG jetty	Personal Injury	Mooring gang injured whilst working on dolphins	Mooring gang sustain injuries during mooring (or unmooring) operations on dolphins	Port Service Craft, All	Mooring Crews and Boats, Shannon LNG	Restricted working room Poor design layout Communication (Language) problems between ship and mooring gangs Lineboat radios cannot be heard over the noise of the engines Lack of/or inadequate training	Minor injury. Person falls into water or mooring boat	Fatality	4	0	0	0	6	2	0	4	3.67	
31	54	Ballybunnion Buoy to Doonaha Buoy, North Carrig to Tarbert inc LNG jetty	Personal Injury	Personal injury to LNG carrier crew	Personal injury to LNG carrier crew during towage and/or connecting up	LNG Carrier, All	Shannon Foynes Port Company, Shannon LNG	Heavy weather resulting LNG carrier motion; Towline parts; Untrained crew handling winch or towline; Incorrect personal protective equipment; Experience of tugmaster in conditions; LNG carrier 's crew unbalanced from heavy landing on vessel; Having to connect up under expediency; Towing points not fit for purpose	Minor injury resulting from fall or slip on LNG carrier; Minor injury to hands or fingers while connecting ropes;	Serious injury to a crew member; possible fatality	4	0	0	0	6	2	0	4	3.67	Risk level may be higher if crew needs to make tug fast with expediency;
32	23	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Dolphin Watch in contact with structure	Dolphin Watch involved in contact with LNG jetty	Passenger, All	Dolphin Watch, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Disoriented by night or in restricted visibility FV proceeding at excessive speed Propulsion/steering failure at critical stage. Lack of knowledge or experience Judgement impaired due to alcohol/fatigue Absence of vessel traffic management	Dolphin Watch is set down onto LNG jetty with no significant damage to either vessel or berth	Dolphin Watch contacts jetty with possible damage causing water ingress and sinking Possibility of fatalities on dolphinwatch	2	2	0	2	6	5	2	5	3.63	
33	26	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Dolphin Watch involved in contact with LNG carrier alongside	Dolphin Watch involved in contact with LNG carrier alongside	Passenger, All	Dolphin Watch, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Disoriented by night or in restricted visibility FV proceeding at excessive speed Propulsion/steering failure at critical stage. Lack of knowledge or experience Judgement impaired due to alcohol/fatigue Absence of vessel traffic management	Dolphin Watch is set down onto LNG carrier with no significant damage to either vessel or berth	Dolphin Watch contacts carrier with possible damage causing water ingress and sinking Possibility of fatalities on dolphinwatch	2	2	0	2	6	5	2	5	3.63	
34	19	Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig	Contact - Navigation	LNG Carrier in contact with Aid to Navigation	LNG Carrier in contact with channel mark	LNG Carrier, All	Commissioner of Irish Lights, Pilot, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Movement attempted in restricted visibility, lack of visual cues Propulsion/steering or bow thrust failure at critical stage Transit impeded by another vessel at critical time Poor or No BRM principles being utilised Failure to monitor position in channel Escort Tug unable to assist in time	Minor contact with buoy with superficial damage, scraped paintwork.	Navigation mark put out of commission by heavy contact Possible steering gear damage	0	4	0	0	0	6	0	6	3.61	
35	11	North Carrig to Tarbert inc LNG jetty	Collision	Fishing vessel run down by LNG Carrier	Fishing vessel in collision with LNG Carrier whilst retrieving pots	Fishing Craft, LNG Carrier	Commericial Anglers, Pilot, Shannon LNG, Tugs and Towing Company	Fishing vessel obstructs LNG Carrier whilst retrieving pots Misjudgement of closest point of approach, lack of appreciation of manoeuvring characteristics or blind sector under and ahead of bow of vessel Fishing vessel unaware of impending LNG movement Fishing Vessel not keeping a porper lookout or VHF watch Fishing vessel becomes hampered by its gear and unable to move in time	Minor contact/glancing blow Possible injuries/man overboard from wash of larger vessel Loss of gear Secondary hazard: Larger vessel's margin of safety reduced when taking avoiding actions.	Fishing vessel run down by the LNG Carrier and sinks. Possible multiple fatalities	3	2	0	3	5	3	2	5	3.58	Fishing vessels lay pots within the channel/estuary particularly in winter
36	45	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig, North Carrig to Tarbert inc LNG jetty	Port Security Incident	Terrorist Incident	Terrorist Incidents can impinge on all activities and operations in the port. They are likely to be unspecified but may have prior warning. It must be assumed that every activity is a hazard and produces maximum risks.	All, All	ESB, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Terrorist attacks could come from the open sea, the air, from the local water access points in the area or from land by road transport. Port security level increased from information received by external official sources	Such an incident would be controlled under the ISPS Code. Possible non-event - politically motivated protest. Delays from increased security levels.	An unexpected attack could cause serious damage to vessels and port facilities resulting in groundings, sinkings, fire or explosions.	0	0	0	3	5	5	4	5	3.57	
37	33	Ballybunnion Buoy to Doonaha Buoy, North Carrig to Tarbert inc LNG jetty	Foundering	Capsize of tug	Tug floods or is capsized during ship assist	Port Service Craft, All	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Tug not fit for purpose Tug-master not trained in towing off the hook Hook fails to release when required, poor maintenance or incorrectly set Misunderstood communications between pilot/ship handler and tug-master Watertight hatches not secured on tug Ship moves ahead unexpectedly while tug connected Inadequate briefing between pilot or ship handler and tug-master	Tug heels and towed sideways but quick release successfully releases towline	Towline fails to release and downflooding occurs quickly through unsecured deck openings when tug takes heel Tug capsizes with loss of life Reduced port facility due to loss of tug	0	2	0	0	6	6	5	6	3.47	
38	32	Port Approaches up to Ballybunnion Buoy	Foundering	Flooding of escort or berthing tug	Escort tug floods whilst assisting LNG Carrier	Port Service Craft, All	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Tug W/T doors not secured during operation Downflooding if tugs heels during connected operation Inattention by tug crew Inappropriate procedures	Deck openings secured, only partial water ingress results from heel	Progressive downflooding leads to loss of stability and capsize of escort tug during active escort Possible fatalities Reduction in port facilities	0	2	0	0	6	6	5	6	3.47	

Ranked Hazard List

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Rank No.	Hazard Ref	Affected Areas	Accident Category	Hazard Title	Hazard Detail	Affected Vessel Types	Affected Stakeholders	Possible Causes	Consequence Descriptions: Most Likely (ML)	Consequence Descriptions: Worst Credible (WC)	Risk By Consequence Category: M L People	M L Property	M L Environment	M L Stakeholders	W C People	W C Property	W C Environment	W C Stakeholders	Risk Overall	Remarks
39	18	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Commercial Angler in contact with structure	Commercial angling craft involved in contact with LNG Carrier jetty	Fishing Craft, All	Commericial Anglers, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Disoriented by night or in restricted visibility FV proceeding at excessive speed Propulsion/steering failure at critical stage. Lack of knowledge or experience Judgement impaired due to alcohol/fatigue Absence of vessel traffic management	FV is set down onto berthed LNG Carrier with no significant damage to either fishing vessel or berth	FV contacts carrier with possible damage causing water ingress and sinking Possibility of fatalities of vessel crew	0	2	0	2	5	5	2	5	3.15	Proposed jetty is well clear of main channels
40	25	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Commercial Angling Craft in contact LNG Carrier Alongside	Commerical angling craft involved in contact with LNG Carrier	Fishing Craft, All	Commericial Anglers, Shannon Foynes Port Company, Shannon LNG	Misjudgement of manoeuvre in tidal stream/wind Adverse weather / tidal conditions Disoriented by night or in restricted visibility FV proceeding at excessive speed Propulsion/steering failure at critical stage. Lack of knowledge or experience Judgement impaired due to alcohol/fatigue Absence of vessel traffic management	Commerical Angler is set down onto berthed LNG Carrier with no significant damage to either fishing vessel or berth	Commercial Angler contacts carrier with possible damage causing water ingress and sinking Possibility of fatalities of vessel crew	0	2	0	2	5	5	2	5	3.15	
41	9	North Carrig to Tarbert inc LNG jetty	Collision	Leisure craft collision with swinging vessel	Leisure craft obstructs vessel manoeuvring on/off berth or swinging in the fairway or manoeuvring in an anchorage.	Leisure, LNG Carrier	Leisure Users, Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Lack of marine knowledge of leisure craft operator Inattention and poor look out Sound signals not used by larger vessel to warn of impending movement Failure of engine on craft or being becalmed on yacht	Larger vessel modifies intended manoeuvre Glancing blow only with minor damage to small vessel	Leisure craft collides with swinging vessel or tug assisting Major damage to craft with potential for fatalities	2	2	0	2	5	3	2	3	3.13	Leisure craft generally keep out of main channels used by commercial shipping
42	5	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig, North Carrig to Tarbert inc LNG jetty	Collision	Pilot Launch/harbour craft in collision with LNG Carrier	Pilot launch or harbour craft in collision with LNG Carrier	Port Service Craft, LNG Carrier	Mooring Crews and Boats, Pilot, Pilot Launch, Shannon LNG	Human error or misjudgement of manoeuvre Poor lookout Lights difficult to detect against shore lighting, or backscatter from harbour crafts own lights (e.g. deck lights on tug)	Glancing blow between pilot launch or craft and LNG Carrier with minor damage to craft	Possibility of some crew being thrown into water with potential for drowning Potential for loss of craft	2	2	0	0	5	5	2	5	2.93	Harbour craft does not include tugs which is another hazard
43	24	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Leisure Craft in contact with LNG Carrier alongside	Leisure craft involved in contact with LNGCarrier alongside	Leisure, All	Leisure Users, Shannon Foynes Port Company, Shannon LNG	Disoriented by night or in restricted visibility Lack of knowledge or experience Judgement impaired due to alcohol/fatigue Excessive speed in close proximity LNG Terminal Disregard of Bye-Laws Misjudgement of clearance under berth	Sailing craft contacts carrier at relatively slow speed Damage to boat or rigging but no damage to jetty structure	Leisure craft sinks in vicinity and possible crew and passenger fatalities	0	2	0	0	5	5	2	3	2.91	
44	17	North Carrig to Tarbert inc LNG jetty	Contact - Navigation	Leisure craft in contact with structure	Leisure craft involved in contact with LNG jetty structure	Leisure, All	Leisure Users, Shannon LNG	Disoriented by night or in restricted visibility Lack of knowledge or experience Judgement impaired due to alcohol/fatigue Excessive speed in close proximity LNG Terminal Disregard of Bye-Laws Misjudgement of clearance under berth	Sailing craft contacts jetty at relatively slow speed Damage to boat or rigging but no damage to jetty structure	Leisure craft sinks in vicinity and possible crew and passenger fatalities	0	2	0	0	5	5	2	3	2.91	Proposed jetty is well clear of main channels Area not currently used by leisure craft to any great extent
45	52	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy	Personal Injury	Personal injury to pilot launch crew	Personal injury to launch crew during pilot transfer or operation in exposed areas of Estuary or outside entrance	Port Service Craft, All	Pilot, Pilot Launch, Shannon Foynes Port Company	Severe movement of pilot launch in heavy weather with resulting slips/trips and falls Inappropriate crew footwear, clothing or PPE Incorrect use of safety systems Best lee not made by ship Speed inappropriate for conditions Ship does not achieve the requested heading or alters speed/course substantially during the launches approach Launch lands heavily on ship's side Crew loses grip on rail / manrope while assisting pilot or not holding on or not tethered to rail Inexperience of crew	Minor injury resulting from slip/trip or fall	Serious injury to crew member Crew member falls overboard Potential for fatality	2	0	0	2	5	0	0	5	2.73	
46	51	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy	Personal Injury	Personal injury to Pilot	Pilot suffers personal injury during transfer to or from an LNG Carrier	Port Service Craft, All	Pilot, Shannon Foynes Port Company	Best lee not made by ship or speed inappropriate for conditions and ship does not achieve the requested heading or alters speed/course substantially during the launches approach Pilot ladder not fit for purpose including incorrect length, poor condition or not rigged / sited properly Pilot misjudges timing of transfer to/from launch in adverse sea conditions Severe movement of pilot launch in heavy weather Cox'n unable to keep launch alongside in heavy weather or with propulsive/steering failure Pilot not secured during transfer to foredeck, loses grip on manrope / rails High freeboard of LNG vessels: a combination ladder arrangement is required both in laden and ballast condition. High swell conditions off the port entrance LNG vessels - tendency to roll?	Misjudged transfer between ladder and launch resulting in minor injury to Pilot - strain or sprain	Pilot falls from height onto launch Pilot falls between launch and ship Possible fatality	2	0	0	2	5	0	0	5	2.73	
47	47	North Carrig to Tarbert inc LNG jetty	Mooring Breakout	Passing LNG Carrier causes mooring breakout.	LNG Carrier passing other jetties causes vessels alongside to part moorings.	LNG Carrier, All	ESB, Pilot, Shannon Foynes Port Company, Shannon LNG	LNG Vessel passing too close and/or too fast (interaction) Incorrect position of vessel during transit Misjudgement of manoeuvre in tidal stream/wind; Adverse weather / tidal conditions; Movement attempted in restricted visibility, lack of visual cues Misjudgement Failure to tend moorings (other vessels). Failure to maintain mooring equipment to OCIMF standards (other vessels). Strong cross winds causing leeway / requiring set or additional power to be applied, especially in squally conditions. Vessel unable to get all tugs fast.	One or more mooring lines parted. Damage to gangway	Vessel dragged from berth. Vesssel grounds before assistance received.	0	1	0	1	1	5	1	5	2.65	

Ranked Hazard List

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Rank No.	Hazard Ref	Affected Areas	Accident Category	Hazard Title	Hazard Detail	Affected Vessel Types	Affected Stakeholders	Possible Causes	Consequence Descriptions: Most Likely (ML)	Consequence Descriptions: Worst Credible (WC)	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall	Remarks
48	21	Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig	Contact - Navigation	Tug contacts navigational mark	Escort tug contacts navigational mark	Port Service Craft, All	Commissioner of Irish Lights, Pilot, Shannon Foynes Port Company, Tugs and Towing Company	Misjudgement of manoeuvre in tidal stream/wind; Adverse weather / tidal conditions; Tug concentrating on LNG carrier and not maintaining lookout; Tug unable to avoid mark when trying to assist vessel;	Superficial damage to tug;	Major damage to tug; Tug unable to assist LNG carrier; Possible loss of navigational mark;	0	3	0	0	0	4	0	3	2.55	Escort tug maybe trying to assist and unable to avoid mark;
49	34	North Carrig to Tarbert inc LNG jetty	Foundering	Line boat capsize	Line boat capsizes during mooring operations.	Port Service Craft, All	Mooring Crews and Boats, Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Line caught in screw or bow thruster due to excessive slack or loss of line control on board line boat Vessel fails to slack line Line boat passes over crossed springs which are heaved on by the vessel Poor handling by coxswain Line boat radios cannot be heard over the noise of the engines Lack of training and/or procedures	Line boat moves violently and crewman falls into water. Crew rescued by other line boat or small craft.	Lineboat capsize with fatality.	2	0	0	0	4	4	1	4	2.45	
50	46	North Carrig to Tarbert inc LNG jetty	Mooring Breakout	Mooring Breakout of another Vessel	Mooring breakout at another berth drifting near LNG Terminal	All, All	ESB, Shannon Ferries, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Moorings not tended on vessel Tension winches not set on the brake Poor condition of mooring lines Mixed moorings Wind loading exceeds breaking strain of lines in use Wind strength and direction not monitored, forecast not obtained Jetty guidelines not followed Tugs unavailable to push on due to commitments to other shipping	Tugs push vessel alongside wharf while extra lines or storm lines rigged	Vessel breaks free and drifts towards LNG terminal on tide before tugs can assist or vessel can mobilise. Escalation if vessel contacts LNG Carrier	0	0	0	0	3	6	0	6	2.44	Vessel that have broken adrift have been observed to drift with the tide along the line of the channel and have not come near any existing of proposed berth
51	38	North Carrig to Tarbert inc LNG jetty	Mooring Breakout	Mooring Breakout of berthed LNG Carrier	Mooring breakout of LNG Carrier during cargo transfer alongside jetty	LNG Carrier, All	ESB, Shannon Ferries, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	LNG Carrier ranges alongside due to tide and/or wind effects Vessel passing to close to berthed LNG Carrier Moorings of vessel slack or not tended, poor deck watch Operating limited exceeded Poor maintenance standards on LNGC or jetty Vessel moorings not suitable for terminal (not matched) Inadequate terminal information exchange Inappropriate chartering of LNG Carrier for terminal Inadequate jetty procedures (training/monitoring/compliance)	Vessel alongside due to slack moorings. Moorings hold, no damage or spill	Strong tides / wind causes LNGC to range heavily with possible mooring breakout. Manifold separates with small cargo spill before auto shutdown Damage to gangway. Escalation to full breakout before tugs can assist	0	0	0	0	3	6	0	6	2.44	
52	1	North Carrig to Tarbert inc LNG jetty	Cargo Release	Cargo Release - Vapour	Uncontrolled LNG gas released from vessel. Failure of cargo containment system on board.	LNG Carrier, All	Shannon Foynes Port Company, Shannon LNG	Pipeline rupture / failure. Valve / compressor gland failure. Machinery failure (reliquification plant).	Limited release contained locally and eliminated by ships crew.	Major damage to plant - unable to effectively isolate. Gas in contact with ignition source and fire occurs. Possible injuries / fatalities.	0	0	0	3	3	2	0	2	2.42	Breakdown of or gap in policing of prohibited zone by water craft creating ignition source
53	43	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig, North Carrig to Tarbert inc LNG jetty	Grounding	Pilot launch grounding	Pilot launch grounds whislt attending LNG Carrier	Port Service Craft, All	Pilot, Pilot Launch, Shannon Foynes Port Company	Misjudgement of manoeuvre in tidal stream/wind. Propulsion/steering/control systems failure at critical stage Failure to keep proper lookout Inattention to track while navigating Radar breakdown in restricted visibility Judgement impaired due to fatigue.	Glancing grounding with minor damage to hull Possible damage to propellers / rudders but able to return to berth	Launch goes ashore in heavy swell and broaches Fatalities possible Loss of pilot boat and delays to commercial vessels	0	1	0	0	0	4	1	4	2.09	
54	49	Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig, North Carrig to Tarbert inc LNG jetty	Near Miss	Towline parts	Towline parts during approach, transit and/or berthing	Port Service Craft, All	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Excessive wear on tow line Sharp edges on fairleads Poor towline leads not enough towline used especially due to high freeboards Line of insufficient strength Tugmaster manoeuvring error Excessive sea movements Poor condition of towline	Delay in operation awaiting reconnection Raising of tension among other tow craft	Insufficient redundancy of towcraft Loss of control Delay to vessel or abort of transit until new line available Secondary hazard - Grounding Secondary Hazrad - Collision with other vessels	0	2	0	0	0	2	0	2	1.67	High freeboards and/or incorrect length of tow line can lead to higher loadings on towlines. Dynamic towing can increase shock loadings to towlines. Shock loadings during connection/ can be more frequent but can be controlled by freewheeling
55	48	Port Approaches up to Ballybunnion Buoy, Ballybunnion Buoy to Doonaha Buoy, Doonaha Buoy to North Carrig, North Carrig to Tarbert inc LNG jetty	Near Miss	LNG Carrier in close quarters situation with other vessel	LNG Carrier in close quarters situation with another vessel	LNG Carrier, All	Pilot, Shannon Foynes Port Company, Shannon LNG, Tugs and Towing Company	Channel usage conflict. Disregard of Port Control advice regarding potential traffic conflict. Misjudgement or miscommunication by either/both vessels. Infringing vessel has difficulty in clearing path of LNG Carrier committed to channel. Anchored vessel swung across channel by tide/wind. Inadequate anchor watch. Not monitoring Port Control VHF channel for weather forecasts/warnings. Engines not ready for immediate manoeuvre on anchored vessel.	Close quarters situation but collision averted. Internal investigation delays.	Very close quarters situation requiring reporting to marine authorities. Delays possible during investigation.	0	0	0	0	0	0	0	4	1.39	Presence of other vessels in vicinity likely to be governed and limited by precautionary manoeuvring area.

ANNEX D

CONTROLS AND MITIGATIONS

IDENTIFIED HAZARDS
(Ranked in Order of Risk Level with Mitigations Applied)

Existing Risk Controls and Proposed Future Mitigations

Rank No.	Hazard Ref	Group	Accident Category	Hazard Detail	Existing Risk Controls	Existing ML People	Existing ML Property	Existing ML Environment	Existing ML Stakeholders	Existing WC People	Existing WC Property	Existing WC Environment	Existing WC Stakeholders	Existing Risk Overall	Future/Possible Mitigations	Expected Reduction in Risk Level	Future ML People	Future ML Property	Future ML Environment	Future ML Stakeholders	Future WC People	Future WC Property	Future WC Environment	Future WC Stakeholders	Future Risk Overall	Remarks
1	3	Commercial	Collision	LNG Carrier in collision with another vessel in port approaches	Compulsory pilotage seaward of Ballybunnion Bar for vessels great than 13.0m draft	3	6	0	6	5	5	5	5	4.98	VTS Information and Traffic Organisation Services Develop compulsory pilotage for all vessels west of Ballybunion Bar irrespective of draught Develop revised pilot baording areas to reflect compulsory pilotage areas.	ML & WC frequency reduced by 1	3	5	0	5	5	5	5	5	4.63	
2	29	Commercial	Fire/Explosion	Fire on LNG Carrier whilst alongside	IMO Gas Codes - SIGTTO procedures, construction fire fighting equipment Ship staff procedures and training Shannon Foynes Emergency Procedures Existing shore fire services Shipping Vetting for charter vessels	4	4	0	2	7	7	2	7	5.03	Jetty fire fighting equipment Proximity FiFi 1 Tug on station. Develop joint emergency plan (inc. evacuation plan) Ship/Shore InterfaceShore services fire fighting training	WC frequency reduced by 1. WC People reduced by 1	4	4	0	2	5	6	2	6	4.45	Joint emergency plan will take into account available services and equipment and procedures.
3	31	Commercial	Fire/Explosion	Fire on LNG Carrier while underway in harbour areas	IMO Gas Codes - SIGTTO procedures, construction fire fighting equipment Ship staff procedures and training Shannon Foynes Emergency Procedures Shore fire services Shipping Vetting for charter vessels	4	4	0	2	7	7	2	7	5.03	Escort FiFi 1 escort tug, second FiFi 1 tug in attendance in transit Develop joint emergency plan (inc. evacuation plan)	WC frequency reduced by 1. WC People reduced by 1	4	4	0	2	5	6	2	6	4.45	Joint emergency plan will take into account available services and equipment and procedures.
4	36	Commercial	Grounding	LNG Carrier grounds in the port approach prior to boarding pilot	Bridge Team Competence Environmental Operating Limits for pilot embarkation	2	6	0	6	4	7	0	7	5.27	VTS surveilence and Navigational Assistance Service Limits to be reviewed in light of LNG Carriers Mismatch in GPS Datum - ships navigation system not set to correct datum source	ML & WC frequency reduced by 1	2	5	0	5	3	6	0	6	4.38	
5	42	Commercial	Grounding	LNG Carrier leaves channel between Doonaha Buoy and North Carrig and grounds	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available Existing Navigation Buoyage	2	6	0	6	4	7	0	7	5.27	VTS Navigational surveilence, Navigational Assistance and Traffic Organisation Services. Absense of passing/overtaking traffic (mobile Control Zone). Use of optimum track Improved navigational marks. Consider Starboard Lateral or improving vis of North Carrig Escort towage Develop generic LNG Carrier Passage Plan	ML & WC frequency reduced by 1	2	5	0	5	3	6	0	6	4.38	Starboard Mark may be useful but unlikley to be cost effective as North Carrig available could cause small vessels to navigate closer to shallows
6	40	Commercial	Grounding	LNG Carrier leaves fairway and grounds between Tail of Beal and Beal Bar Buoys	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available Existing Underkeel Clearance Software Existing Navigation Buoyage	2	6	0	6	4	7	0	7	5.27	Embark Pilot to seaward of Ballybunnion Buoy or Vessel to remain at sea until conditions improve VTS Navigational Surveilence and Navigational Assistance Organisation Escort towage Environmental Operating Limits Develop generic LNG Carrier Passage Plan Consider repositioning Beal Bar buoy Consider removing Carrigaholt buoy or moving to new position on 14.9m patch on leads. Consider updating hydrographic survey of Estuary	ML & WC frequency reduced by 1	2	5	0	5	3	6	0	6	4.38	The option "Consider replacing 3 x Cardinal marks with Starboard Lateral marks" deemed to be inappropriate as Starboard marks difficult to see at day. The Carrigaholt buoy is in 30m. Moving this bouy to the 14.9m patch would 'force' vessels to turn into Estuary and avoid them delaying the turn. This would be very appropriate if Doonaha could be swept to a greater depth and he Doonaha bouy removed.
7	20	Commercial	Contact - Navigation	Large vessel such as a Capesize BC contacts jetty or vessel berthed alongside whilst swinging off Money Point	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available Width of estuary 1'	0	4	0	4	5	5	5	5	4.07	Standby tug is to be stationed off LNGC when alongside	ML & WC frequency reduced by 2	1	4	3	3	3	5	4	5	4.07	Width of estuary 1'. Laden vessels turning onto berth swings away from LNG berth Understood to bew virtually impossible due to width and tidal currents
8	14	Commercial	Contact - Navigation	Other vessel comes into contact with unoccupied LNG Terminal jetty		2	4	0	2	3	6	3	5	4.28	Remove/Reposition Small Ship Anchorage at Glencloosagh Bay	WC frequency reduced by 1	2	4	0	2	3	5	3	4	3.89	
9	30	Service Craft	Fire/Explosion	Fire on Service Craft in attendance at LNG terminal	Onboard fire fighting systems. Crew training	4	0	0	2	5	5	3	5	3.88			4	0	0	2	5	5	3	5	3.88	
10	12	Commercial Leisure	Collision	Dolphin Watch collides with LNG Carrier in Port Approaches	Experienced coxswains Licenced/inspected Vessels	5	2	0	5	6	6	5	6	4.83	VTS Information and Traffic Organisation Services Impose Control Zone around LNGC whilst in transit Develop SFPA procedures to ensure Dolphin Watch does not hamper LNGC	ML & WC frequency reduced by 2	3	1	0	3	5	5	4	5	3.87	
11	15	Commercial	Collision	LNG Carrier unable to maneouvre onto berth and drifts down onto ferry	Port Byelaw 85	3	3	0	4	4	5	0	5	3.80	VTS Information Service Tugs available and fast		3	3	0	4	4	5	0	5	3.80	
12	10	Service Craft	Collision	LNG Carrier damaged by contact with tug	Experienced tugmasters	2	6	0	2	2	6	0	6	4.49	New construction tugs with dual redundancy in systems Tugmasters undergo joint bridge simulation and bridge team management training Connecting up procedures and training	ML & WC frequency reduced by 1	2	5	0	2	1	5	0	5	3.75	

Existing Risk Controls and Proposed Future Mitigations

Rank No.	Hazard Ref	Group	Accident Category	Hazard Detail	Existing Risk Levels: Existing Risk Controls	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall	Future Risk Levels: Future/Possible Mitigations	Expected Reduction in Risk Level	ML People	ML Property	ML Environment	ML Stakeholders	WC People	WC Property	WC Environment	WC Stakeholders	Risk Overall	Remarks
13	2	Recreational	Collision	Leisure craft collides with LNG Carrier in Port Approaches		5	2	0	3	6	5	2	5	4.42	VTS Information Service and Traffic Control Impose Control Zone around LNGC whilst in transit Second passive tug in attendance enforcing control zone Consider defining 'deep water route' as 'narrow channel' as per Colregs	ML & WC frequency reduced by 1	4	1	0	3	5	4	1	4	3.74	Control Zone reduces frequency but cannot entirely negate hazard.
14	13	Commercial	Contact - Berthing	LNG Carrier contacts berth heavily	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available Existing Navigation Buoyage Berthing tugs	2	4	0	2	2	5	2	5	3.74	Dopler docking system		2	4	0	2	2	5	2	5	3.74	
15	41	Commercial	Grounding	Vessel misjudges turn in vicinity of Beal Bar/ Doonaha Buoy	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available Existing Underkeel Clearance Software Existing Navigation Buoyage	2	5	0	5	3	6	0	6	4.38	VTS Navigational Surveilence and Navigational Assistance Organisation Escort towage Environmental Operating Limits Consider repositioning North Beal Develop generic LNG Carrier Passage Plan Consider sweeping Doonaha wreck with aim to remove Doonaha Buoy	ML & WC frequency reduced by 1	1	4	0	4	3	5	0	5	3.71	The option "Consider replacing 3 x Cardinal marks with Starboard Lateral marks" deemed to be inappropriate as Starboard marks difficult to see at day. The Carrigaholt buoy is in 30m. Moving this bouy to the 14.9m patch would 'force' vessels to turn into Estuary and avoid them delaying the turn. This would be very appropriate if Doonaha could be swept to a greater depth and the Doonaha bouy removed.
16	39	Commercial	Grounding	LNG Carrier grounds during transit of Ballybunnion Bar inward or outward	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available Existing Underkeel Clearance Software Existing Navigation Buoyage	1	4	0	4	3	5	0	5	3.71	VTS Navigational Surveilence and Navigational Assistance Organisation Escort towage		1	4	0	4	3	5	0	5	3.71	
17	7	Service Craft	Collision	Escort tug in collision with LNG Carrier during ship escort / connection	Experienced tugmasters	4	4	0	0	5	6	0	3	4.04	New construction - escort notated - tugs Tugmasters undergo joint bridge simulation and bridge team management training Connecting up procedures and training Dual redundancy of tugs	WC frequency reduced by 1	4	4	0	0	4	5	0	3	3.69	
18	53	Service Craft	Personal Injury	Personal injury to tug crew during towage and/or connecting up	Experienced tugmaster and tug crews	4	2	0	2	6	4	0	4	4.09	Connecting up and towing procedures Environmental operating parameters Towline configuration Tug winch freewheel capabilities	WC frequency reduced by 1	4	2	0	2	5	3	0	3	3.64	
19	27	Commercial	Contact - Navigation	LNG Carrier contacts vessel at anchor	Designated Anchorages are clear of the main channel	0	5	0	5	3	6	0	6	4.26	VTS surveilence of vessels at anchor LNG Carriers to use designated channel	ML & WC frequency reduced by 1	0	4	0	4	3	5	0	5	3.62	
20	37	Commercial	Grounding	LNG Carrier grounds near berth during swinging manoeuvre	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available Existing Underkeel Clearance Software Existing Navigation Buoyage	0	5	0	5	3	5	0	5	3.91	Consider navigational mark on West Point of Glencloosagh Bay shallows Tug procedures Develop generic LNG Carrier Passage Plan Tugs fast prior to berthing	ML & WC frequency reduced by 2	0	4	0	4	3	5	0	5	3.62	
21	45	Commercial	Port Security Incident	Terrorist Incidents which can impinge on all/any activities and operations in the port.	ISPS Code	0	0	0	3	5	5	4	5	3.57	ISPS Code. High level of physical security throughout LNG site		0	0	0	3	5	5	4	5	3.57	ISPS Code will cover this hazard in greater depth
22	16	Commercial	Contact - Navigation	Berthed LNG Carrier contacted by passing vessel	Experienced pilots	2	5	0	2	4	5	4	5	4.17	Control zone of 150m when LNG Carrier alongside Remove/Reposition Small Ship Anchorage at Glencloosagh Bay Use of standby tug in vicinity when LNG berth occupied	ML & WC frequency reduced by 1	1	4	0	1	3	4	3	4	3.56	
23	8	Service Craft	Collision	Tug in collision with LNG Carrier during maneouvring and/or connecting up operations	Experienced tugmasters	3	0	0	0	6	6	5	5	3.92	New construction tugs with dual redundancy in systems Tugmasters undergo joint bridge simulation and bridge team management training Connecting up procedures and training	WC frequency reduced by 1	3	0	0	0	5	5	4	4	3.51	
24	35	Service Craft	Foundering	Pilot launch floods in adverse weather/sea conditions during LNGC pilot operations	Compliance with Pilot Cutter regulations. Environmental operating limits Coxswain has power to suspend operations	0	2	0	5	5	5	3	4	3.97	Consider use of uprated Pilot Cutter for rough weather operations to west of Ballybunnion Buoy LNG Carrier environmental operating parameters Improved reliability of service	ML & WC frequency reduced by 1	0	1	0	4	4	4	2	3	3.40	

Existing Risk Controls and Proposed Future Mitigations

					Existing Risk Levels										Future Risk Levels											
						ML				WC							ML				WC					
Rank No.	Hazard Ref	Group	Accident Category	Hazard Detail	Existing Risk Controls	People	Property	Environment	Stakeholders	People	Property	Environment	Stakeholders	Risk Overall	Future/Possible Mitigations	Expected Reduction in Risk Level	People	Property	Environment	Stakeholders	People	Property	Environment	Stakeholders	Risk Overall	Remarks
25	55	Service Craft	Personal Injury	Mooring gang sustain injuries during mooring (or unmooring) operations on dolphins	Crew Experience PPE	4	0	0	0	6	2	0	4	3.67	Berthing Master or Mooring Supervisor Design of Mooring systems (Optimoor) Trained Personnel Training and HSE Effective Communications Environmental Operating Parameters Use of correct, properly maintained mooring ropes	WC frequency reduced by 1	4	0	0	0	5	2	0	3	3.24	
26	54	Commercial	Personal Injury	Personal injury to LNG carrier crew during towage and/or connecting up	Trained officers and crews ISM Code Safe Working Procedures	4	0	0	0	6	2	0	4	3.67	Experienced tugmaster and tug crews Environmental operating parameters Towline configuration Tug winch freewheel capabilities	WC frequency reduced by 1	4	0	0	0	5	2	0	3	3.24	
27	11	Commercial Leisure	Collision	Fishing vessel in collision with LNG Carrier whilst retrieving pots		3	2	0	3	5	3	2	5	3.58	(VTS Information Service of pending traffic arrival) (Second passive tug in attendance enforcing control zone) Consider defining 'deep water route' as 'narrow channel' as per Colregs		3	2	0	3	4	3	1	4	3.23	
28	33	Service Craft	Foundering	Tug floods or is capsized during ship assist	Experienced tugmasters and crew. Port Byelaw 87(4) Tug QMS	0	2	0	0	6	6	5	6	3.47	Design of tug Towage procedures Freewheel/quick release factilities Joint pilot/tugmaster simulation training	WC frequency reduced by 2	0	2	0	0	5	5	4	5	3.06	
29	32	Service Craft	Foundering	Escort tug floods whilst assisting LNG Carrier	Experienced tugmasters and crew	0	2	0	0	6	6	5	6	3.47	Design of tug - escort notated tugs Towage procedures Freewheel/quick release factilities Joint pilot/tugmaster simulation training Watertight integrity procedures	WC frequency reduced by 2	0	2	0	0	5	5	4	5	3.06	
30	23	Commercial Leisure	Contact - Navigation	Dolphin Watch involved in contact with LNG jetty	Experienced coxswains Licenced/inspected Vessels	2	2	0	2	6	5	2	5	3.63	Maintain safe distance from structure	WC frequency reduced by 1	2	2	0	2	5	4	1	4	3.00	
31	26	Commercial Leisure	Contact - Navigation	Dolphin Watch involved in contact with LNG carrier alongside	Experienced coxswains Licenced/inspected Vessels	2	2	0	2	6	5	2	5	3.63	Impose 150m control zone around berthed vessel Standby tug on patrol.		2	2	0	2	5	4	1	4	3.00	
32	50	Service Craft	Personal Injury	Line boat crew suffer personal injury during berthing operations	Crew Experience PPE ISO SFPA Line boat procedures	6	0	0	0	5	2	0	3	3.70	Line boats built for purpose Trained Personnel Effective Communications Training and HSE Environmental Operating Parameters Use of correct, properly maintained mooring ropes	WC frequency reduced by 1	4	0	0	0	4	1	0	3	2.93	It is always possible of a major injury due to nature of the work. ML risk level of 6 highlights this danger.
33	5	Service Craft	Collision	Pilot launch or harbour craft in collision with LNG Carrier	Experienced Tug and Launchmasters	2	2	0	0	5	5	2	5	2.93			2	2	0	0	5	5	2	5	2.93	
34	19	Commercial	Contact - Navigation	LNG Carrier in contact with channel mark	Pilot embarked at Kilstiffen Buoy Experienced Pilots	0	4	0	0	0	6	0	6	3.61	Embark Pilot to seaward of Ballybunnion Buoy Move Beal Bar Buoy Increase Clearance over Doonaha wreck - remove buoy Escort tug VTS Traffic Organisation Environmental Operating Limits	ML & WC frequency reduced by 1	0	3	0	0	0	5	0	5	2.91	The option "Consider replacing 3 x Cardinal marks with Starboard Lateral marks" deemed to be inappropriate as Starboard marks difficult to see at day. The Carrigaholt buoy is in 30m. Moving this bouy to the 14.9m patch would 'force' vessels to turn into Estuary and avoid them delaying the turn. This would be very appropriate if Doonaha could be swept to a greater depth and the Doonaha bouy removed.
35	18	Commercial Leisure	Contact - Navigation	Commerical angling craft involved in contact with LNG Carrier jetty		0	2	0	2	5	5	2	5	3.15	Proposed mitigations for higher ranked risks will apply	WC frequency reduced by 1	0	2	0	2	4	4	1	4	2.79	
36	25	Commercial Leisure	Contact - Navigation	Commercial angling craft involved in contact with LNG Carrier		0	2	0	2	5	5	2	5	3.15	Proposed mitigations for higher ranked risks will apply	WC frequency reduced by 1	0	2	0	2	4	4	1	4	2.79	
37	9	Recreational	Collision	Leisure craft obstructs vessel manoeuvring on/off berth or swinging in the fairway or manoeuvring in an anchorage.		2	2	0	2	5	3	2	3	3.13	Proposed mitigations for higher ranked risks will apply	WC frequency reduced by 1	2	2	0	2	4	3	1	3	2.79	
38	52	Service Craft	Personal Injury	Personal injury to launch crew during pilot transfer or operation in exposed areas of Estuary or outside entrance	Experienced Launchmasters and Crews Environmental Conditions PPE	2	0	0	2	5	0	0	5	2.73			2	0	0	2	5	0	0	5	2.73	
39	51	Service Craft	Personal Injury	Pilot suffers personal injury during transfer to or from an LNG Carrier	Experienced pilots Environmental Conditions PPE	2	0	0	2	5	0	0	5	2.73			2	0	0	2	5	0	0	5	2.73	
40	47	Commercial	Mooring Breakout	LNG Carrier passing other jetties causes vessels alongside to part moorings.	Experienced pilots Width of Estuary	0	1	0	1	1	5	1	5	2.65			0	1	0	1	1	5	1	5	2.65	
41	24	Recreational	Contact - Navigation	Leisure craft involved in contact with LNGCarrier alongside		0	2	0	0	5	5	2	3	2.91	Proposed mitigations for higher ranked risks will apply	WC frequency reduced by 1	0	2	0	0	4	4	1	3	2.56	

Existing Risk Controls and Proposed Future Mitigations

Rank No.	Hazard Ref	Group	Accident Category	Hazard Detail	Existing Risk Levels										Future Risk Levels											Remarks
					Existing Risk Controls	ML				WC				Risk Overall	Future/Possible Mitigations	Expected Reduction in Risk Level	ML				WC				Risk Overall	
						People	Property	Environment	Stakeholders	People	Property	Environment	Stakeholders				People	Property	Environment	Stakeholders	People	Property	Environment	Stakeholders		
42	17	Recreational	Contact - Navigation	Leisure craft involved in contact with LNG jetty structure		0	2	0	0	5	5	2	3	2.91	Proposed mitigations for higher ranked risks will apply	WC frequency reduced by 1	0	2	0	0	4	4	1	3	2.56	
43	21	Service Craft	Contact - Navigation	Escort tug contacts navigational mark	Experienced tugmasters and crew	0	3	0	0	0	4	0	3	2.55			0	3	0	0	0	4	0	3	2.55	
44	22	Commercial	Contact - Navigation	LNG Carrier comes into contact with berth or another vessel alongside during transit and swing	Compulsory Pilot for large vessels Experienced pilots Pilots portable laptop available	1	4	3	3	3	5	4	5	4.07	Develop generic LNG Carrier Passage Plan Berthing and Escort tugs are fast.		0	2	0	2	3	3	3	3	2.49	
45	34	Service Craft	Foundering	Line boat capsizes during mooring operations.	Experienced Mooring Boat Operators SFPA Operating Porcedures	2	0	0	0	4	4	1	4	2.45			2	0	0	0	4	4	1	4	2.45	
46	1	Commercial	Cargo Release	Uncontrolled LNG gas released from vessel. Failure of cargo containment system on board.	IMO Gas Codes Construction of vessel and equipment Detection Systems Auto-shut down systems	0	0	0	3	3	2	0	2	2.42	IMO Gas Codes Construction of vessel and equipment Detection Systems Auto-shut down systems		0	0	0	3	3	2	0	2	2.42	
47	43	Service Craft	Grounding	Pilot launch grounds whislt attending LNG Carrier	Sufficient Water for majority of Estuary Competent Launchmasters	0	1	0	0	0	4	1	4	2.09			0	1	0	0	0	4	1	4	2.09	
48	38	Commercial	Mooring Breakout	Mooring breakout of LNG Carrier during cargo transfer alongside jetty	Existing mooring plans Procedures regarding of tending lines (Port Byelaw 26)	0	0	0	0	3	6	0	6	2.44	Environmental Operating Parameters Environmental Monitoring Equipment and Display on Jetty Load cells on Mooring Equipment Standby tug on patrol Effective design Proximity of second tug in extreme weather Trained jetty supervisors	WC frequency reduced by 2 and Property by 1	0	0	0	0	3	4	0	5	2.02	Design and avaiable computer simulations assist in the risk reduction
49	49	Service Craft	Near Miss	Towline parts during approach, transit and/or berthing	Experienced tugmasters and crew	0	2	0	0	0	2	0	2	1.67	Design of tug Towage procedures Freewheel/quick release factilities Joint pilot/tugmaster simulation training		0	2	0	0	0	2	0	2	1.67	
50	48	Commercial	Near Miss	LNG Carrier in close quarters situation with another vessel	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots	0	0	0	0	0	0	0	4	1.39	VTS Navigational Surveilence and Navigational Assistance Organisation		0	0	0	0	0	0	0	4	1.39	
51	46	Commercial	Mooring Breakout	Mooring breakout at another berth drifting near LNG Terminal	Existing mooring plans Procedures regarding of tending lines (Port Byelaw 26)	0	0	0	0	3	6	0	6	2.44	Safe passing clearance imposed Develop generic LNG Carrier Passage Plan	WC frequency reduced by 2. Highly unlikely	0	0	0	0	2	3	0	3	1.29	There has not been a mooring breakout at Tarbert or Money Poin to date.
52	4	Commercial	Collision	LNG Carrier in collision at a navigation pinch point	Compulsory pilotage area for all large vessels Experienced pilots Infrequency of simultaneous large ship movements Simulator Training and Emergency Procedures	4	7	0	7	6	6	6	6	5.86	VTS traffic control and associated procedures Impose Control Zone around LNGC whilst in transit Second passive tug in attendance enforcing control zone Develop generic LNG Carrier Passage Plan	Hazard negated by mitigations	0	0	0	0	0	0	0	0	0.00	Single vessel only at pinch point negates this hazard
53	44	Commercial	Grounding	A Lead-In LNG Carrier leaves fairway and grounds between Tail of Beal and Beal Bar Buoys	Bridge Team Competence Pilotage Advice by VHF Lead-in with pilot cutter Existing navigational buoyage. Existing leading lights Existing Underkeel Clearance Software	2	6	0	7	4	7	0	7	5.61	Embark Pilot to seaward of Ballybunnion Buoy or Vessel to remain at sea until conditions improve Escort tug VTS Traffic Organisation Service Environmental Operating Limits	Hazard negated by mitigations	0	0	0	0	0	0	0	0	0.00	LNGC Carriers will not be lead-in, but this is an accepted practice on some vessels. Not being lead-in negates this hazard. The option "Consider replacing 3 x Cardinal marks with Starboard Lateral marks" deemed to be inappropriate as Starboard marks difficult to see at day
54	6	Commercial	Collision	Cruise vessel in collision with LNG Carrier	Bridge Team Competence Compulsory Pilot for large vessels Experienced pilots Infrequency of visitors	4	5	0	5	5	5	5	5	4.71	VTS Information and Traffic Organisation Services Compulsory pilotage for all vessels west of Ballybunion Bar irrespective of draught Impose Control Zone around LNGC whilst in transit	Hazard negated by mitigations	0	0	0	0	0	0	0	0	0.00	Very few cruiseships at present. Control Zone removes this hazard
55	28	Commercial	Contact - Navigation	A Lead-In LNG Carrier in contacts channel mark	Pilotage Advice by VHF Lead-in with pilot cutter	0	4	0	6	0	6	0	6	4.35	Embark Pilot to seaward of Ballybunnion Buoy Move Beal Bar Buoy Increase Clearance over Doonaha wreck - remove buoy Escort tug VTS Traffic Organisation Environmental Operating Limits Develop generic LNG Carrier Passage Plan	Hazard negated by mitigations	0	0	0	0	0	0	0	0	0.00	LNGC Carriers will not be lead-in, but this is an accepted practice on some vessels. Not being lead-in negates this hazard. The option "Consider replacing 3 x Cardinal marks with Starboard Lateral marks" deemed to be inappropriate as Starboard marks difficult to see at day

ANNEX E

RISK CONTROL MEASURES
Expansion of Annex D
Initial Risk Control Measures and Possible Mitigations

MARICO MARINE

NOTE

The following risk control measures, and suggested mitigations, were initially created by Marico Marine in advance of the risk control mitigation meeting.

Initially the existing controls were identified and discussed to ensure these were being utilised and were effective. This was to avoid suggesting a future control that was already in place.

The measures found within this annex were discussed at length and from this set of controls, a set of suggested control measures were derived. This finalised set of controls can be found in the main text of the report.

This was a working set of suggested controls, some were discounted, some were expanded upon/improved and some additional controls were added.

For this reason this annex is for reference only.
Blue measures are existing controls; Red and suggested controls.

Grounding Control Measures

Commercial Vessels

The following existing controls are in place to manage risks related to grounding hazards on commercial vessels.

• Compulsory pilot	Pilotage is compulsory for large vessels
• Experienced pilots (SIGTTO)	Experience and training of SFPC pilots – Master/Pilot Information Exchange – adjusting passage plan accordingly.
• Pilots portable laptop available	Although a portable navigation system is available, its use by pilots is generally limited to berthing manoeuvres only.
• Pilotage Advice by VHF	Approaching vessels without an embarked can occasionally be given advice from the pilot station and/or pilot cutter
• Lead-in with pilot cutter	Vessels are occasionally talked-in through the entrance channel prior to boarding a pilot. The pilot cutter is able to closely monitor the vessel during transit. Note: Whilst both VHF advice and Talk-in procedures reduce the risk to an unpiloted vessel, they nevertheless retain a significant risk of grounding, and should only be used in exceptional circumstances
• Environmental constraints	If conditions are adverse for pilot embarkation, a vessel can be delayed until conditions improve, thereby eliminating the risk on grounding
• Navigational buoyage and leading lights	Navigational buoyage and leading lights play a critical role in preventing grounding.
• Bridge team competence	Navigational competence in the context of a grounding is a primary method of reducing risk. It is, however, not a control within the gift of a port authority.
• Width and depth of estuary	The width and depth of the Shannon Estuary compares favourably with other similar ports and makes a significant contribution to safe navigation.
• Underkeel Clearance software	Existing underkeel clearance software allows SFPC to determine whether there will be enough water to permit a safe passage throughout the passage. Existing procedures ensure that where the software does not so indicate, the transit is delayed.

The following possible mitigation measures could be implemented to further reduce these hazards to commercial vessels:

• VTS traffic organisation and information service (SIGTTO)	VTS to oversee the movement of all vessels within the port limits and to give timely information to vessels of pending traffic movements.
• VTS surveillance (SIGTTO)	VTS can monitor vessels. They are able to monitor vessels movements and notify them of any unusual deviations from expected tracks.
• VTS navigational assistance (SIGTTO)	Second level assistance where a VTS service is able to give advice to vessels within the port limits.
• GPS Datum	Update existing charts to the WGS 84 datum. Most international charts use WGS84 and ships GPS navigation system set by default to this. Possible mismatch in datum sources leading to incorrect transit and LNGC standing into danger (visual navigation does not have this error).
• Embark pilot to seaward of Ballybunnion Buoy	LNGC's can be boarded at Kilstiffen Buoy under present rules. The boarding area could be moved to the same position as deep-draught vessels. LNGC vessels would thereby by under the control of an experienced pilot prior to entering restricted waters.
• Bridge team management training (SIGTTO)	Pilots to attend bridge team management courses so that they are fully conversant with, and understand, bridge team management techniques and communications. This will create a more effective bridge team.
• Develop generic LNG Carrier passage plan (SIGTTO)	This will standardise the Master/Pilot information exchange and also standardise the expected approach. Passage Plans increase the quality of service delivered by SFPC licensed pilots.
• Optimum track	Ensure optimum transit track (including speed of transit) is assessed properly to enhance safety. This will include reassessing navigational marks as described in other options.
• Mobile Control Zone (SIGTTO)	The use of a Mobile Control Zone around a manoeuvring LNGC vessel will ensure the LNGC is not hampered in her manoeuvre by other vessels thereby eliminating the need for her to take avoiding action which could lead to an LNGC standing into shallow water.
• Environmental operating limits (SIGTTO)	Set maximum environmental operating limits to ensure the transit can be undertaken safely (part of passage planning)
• Escort tugs	Utilise escort tug/s prior to transit as this may reduce grounding hazards in the event of a failure. Escort tugs can also stabilise an incident more quickly thereby reducing damage incurred thereafter.
• Designated channel (SIGTTO)	LNG Carriers to use same deep-water designated deep water channel as per bulk carriers to Money Point.
• Increase clearance over Doonaha wreck - remove buoy	Increasing the depth over the Doonaha wreck would reduce/eliminate this hazard. The removal of the buoy would also allow greater room for the turn onto the leads.
• Reposition Beal Bar Buoy	Repositioning Beal Bar Buoy to the South would increase the manoeuvring room for a vessel turning from the leads into the main channel.
• Improved navigational marks	Consider utilising starboard lateral mark and/or improving visibility of North Carrig Buoy to ensure Carrig Shoals are well marked.
• Reposition Carrigaholt Buoy	Consider removing Carrigaholt buoy or moving it to new position on 14.9m patch on leads to West of Doonaha Buoy. This could be done in conjunction of sweeping Doonaha wreck and removing the Doonaha buoy. This option would ensure vessels turn into the estuary correctly and not 'overshoot' the turn thereby standing into shallower water to the North. The present buoy is in 30m+ water and not considered to be useful.
• Consider navigational mark on West Point of Glencloosagh Bay shallows	A mark will highlight the shallow area. The actual usefulness of this mark will be determined by the final position and heading of the proposed LNG terminal. It could also mark the Eastern boundary of any control zone.
• Tug procedures	Implement procedures regarding tugs, where they are to attend and when to be made fast, as well as connecting up procedures. Tugs fast prior to berthing
• Review of Limits	Limits and operating procedures to be reviewed once details and simulator models available, with a further review once LNGC's are in service.

Grounding Control Measures

Service Craft

The following existing controls are in place to manage risks related to grounding hazards on service craft.

• Width and depth of estuary	The width of the Estuary is a natural control the majority of which is wide and deep allowing for safe navigation and manoeuvring, especially for service craft.
• Experienced coxswains	SFPC employ experienced coxswains for the pilot cutter. These coxswains presently monitor approaching vessels and, in conjunction with the pilot, decide whether it is safe to proceed out to board a vessel.

The hazards to service craft are well managed and specific mitigation measures are unlikely to increase safety. Suggested mitigation measures for commercial vessels will indirectly benefit service craft and other vessels.

Contact - Navigation Control Measures

Commercial Vessels

The following existing controls are in place to manage risks related to contact-navigation hazards on commercial vessels.

• Pilot embarkation positions	There are four designated pilot boarding positions dependant on the size of vessel. An LNGC vessel would be required to be boarded no closer than Kilstiffen Buoy.
• Compulsory pilot	Pilotage is compulsory for large vessels
• Experienced pilots (SIGTTO)	Experience and training of SFPC pilots – Master/Pilot Information Exchange – adjusting passage plan accordingly.
• Pilots portable laptop available	Portable navigation system independent of ships systems is available and utilised by pilots.
• Pilotage Advice by VHF	Approaching vessels can be given advice from the pilot station and/or pilot cutter
• Lead-in with pilot cutter	Vessels can be lead-in to calmer waters to board a pilot.
• Environmental constraints	If conditions adverse for the pilot cutter to proceed out the vessel can be delayed until conditions improve or lead-in to calmer waters. Delaying a vessel eliminates contact hazards, and indirectly reduces contact hazards when transiting under pilotage as conditions will be inherently more favourable for a safer transit.
• Anchorages	Designated Anchorages are clear of the main channel.
• Bridge team competence	Competence of the bridge team, who monitor a vessels track and bring to the ship handler's attention any deviations. Bridge Resource Management ensuring effective communications.
• Width and depth of estuary	The width of the Estuary is a natural control the majority of which is wide and deep allowing for safe navigation and manoeuvring.
• Vetting procedures	Vessels calling at Shannon are subject to inspection and periodic re-inspection to ensure compliance with proper safety and environmental standards by charter companies.

The following possible mitigation measures could be implemented to further reduce these hazards to commercial vessels:

• VTS traffic organisation and information service (SIGTTO)	VTS to oversee the movement of all vessels within the port limits and to give timely information to vessels of pending traffic movements.
• VTS surveillance (SIGTTO)	VTS can monitor vessels. They are able to monitor vessels movements and notify them of any unusual deviations from expected tracks. VTS can monitor anchored vessels to ensure that they maintain position

	and alert a vessel if it appears to be dragging anchor.
• Embark pilot to seaward of Ballybunnion Buoy	LNGC's can be boarded at Kilstiffen Buoy under present rules. The boarding area could be moved to the same position as deep-draught vessels. LNGC vessels would thereby by under the control of an experienced pilot prior to entering restricted waters.
• Bridge team management training (SIGTTO)	Pilots to attend bridge team management courses so that they are fully conversant with, and understand, bridge team management techniques and communications. This will create a more effective bridge team.
• Develop generic LNG Carrier passage plan (SIGTTO)	This will standardise the Master/Pilot information exchange and also standardise the expected approach. Passage Plans increase the quality of service delivered by SFPC licensed pilots.
• Berthing and escort tugs	Ensure berthing and escort tugs are in attendance and fast before manoeuvring onto the berth. Tugs will also reduce the chance of contact if the LNGC suffered a failure.
• Environmental operating limits (SIGTTO)	Set maximum environmental operating limits to ensure the transit can be undertaken safely (part of passage planning)
• Designated channel (SIGTTO)	LNG Carriers to use same deep-water designated deep water channel as per bulk carriers to Money Point.
• Remove/reposition small ship anchorage at Glencloosagh Bay	This will remove/ reduce the risk of small coastal vessels coming close to the proposed LNGC terminal.
• Increase clearance over Doonaha wreck - remove buoy	Increasing the depth over the Doonaha wreck would reduce/eliminate the requirement for a buoy. It would also remove any grounding hazard. The removal of the buoy would also allow greater room for the turn onto the leads.
• Reposition Beal Bar Buoy	Repositioning Beal Bar Buoy to the South would increase the manoeuvring room for a vessel turning from the leads into the main channel.
• Control zone of 150m when LNG Carrier alongside	The use of a control zone would ensure smaller transiting vessels and other craft to keep clear of a berthed LNGC thereby eliminating the risk of contact.
• Standby tug in vicinity when LNG berth occupied	A standby tug would enforce the control zone mentioned in point above.
• Marine guidelines for handling LNG Carrier - towage	Create Marine Guidelines for Handling LNG Carriers developed for numbers of tugs used for berthing / unberthing at Shannon. This ensures sufficient tugs are utilised for safe berthing / unberthing, taking into account the size of the vessel and fitted manoeuvring aids.

Contact - Navigation Control Measures

Other Vessels

The following existing controls are in place to manage risks related to contact-navigation hazards for other vessels such as service craft and commercial leisure craft.

• Experienced coxswains	SFPC employ experienced coxswains for the pilot cutter. These coxswains presently monitor approaching vessels and, in conjunction with the pilot, decide whether it is safe to proceed out to board a vessel.
• Experienced tug masters and crew	The tugs utilise experienced tug masters and crew.
• Licensed/inspected vessels	Small commercial vessels, such as the dolphin watch are licensed and inspected to ensure compliance with operating rules.

The following possible mitigation measures could be implemented to further reduce these hazards to commercial and service craft:

• Maintain safe distance from structure	SFPC can implement bye-law or operating procedure, or the commercial operator to show evidence of own procedures, for commercial leisure craft to ensure they maintain a safe distance of the LNGC terminal; this could be extended to other terminals.
• Impose 150m control zone around berthed vessel (SIGTTO)	The use of a control zone would ensure commercial leisure craft and other craft to keep clear of a berthed LNGC thereby eliminating the risk of contact.
• Standby tug on patrol	A standby tug would enforce the control zone mentioned in point above.
• VTS surveillance (SIGTTO)	VTS can monitor vessels within the vicinity of an LNGC. They are able to monitor vessels movements and notify them if they breach the control zone.

Collision Control Measures

Commercial Vessels

The following existing controls are in place to manage risks related to collision hazards on commercial vessels.

• Compulsory pilot	Pilotage is compulsory for large vessels. Vessels over 13.0m have compulsory pilotage seaward of Ballybunnion Bar. The pilot would be aware of other movements.
• Experienced pilots (SIGTTO)	Experience and training of SFPC pilots – Master/Pilot Information Exchange – adjusting passage plan accordingly.
• Bridge team competence	Competence of the bridge team, who monitor a vessels track and bring to the ship handler's attention any deviations. Bridge Resource Management ensuring effective communications.
• Vessel Movements	There are relatively few simultaneous large vessel movements thereby reducing the likelihood of two vessels meeting, especially at a navigation pinch point.
• Width and depth of estuary	The width of the Estuary is a natural control the majority of which is wide and deep allowing for safe navigation and manoeuvring. The majority of the estuary would allow two vessels to pass safely.
• Port Byelaws	Port byelaws control aspects of navigation. e.g. Bye-law 85 requires the ferry to keep out of the way of a commercial transiting vessel
• Simulator Training and Emergency Procedures	Pilots undergo simulator training incorporating emergency procedures.
• Cruise Ship Frequency	Cruise ships are infrequent visitors. The likelihood of a cruise ship being involved in a collision is remote due to this infrequency.

The following possible mitigation measures could be implemented to further reduce these hazards to commercial vessels:

• VTS traffic organisation and information service (SIGTTO)	VTS to oversee the movement of all vessels within the port limits and to give timely information to vessels of pending traffic movements. The movement and progress of vessels can be promulgated to other vessels thereby allowing passage plans to be adapted to avoid meeting other vessels at critical points.
• VTS surveillance (SIGTTO)	VTS can monitor vessels. They are able to monitor vessels movements and notify them of any unusual deviations from expected tracks.
• VTS navigational assistance (SIGTTO)	Second level assistance where a VTS service is able to give advice to vessels within the port limits.
• Bridge team management training (SIGTTO)	Pilots to attend bridge team management courses so that they are fully conversant with, and understand, bridge team management techniques and communications. This will create a more effective bridge team.
• Develop generic LNG Carrier passage plan (SIGTTO)	This will standardise the Master/Pilot information exchange and also standardise the expected approach. Passage Plans increase the quality of service delivered by SFPC licensed pilots.
• Mobile Control Zone (SIGTTO)	The use of a Mobile Control Zone around a manoeuvring LNGC vessel will ensure the LNGC is not hampered in her manoeuvre by other

	vessels thereby eliminating the likelihood of collision.
• Embark pilot to seaward of Ballybunnion Buoy	LNGC's can be boarded at Kilstiffen Buoy under present rules. The boarding area could be moved to the same position as deep-draught vessels. LNGC vessels would thereby by under the control of an experienced pilot prior to entering restricted waters.
• Escort tugs	Utilise escort tug/s prior to transit as this may reduce collision hazards in the event of a failure.
• Designated channel (SIGTTO)	LNG Carriers to use same deep-water designated deep water channel as per bulk carriers to Money Point.
• Define 'narrow channel' (SIGTTO)	Designate the deep water channel as a 'narrow channel' within byelaws. This will allow full implementation of the Colregs and the requirement of other vessels not to impede the passage of a vessel that can only safely navigate in the channel.
• Tug procedures	Implement procedures regarding tugs, where they are to attend and when to be made fast, as well as connecting up procedures.
• Second passive tug in attendance	A second passive tug could enforce control zone.

Collision Control Measures

Service Craft and Commercial Leisure Craft

The following existing controls are in place to manage risks related to collision hazards on service craft and commercial leisure craft.

• Experienced coxswains	SFPC employ experienced coxswains for the pilot cutter. These coxswains presently monitor approaching vessels and, in conjunction with the pilot, decide whether it is safe to proceed out to board a vessel.
• Experienced tug masters and crew	The tugs utilise experienced tug masters and crew.
• Licensed/inspected vessels	Small commercial vessels, such as the dolphin watch are licensed and inspected to ensure compliance with operating rules.
• Width and depth of estuary	The width of the Estuary is a natural control the majority of which is wide and deep allowing for safe navigation and manoeuvring. The majority of the estuary would allow two vessels to pass safely.

The following possible mitigation measures could be implemented to further reduce these hazards to commercial vessels:

• VTS traffic organisation and information service (SIGTTO)	VTS to oversee the movement of all vessels within the port limits and to give timely information to vessels of pending traffic movements. The movement and progress of vessels can be promulgated to other vessels thereby allowing passage plans to be adapted to avoid meeting other vessels at critical points.
• VTS surveillance (SIGTTO)	VTS can monitor vessels. They are able to monitor vessels movements and notify them of any unusual deviations from expected tracks.
• Mobile Control Zone (SIGTTO)	The use of a Mobile Control Zone around a manoeuvring LNGC vessel will ensure the LNGC is not hampered in her manoeuvre by other vessels thereby eliminating the likelihood of collision.
• Define 'narrow channel'	Designate the deep water channel as a 'narrow channel' within byelaws. This will allow full implementation of the Colregs and the requirement of other vessels not to impede the passage of a vessel that can only safely navigate in the channel.
• Dolphin Watch procedures	SFPC to develop procedures to ensure Dolphin Watch craft do not hamper LNGC
• Second passive tug in attendance	A second passive tug could enforce control zone.

These mitigation measures could be implemented for the proposed tugs that are being considered:

• Tug construction	Use specially designed escort-notated tugs. These have better sea-keeping capabilities than normal harbour tugs and are designed to work in a seaway. Consequently the fendering systems are designed for escort work. Tugs fender systems should be designed to avoid point loadings above the maximum tonnes/metre of the proposed vessels
• Dual redundancy with tug systems	Dual redundancy of tug systems reduces likelihood of total tug failure.
• Joint bridge simulation	Tug masters to attend joint bridge simulation trials with pilots and/or masters to gain better awareness of each others roles and understanding of problems.
• Bridge team management training	Tug masters to attend bridge team management so that they are fully conversant with, and understand, the bridge team (and pilot) anticipated manoeuvre. It will ensure that tug masters will also alert/question the pilot if the tug has a problem or the tug master sees a potential problem or deviation.
• Tug procedures	Implement procedures regarding tugs, where they are to attend and when to be made fast, as well as connecting up procedures.
• Tug connecting up procedures	Implement connecting up procedures and training to enhance safety.

Contact-Berthing Control Measures

The following existing controls are in place to manage risks related to contact berthing hazards with existing commercial vessels.

• Compulsory pilot	Pilotage is compulsory for large vessels. Vessels over 13.0m have compulsory pilotage seaward of Ballybunnion Bar. The pilot would be aware of other movements.
• Experienced pilots (SIGTTO)	Experience and training of SFPC pilots – Master/Pilot Information Exchange – adjusting passage plan accordingly.
• Bridge team competence	Competence of the bridge team, who monitor a vessels track and bring to the ship handler's attention any deviations. Bridge Resource Management ensuring effective communications.
• Marine Operation Staff	Marine Operations Staff attend berthing and sailing of vessels to ensure shore readiness and pass information on tides etcetera to the Pilot.
• Simulator Training and Emergency Procedures	Pilots undergo simulator training incorporating emergency procedures.
• Pilots portable laptop available	Portable navigation system independent of ships systems is available and utilised by pilots.
• Environmental constraints	If conditions are adverse for the pilot cutter to proceed out the vessel can be delayed until conditions improve. Delaying a vessel indirectly eliminates contact-berthing hazards due to adverse weather.
• Berthing Tugs	The three existing tugs have approximately 150t bollard pull available designed to safely handle cape sized vessels at Money Point.

The following possible mitigation measures could be implemented to further reduce these hazards to LNGC Carriers:

• VTS information service (SIGTTO)	VTS can update pilot with weather and tidal information if requested.
• Bridge team management training (SIGTTO)	Pilots to attend bridge team management courses so that they are fully conversant with, and understand, bridge team management techniques and communications. This will create a more effective bridge team.
• Develop generic LNG Carrier passage plan (SIGTTO)	This will standardise the Master/Pilot information exchange and also standardise the expected approach. Passage Plans increase the quality of service delivered by SFPC licensed pilots.
• Doppler docking system	Doppler docking system can give real time approach data to the ship handler (pilot) independent of the ships systems. This will enhance the assessment of approach speed for bow and stern.

• New tug fleet	New tugs with increased bollard pull and escort notated tugs will allow increased control of the vessel in adverse conditions.
• Joint bridge simulation	Tug masters to attend joint bridge simulation trials with pilots and/or masters to gain better awareness of each others roles and understanding of problems.
• Bridge team management training	Tug masters to attend bridge team management so that they are fully conversant with, and understand, the bridge team (and pilot) anticipated manoeuvre. It will ensure that tug masters will also alert/question the pilot if the tug has a problem or the tug master sees a potential problem or deviation.
• Tug procedures	Implement procedures regarding tugs, where they are to attend and when to be made fast, as well as connecting up procedures.

Mooring Breakout Control Measures

The following existing controls are in place to manage risks related to mooring breakouts on commercial vessels.

• Compulsory pilot	Pilotage is compulsory for large vessels. The pilot would be aware of other vessels alongside.
• Experienced pilots (SIGTTO)	Experience and training of SFPC pilots – Master/Pilot Information Exchange – adjusting passage plan accordingly.
• Bridge team competence	Competence of the bridge team, who monitor a vessels track and bring to the ship handler's attention any deviations. Bridge Resource Management ensuring effective communications.
• Vessel movements	There are relatively few large vessel movements which reduces the likelihood of a large vessel causing a breakout.
• Width and depth of estuary	The width of the Estuary is a natural control the majority of which is wide and deep allowing for safe navigation and manoeuvring. This avoids the necessity of a transiting vessel to pass close by to another berthed vessel.
• Port Byelaws	Port byelaws 25 and 26 stipulate the requirements for moorings and tending of moorings.
• Existing mooring plans	Existing mooring plans have proven reliability in keeping vessels alongside. There has not been a breakout of any vessels at Money Point and Tarbert terminals.

The following possible mitigation measures could be implemented to further reduce these hazards to commercial vessels:

• VTS surveillance (SIGTTO)	VTS can monitor vessels. They are able to monitor vessels movements and notify them of any unusual deviations from expected tracks and possible encroachment on another berthed vessel.
• Develop generic LNG Carrier passage plan (SIGTTO)	This will standardise the Master/Pilot information exchange and also standardise the expected approach. This would also ensure a LNGC does not transit too close to another berthed vessel at Money Point.
• Environmental Operating Parameters (SIGTTO)	Have operating parameters in place at the LNG terminal with procedures to stop cargo and/or possible disconnection of loading arms in the event of adverse weather.
• Environmental Monitoring Equipment and Display	Real-time display of environmental data on the berth that the LNGC can readily view. This will allow the LNGC to also determine whether conditions are unsafe to continue operations.
• Control zone of 150m when LNG Carrier alongside	The use of a control zone would ensure smaller transiting vessels and other craft to keep clear of a berthed LNGC thereby eliminating the risk of interaction.
• Load cells on Mooring Equipment	Utilise load cells on the berth mooring equipment that can allow a jetty supervisor to identify either: lines coming under undue tension or lines being slack. This will allow the supervisor to pro-actively ensure lines are optimally maintained at all times.

• Effective design (SIGTTO)	Ensure the design of the terminal, fender systems and mooring points are optimised for the environmental conditions. Optimoor Software can be used to verify safe environmental limits of and optimise mooring retention of large vessels.
• Trained jetty supervisors	Train the jetty supervisors so that they are fully aware of the requirements to maintain lines at all times.
• Proximity of second tug in extreme weather	Have procedures in place to ensure second tug available in the event of extreme weather.
• Standby tug in vicinity when LNG berth occupied	A standby tug would enforce the control zone mentioned in point above.
• Marine guidelines for handling LNG Carrier - towage	Create Marine Guidelines for Handling LNG Carriers developed for numbers of tugs used for berthing / unberthing at Shannon. This ensures sufficient tugs are available in the event of adverse weather.
• Vetting Procedures (SIGTTO)	LNG Carriers can be vetted by Shannon LNG (or charterer) prior to arrival to ensure mooring equipment and layout is satisfactory for the terminal.

Fire/Explosion, Cargo Release and Port Security Incident Control Measures

Commercial Vessels

The following existing controls are available to manage risks related to fire/explosion, cargo release and port security incident hazards on commercial vessels.

• IMO Gas Codes	LNG Carriers are built to stringent rules, known as the IMO Gas Codes. This covers: construction, equipment, fire and detection, cargo systems etcetera and has been the primary key to an enviable safety record within the industry.
• SIGTTO procedures	The Internationally recognised SIGTTO procedures outline the essential best practices for LNGC's and terminals. It describes all aspects of LNG operations.
• Shannon Foynes Emergency Procedures	SFPC have emergency procedures in place to deal with incidents within their jurisdiction.
• ISPS Code	ISPS Code is a required international standalone document that sets down procedures and obligations with International Ship and Port Facility Security.
• Shore fire services	Shore fire services are available to assist in ship fires and have joint procedures with SFPC.
• Ship staff procedures and training (SIGTTO)	Ships staff are trained under international standards and all vessels have emergency procedures that are part of the ISM code.
• Shipping Vetting for charter vessels (SIGTTO)	LNG Carriers are often vetted prior to charter to ensure they meet the charterer's exacting safety requirements.
• Experienced pilots (SIGTTO)	Experience and training of SFPC pilots – Pilots can implement SFPC emergency procedures and be able to liaise with emergency services.
• Detection Systems (SIGTTO)	LNG Carriers have sophisticated detection and alarm systems for fire and gas (vapour) release.
• Auto-shut down systems (SIGTTO)	LNG Carriers and terminals have auto-shut down systems that will shut down, and cease cargo operations, in the event if a failure within the cargo system.

The following possible mitigation measures could be implemented to further reduce these hazards to commercial vessels:

• VTS information service (SIGTTO)	VTS can promulgate emergencies to other vessels. They can be used to co-ordinate any actions required by other vessels and/or shore assistance.

• VTS surveillance (SIGTTO)	VTS can be used to monitor traffic and other activities as part of the ISPS code.
• Jetty fire fighting equipment (SIGTTO)	Fire fighting equipment to be fitted to meet SIGTTO and terminal fire fighting standards.
• ISPS Code	The ISPS Code to be updated to reflect LNG operations.
• FiFi 1 escort tug	The escort tug could be fitted with FiFi 1 equipment to assist the Carrier in the event of a fire.
• Second FiFi 1 tug in attendance in transit	Second tug increases the coverage and also allows escort tug to continue towing if required. Dual coverage allows increased flexibility in fire fighting and boundary cooling.
• Standby FiFi 1 Tug	The utilisation of a standby tug when a Carrier is alongside would benefit from having FiFi 1 equipment as it can be in attendance and assist with minimum delays.
• Develop joint emergency plan (SIGTTO)	SFPC and Shannon LNG, together with shore fire services and tug services to develop joint emergency plan, which incorporates training and exercises.
• Ship/Shore Interface (ISGOTT & SIGTTO)	Full ship shore interface as per ISGOTT guide prior to any cargo operations commencing. Also pre-arrival information plans notifying SFPC and Shannon LNG of any defects.
• Shore services fire fighting training	Shore services to be trained in LNG fire fighting procedures
• High level of physical security throughout LNG site	In conjunction with the ISPS Code: the terminal needs to incorporate best security practices that are at other LNG terminals.

Fire/Explosion, Cargo Release and Port Security Incident Control Measures

Service Craft

The following existing controls are in place to manage risks related to fire/explosion hazards on service craft.

• Experienced coxswains and crew	SFPC employ experienced coxswains and crew for the pilot cutter.
• Experienced tug masters and crew	The tugs utilise experienced tug masters and crew.
• Crew training	Both tugs and crew are trained with onboard fire fighting.
• Onboard fire fighting systems	Tugs and pilot cutters have onboard fire fighting systems.

The hazards to service craft are well managed and specific mitigation measures are unlikely to increase safety. Suggested mitigation measures for commercial vessels will indirectly affect service craft, especially with any updated emergency plans.

Personal Injury Control Measures

The following existing controls are in place to manage risks related to personal injury hazards identified with all vessels, but primarily service craft.

• Experienced pilots	SFPC pilots are experienced and trained in boarding vessels in adverse conditions, reducing personal injuries during transfer.
• Experienced tug masters and crew	The tugs utilise experienced tug masters and crew.
• Experienced coxswains and crew	SFPC employ experienced coxswains and crew for the pilot cutter.
• Experienced ship crews	Ship crews are normally experienced and work to ISM Code of Safe Working Practices.
• Experienced Mooring Boat Operators	The present mooring boat crews are experienced operators and have procedures in place regarding mooring operations.
• Personal Protective Equipment	Personal Protective Equipment is used by most parties and is one of the primary controls in reducing personal injury hazards.
• Environmental conditions	If conditions are detrimental to safety, the pilot and pilot cutter coxswains can abort and delay a movement. The decision to delay can also apply to ship masters if they feel it is too dangerous to undergo the proposed manoeuvre.
• Vetting procedures	Vessels calling at Shannon are subject to inspection and periodic re-inspection to ensure compliance with proper safety and environmental standards by charter companies.

The following possible mitigation measures could be implemented to further reduce hazards to tug and mooring boat personnel:

• Effective design (SIGTTO)	Ensure the design of the terminal, fender systems and mooring points are optimised for the environmental conditions and for the safety of personnel, such as mooring gangs. Optimoor Software can be used to verify safe environmental limits of and optimise mooring retention of large vessels.
• Berthing Master or Mooring Supervisor •	Consider utilising a berthing master or mooring supervisor who can oversee the mooring operations and ensure correct procedures are being utilised.
• Trained Mooring Personnel	SFPC should ensure only trained mooring personnel are employed in mooring operations.
• Training and HSE	SFPC should ensure there are training programs in place for all SFPC operational personnel and that Health and Safety in Employment (HSE) is effective and understood by all.
• Correct and properly maintained mooring ropes	Only correct and properly maintained mooring ropes should be used (part of vetting procedures).
• Line boats built for purpose	Line boats should be built for purpose and in keeping with current legislation and best practices.
• Marine guidelines for handling LNG Carrier - towage	Create Marine Guidelines for Handling LNG Carriers developed for numbers of tugs used for berthing / unberthing at Shannon. This ensures sufficient tugs are utilised for safe berthing / unberthing, taking into account the size of the vessel and fitted manoeuvring aids.
• Environmental operating limits (SIGTTO)	Set maximum environmental operating limits to ensure the transit can be undertaken safely (part of passage planning)
• Tug procedures	Implement procedures regarding tugs, where they are to attend and when to be made fast, as well as connecting up procedures. Procedures should include water-tight integrity procedures which stipulate what vents and doors are required to be closed when operating.
• Freewheel/quick release facilities for winches	Freewheel and quick release facilities increases safety as it allows tow master to release high load if required. Also allows ease of connecting up as freewheel winch can allow rope to run freely when vessel dropping into position.

• Towline configuration	The towline configuration can increase safety and should be assessed during the design phase, which should include the use of quick connection units (Foslink), LNGC dedicated towing points etcetera.
• Tug construction	Use specially designed escort-notated tugs. These have better sea-keeping capabilities than normal harbour tugs for escort work and are designed to work in a seaway.
• Effective Communications	SFPC should ensure there are effective communications between all parties (Pilot, Cutter, Tugs, Mooring Gangs/Boats and Terminal)

Foundering Control Measures

The following existing controls are in place to manage risks related to foundering hazards identified with service craft.

• Experienced coxswains	SFPC employ experienced coxswains for the pilot cutter. These coxswains presently monitor approaching vessels and, in conjunction with the pilot, decide whether it is safe to proceed out to board a vessel.
• Experienced tug masters and crew	The tugs utilise experienced tug masters and crew.
• Compliance with Pilot Cutter regulations	Pilot cutters are licensed and inspected to ensure compliance with operating rules.
• Environmental operating limits	The pilot cutter has maximum operating limits as stipulated under the licence.
• Pilot Cutter coxswain has power to suspend operations	The pilot cutter coxswains have the power to suspend operations, or abort a transit in adverse weather. This is normally done in conjunction with a licensed pilot.
• SFPC Operating Procedures	SFPC have operating procedures in place for the Pilot Cutters.
• Tug QMS	The tug is required to be run under a Quality Management System (QMS or ISM) as per Port Byelaw 87(4).
• Experienced Mooring Boat Operators	The present mooring boat crews are experienced operators and have procedures in place regarding mooring operations.

The following possible mitigation measures could be implemented to further reduce these hazards to these vessels:

• Environmental operating limits (SIGTTO)	Set maximum environmental operating limits to ensure the transit by Carrier and service craft can be undertaken safely.
• Uprated Pilot Cutter for rough weather operations	Consider the use of uprated Pilot Cutter for rough weather operations to west of Ballybunnion Buoy. This is to ensure pilot cutter can proceed to boarding ground safely within the maximum environmental operating limits.
• Improved Pilot Cutter reliability of service	Increase reliability of service of the Pilot Cutter with effective planned maintenance systems. This may require the consideration of a second boat to ensure maintenance can be planned rather than when required.

The following mitigation measures could be implemented for the proposed tugs that are being considered:

• Tug construction	Use specially designed escort-notated tugs. These have better sea-keeping capabilities than normal harbour tugs for escort work and are designed to work in a seaway.
• Dual redundancy with tug systems	Dual redundancy of tug systems reduces likelihood of total tug failure.
• Joint bridge simulation	Tug masters to attend joint bridge simulation trials with pilots and/or masters to gain better awareness of each others roles and understanding of problems.
• Bridge team management training	Tug masters to attend bridge team management so that they are fully conversant with, and understand, the bridge team (and pilot) anticipated manoeuvre. It will ensure that tug masters will also alert/question the pilot if the tug has a problem or the tug master sees a potential problem or deviation.
• Freewheel/quick release facilities for winches	Freewheel and quick release facilities increases safety as it allows tow master to release high load if required. Also allows ease of connecting up as freewheel winch can allow rope to run freely when vessel dropping into position.
• Tug procedures	Implement procedures regarding tugs, where they are to attend and when to be made fast, as well as connecting up procedures. Procedures should include water-tight integrity procedures which stipulate what vents and doors are required to be closed when operating.

ANNEX F

VTS OPERATING PRINCIPLES

VTS OPERATING PRINCIPLES

The International requirement for VTS is laid down in Chapter V of the SOLAS convention1. The International Maritime Organisation (IMO) in IMO Resolution A.857(20), define a Vessel Traffic Service (VTS) as "a service implemented by a Competent Authority that is designed to improve safety and efficiency of vessel traffic, and to protect the environment. The service shall have the capability to interact with traffic and respond to traffic situations developing situations in the VTS area". IMO further states that a Competent Authority is: "the authority made responsible, in whole or in part, by the Government for vessel traffic safety, including environmental safety, and the protection of the environment in the area".

VTS is referenced in several International Conventions, the most important of which is the International Convention for the Safety of Life at Sea (SOLAS). SOLAS Chapter V, regulation 12 provides a specific paragraph placing a duty on Contracting Governments to oversee the implementation of VTS standards into their territorial waters.

Therefore, any VTS established in conformity with IMO guidelines is designed to improve the safety and efficiency of navigation and therefore reduce potential loss of life and protect the marine environment. A VTS should therefore provide services targeted to reduce the risk of collision, grounding, pollution, as well as delay.

IALA (the International Association of Marine Aids to Navigation and Lighthouse Authorities) is the international organisation that provides the standards for VTS. IALA has a VTS Committee that periodically publishes hardware standards, policy and training standards. This is called the VTS manual. The link between internationally agreed conventions and the provision of VTS at a local level is explained in the IALA VTS manual[2]. A new IALS VTS manual is presently in draft and will be released in July 2008. Both the existing VTS manual (the 2002 manual) and the 2008 draft manual have been used to establish the gap between the present harbour control operation and the IALA requirements.

Essentially there are three types of VTS delivery:

1. An Information Service (INS)

2. A Traffic Organisation Service (TOS)

3. A Navigational Assistance Service (NAS)

[1] "Contracting Governments undertake to arrange for the establishment of VTS's where, in their opinion, the volume of traffic or degree of risk justifies such services".
[2] The 2002 IALA Manual is being updated by the 2008 manual (Edition 4), which at time of this report was in draft, for approval by the IALA VTS committee, July, 2008.

The IALA VTS manual lays out what needs to be done to derive the level of VTS required for port waters. This is essentially an analysis of traffic (type and density) using the area of VTS responsibility, to determine the level of risk posed. Different combinations of marine competence and IALA VTS training are needed for each level of VTS delivery. Once the risk is determined, the level of VTS required is established.

A scheme that successfully delivers to all these area relies extensively on the knowledge, skill and experience of the personnel responsible for the VTS system and its watch management

A well trained and experienced VTS watch has been proven to have a significant influence on ship safety by reducing transit risk through port waters. As a corollary, failing to establish the correct level of VTS (or inappropriate specification and/or operation thereof) can in itself provide a potential liability. A number of large ports have suffered large claims for being unprepared to properly deliver an appropriate VTS service[3].

[3] For example, Cape Town, South Africa settled two Harbour Control cases associated with shipping casualties in its harbour entrance. The failure of radar equipment was also a key aspect of litigation involving the port of Milford Haven after a significant tanker grounding

ANNEX G

DEFINITIONS AND REFERENCES

The following comprehensive set of definitions and references are used by Marico Marine. Not all definitions or references are used within a report. All references within this report relate to the following unless otherwise specified:

Abeam	direction at right angles to the length of a ship (also used: On the beam)
Accident	An unintended event or sequence of events
Aft / Stern	rear of the vessel
Agent	Person, normally based at the port, who is appointed by the vessel's charterer or owner to look after their interests for the duration of the vessel's visit. Normally the primary intermediatory between vessel and shore services.
Aground	Resting on the bottom. Grounding - the action of a vessel going aground.
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
Alongside	A ship is alongside when side by side with a wharf, wall, jetty, or another ship.
Amidships	the centre of the vessel (half ships length)
Ballast	Any solid or liquid that is brought on board a vessel to increase the draft, change the trim, regulate the stability or to maintain stress loads within acceptable limits. It is normally seawater.
Beam	width of a vessel
Bollard	A post (usually steel or reinforced concrete) firmly embedded in or secured on a wharf, jetty, etc, for mooring vessels by means of wires or ropes extending from the vessel and secured to the post.
Bollard Pull	The measure used to determine the towage power of a tug, normally expressed in tonnes.
Bow	front / forward end of the vessel
Break Its Back	When a vessel is subjected to uneven stresses over the length of the ship causing structural failure of the longtitudinal body. Is either caused through incorrect loading/discharge of the vessel, or through an external force such as taking the bottom which reduces buoyancy and thereby increasing stresses.
Breakwater (B/W)	A solid structure, such as a wall to protect the harbour from the force of the waves.
Bridge	An area or room where the ship is navigated from. Normally a dedicated deck - The Navigating or Bridge Deck.
Bridge Resource Management	A management system that aims to increase the effectiveness of the bridge team, which includes the pilot, and is based round the premise that human errors happen. It uses the closed communication loop of challenge and response.
Bulk Carrier	A ship specifically designed and constructed to carry homogenous dry cargoes in bulk.
Byelaws	Byelaws empower harbour authorities to regulate activities for specific purposes. This regulation power goes beyond simple management to include a power to create and prosecute in the Courts offences for which fines may be levied. Byelaws are a means of reflecting the local needs and circumstances of individual harbour authorities and are intended to allow them to conduct their business efficiently and safely. Harbour byelaws vary widely to suit local powers and needs. Byelaws are generally available to regulate rather than prohibit. Therefore activities cannot be banned from the entire harbour unless the appropriate byelaw-making power so specifies.
Cable	A nautical unit of measurement, being one tenth of a sea mile. See mile.
Cb	Block Coefficient is the ratio of the actual volume of water displaced (V) divided by volume of water displaced if the vessel was a box (ie Length x beam x draught). andthe LWL x BWL x T. Full forms such as oil tankers will have a high Cb where fine shapes such as containerships will have a low Cb.
chart datum	zero height referred to on a marine chart
class	category in classification register
conduct (con)	in control of the vessel (see bridge)
Consequence	The outcome, or outcomes, resulting from an event.
Controlling depth	The least depth within the limits of a channel: it restricts the safe use of the channel to draughts of less than that depth.
Course	The intended direction of the ship's head.

Deadfreight	a form of compensation payable by the charterer or shipper to the shipowner when the charterer is unable to load the cargo quantity agreed in the charterparty; the amount payable is the loss of freight equivalent to the cargo unavailable
Depth	The vertical distance from the sea surface to the seabed, at any state of the tide. Hydrographically, the depth of water below chart datum. cf sounding.
Directions (General or Special)	The harbour master duly appointed by a harbour authority has powers of direction to regulate the time and manner of ships' entry to, departure from and movement within the harbour waters, and related purposes. These powers are given for the purpose of giving specific directions to specific vessels for specific movements, unless the powers have been extended for other purposes. Harbour master's directions may be referred to as 'special directions' to distinguish them from 'general directions' given by the authority itself. Special directions are not for setting general rules but relate to specific vessels on particular occasions. The master - or pilot - of a vessel is not obliged to obey directions if he believes that compliance would endanger the vessel.
Disp / Displacement	Displacement. Equals the weight of the ship and is the amount of water that a vessel displaces measured in tonnes.
Draught	The distance (Depth) from the sealevel to the keel of the vessel
Dredge	To deepen or attempt to deepen by removing material from the bottom.
dwt	Deadweight tonnes - The total weight of the cargo carried plus fuel etc., i.e., the maximum load that can be carried without submerging the load line.
Dwt, Deadweight	A measure of the carrying capacity of the vessel including cargo, fuel and other consumables
Ebb tide	A loose term applied both to the falling tide and to the outgoing tidal stream
Echo Sounder	Equipment that measures the distance between the unit and seabed. The transducer is normally on the ships bottom and measures the underkeel clearance at that point.
ETA	Estimated Time of Arrival - When a ship is expected to arrive at a port
ETD	Estimate Time of Departure - When a ship is expected to sail from a port
Fairway	The main navigable channel, often buoyed, in a river, or running through or into a harbour.
Falling tide	The period between high water and the succeeding low water.
Fender	A protective device placed between a vessel and wharf to prevent damage to the hull and wharf. Can also be used between two vessels.
Fetch	The area of the sea surface over which seas are generated by a wind having a constant direction and speed. Also, the length of the generating area, measured in the direction of the wind, in which the seas are generated.
Flood tide	A loose term applied both to the rising tide and to the incoming tidal stream. cf ebb tide.
GM	metacentric height (measure of a vessel's statical stability)
GMT	Greenwich Mean Time (which in practical terms is the same as UTC)
GPS	1global positioning system
gross tonnage (GRT) (GT)	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
Harbour	A stretch of water where vessels can anchor, or secure to buoys or alongside wharves etc, and obtain protection from sea and swell. The protection may be afforded by natural features or by artificial works. cf. artificial harbour, island harbour
Harbourmaster	A harbourmaster is an official responsible for enforcing the regulations of a particular harbour or port, in order to ensure the safety of navigation, the security of the harbour and the orderly operation of the port facilities.
Harm	Death, physical injury or damage to the health of people, or damage to property or the environment.
Hazard	A physical situation or state of a system, with the potential to cause harm.
Heading	Synonymous with ship's head.
Heel	angle of tilt caused by external forces
Height of the tide	The vertical distance at any instant between sea level and chart datum.
High water	The highest level reached by the tide in one complete cycle.
HM	Harbourmaster

Hogging/Sagging Deformation	When a vessel is loaded she bends due to uneven loading along the length of the vessel. the aim is to evenly load a vessel but if extra weight is in the middle of the vessel the midships section will 'sag' against the fore and aft sections and midships will be deeper. Conversely if the ends at heavier she will 'hog' and the ends will be deeper than midships.
hp	horsepower
hPa	hectoPascal(s)
Hunting	the action caused as a stressed mooring tries to return to its normal state thereby forcing the vessel to move. The vessel moves under the inertia created and this is resisted by the opposite mooring lines thereby starting the cycle again. To avoid this requires all moorings to be tensioned evenly and backsprings are often the biggest cause of hunting.
IALA	International Lighthouse Association
IMO	International Maritime Organization
International Oil Pollution Compensation Fund	This provides compensation for oil pollution damage resulting from spills of persistent oil from tankers.
IOPC	International Oil Pollution Compensation
ISM	International Safety Management Code
Knot	The nautical unit of speed, i.e. 1 nautical mile (of 1852m) per hour.
kt(s)	knot(s)
kW	kilowatt
LBP	Length between perpendiculars and is normally the waterline length of the vessel when loaded.
Leading Light	Lights at different elevations so situated as to define a leading line when brought into transit.
Leading line	A suitable line for a vessel to follow through a given area of water as defined by leading marks located on a farther part of the line.
Leading mark	One of a set of two or more navigation marks that define a leading line.
Leeway/Set	Leeway is
Lift Off the Berth	A ship handlers term when a vessel moves off a berth. It can from wind, tugs, engines, thrusters etc . The vessel is said to 'lift off the berth' once she is let go and moves into the channel.
LOA	Maximum length of the vessel (which is greater than the LBP)
LOF	Lloyds Open Form
Long Waves	Long Waves – Periods from 30 to 300 seconds. Are generated in storms and initially travel with swells, though they can separate. Usually the height of long waves is less than 0.1m, so they do not induce violent vertical vessel motions. Long waves are more significant for moored vessels as they induce horizontal motions. Situations when a vessel is moving in a berth on what appears to be a still day are usually caused by long waves.
Low water (LW)	The lowest level reached by the tide in one complete cycle.
m	metre(s)
m3	cubic metres
Made Fast	When a vessel is tied up to a wharf she is said to be 'made fast'. Also when a tug is connected to a vessel the tug is said to be 'made fast'.
MARPOL	International Convention for the Prevention of Pollution from Ships.
Master	the Captain of the vessel and is in overall command and has the responsibility of the vessel.
Mean sea level (MSL)	The average level of the sea surface over a long period,preferably 18.6 years, or the average level which would exist in the absence of tides.
Midships	See Amidships
mm	millimetre(s)
Moorings	the gear used to make a vessel fast to the wharf. Normally ropes or wires.
Neaps/Springs Tides	tidal ranges vary with the position of the moon and sun. When the range is at its maximum it is known as spring tides and when the range is at a minimum it is known as neap tides.
nm	nautical mile(s)
Norwegian Shackles	A specialised shackle used in shore mooring systems. It utilises a locking pin system that is flush with the external part of the shackle allowing it to pass through mooring leads and reduces the problems of snagging.

Oil Tanker	A ship specifically designed and constructed to carry crude oil and / or petroleum products in bulk.
Operating Environment	The total set of all external natural and induced conditions to which a system is exposed at any given moment.
OPRC	International Convention on Oil Pollution Preparedness, Response and Cooperation Convention
P & I	Professional and Indemnity.
P & I Clubs	P & I insurance providers for international shipping. Generally this provides the owner with 'third party' cover for any damage resulting from a ship's actions.
PANAMAX	The maximum size of ship that can use the locks of the Panama Canal
Passage	A sea journey between defined points; one or many passages may constitute a voyage.
Pennant	Normally a wire (or rope) with an eye at either end. Part of the shore mooring system.
Pilot	Person qualified to take charge of ships entering, leaving and moving within certain navigable waters.
Pilotage	The conducting of a vessel within restricted waters. Also, the fee for the services of a pilot.
Pitch	Angular motion of a ship in the fore-and-aft plane. cf roll, scend
Port	left-hand side when facing forward
PPE	Personal Protective Equipment
Push On	When a tug is on the hull of a vessel and using its thrust to 'push on'. The alternative is to pull where the tug is made fast and the force is applied to the vessel through the tug line.
range of tide	difference in height between successive high and low waters
Ranging	fore and aft movement of a ship alongside its berth
Risk	Combination of the likelihood of harm and the severity of that harm.
Risk Management	The systematic application of management policies, procedures and practices to the tasks of Hazard Identification, Hazard Analysis, Risk Estimation, Risk Evaluation, Risk Reduction and Risk Acceptance.
Risk Reduction	The systematic process of reducing risk.
Roll	The angular motion of a ship in the athwartship plane. Cf pitch.
rpm	revolutions per minute
Safe	Risk has been demonstrated to have been reduced to a level that is broadly acceptable or tolerable and ALARP, and relevant prescriptive Safety Requirements have been met, for a system in a given application in a given operating environment.
Safety Management	The application of organisational and management principles in order to achieve safety with high confidence.
Safety Management System	The organisational structure, processes, procedures and methodologies that enable the direction and control of the activities necessary to meet Safety Requirements and safety policy objectives.
SBE	Standby Engines. When the engines are made ready prior to maneouvring the vessel.
Sea State	A generic measurement for the marine environmental conditions at a particular location and time.
Sea Waves	Sea waves – Periods below 7 seconds. Generated by local wind conditions and whilst they can have large heights, they generally do not induce significant motions on large vessels .
Senhouse Slips	A device with a hinged tounge that goes through an eye of a cable, or chain link, being closed by a ring that can be knocked off. Senhouse slips are used in the shore mooring system on the vessel to allow quick release of a shore mooring.
Setdown	Setdown is caused when the vessel is in a long wave trough, so underkeel clearance is reduced. This is an effect of Long Waves.
Shackle (of cable)	The length of a continuous portion of chain cable between two joining shackles. In British ships the standard length of a shackle of cable is 15 fathoms (27.432 m).
Ship's head or heading	The direction in which a ship is pointing at any moment.
Shoal	A shoal is a somewhat linear landform within or extending into a body of water, typically resulting in localized shallowing (shoaling) of the water.
Shock Loadings	Shock loadings is the near instantaneous stress loading on a rope or wire which can substantially increase the stresses on an object

Significant Wave Height	Significant wave height, Hs, is approximately equal to the average of the highest one-third of the waves.
SMS	Safety Management System
Sounding	the depth of water from sealevel to seabed
Springs	Springs (back springs) are the moorings that lead from the ends of the vessel to the shore towards amidships.
Squat	Squat: return flow are speeded up under the ship. This causes a drop in pressure, resulting in the ship dropping vertically in the water. As well as dropping vertically, the ship generally trims forward or aft. The overall decrease in the static under keel clearance, forward or aft, is called Ship Squat
stability	property of a ship by which it maintains a position of equilibrium, or returns to that position when a force that has displaced it ceases to act
Starboard	right-hand side when facing forward
Steerage way	The minimum speed required to keep the vessel under control by means of the rudder.
Surge	Surge is a long period energy source that is often generated by events at great distances inducing horizontal motions in the vessel. See Long Waves.
surging	movement of a ship at its berth caused by surge in a harbour. Surging includes ranging along the berth, vertical lift at the berth and movement away from the berth
Swell Waves	Swell – Periods from 7 to 30 seconds. Generated by storms outside the local area (can be over 1000km away). Swells cause the most significant vessel motions. The natural period of roll of large vessels is approximately 17 seconds. If the swell period matches the vessels natural period, significant motions will be induced. If wave energy is present at periods close to the resonant period of the vessel, then the vessel motion will be enhanced.
t	tonne(s)
Tidal Window	The period of time that the vessel has enough water under the keel to safely transit a channel/fairway. Normally the time ranges around high water and is determined by the draught of the vessel and the maximum height of tide.
Tide gauge	An instrument which registers the height of the tide against a scale.
track	the path intended or actually travelled by a ship
Training wall	A mound often of rubble, frequently submerged, built alongside the channel of any estuary or river to direct the tidal stream or current, or both, through the channel so that they may assist in keeping it clear of silt.
Transit	Two objects in a line are said to be 'in transit'. cf range
TSS	Traffic Separation Scheme
UKC	under keel clearance
Underkeel Clearance	The distance from the keel to the seabed
UTC	Coordinated Universal Time
VHF	Very High Frequency - Used as an abbreviation for VHF Radio. VHF is the primary communication link between parties. i.e. pilot and tugs, pilot and shore.
Yaw	Unavoidable oscillation of the ship's head either side of the course being steered or when at anchor due to wind and waves.