MARICO MARINE

BELFAST HARBOUR COMMISSIONERS

TOWAGE RISK ASSESSMENT

Report Number:	17UK1389
Issue:	02
Date:	29 March 2018

UK HMA | British Ports Association | IHMA

MARINE AND RISK CONSULTANTS LTD

BELFAST HARBOUR COMMISSIONERS

TOWAGE RISK ASSESSMENT

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Date	Release	Prepared	Authorised	Notes
08 Feb 2018	Draft A	AR / PF	JH	Draft for BHC Comment
20 March 2018	01	PF	JH	Final
29 March 2018	02	PF	JH	Final (minor revision)

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29/03/2018

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ABBREVIATIONS

Abbreviation	Detail
ALARP	As Low as Reasonably Practicable
BHC	Belfast Harbour Commissioners
BLPS	Belfast Lough Pilotage Services Ltd
CHA	Competent Harbour Authority
GtGP	The Guide to Good Practice on Port Marine Operations
HW	High Water
H&W	Harland & Wolff
ICW	In Collision With
IMO	International Maritime Organisation
kt	Knot (unit of speed equal to nautical mile per hour, approximately 1.15 mph)
LW	Low Water
m	Metre
Marico Marine	Marine and Risk Consultants Ltd
MCA	Maritime and Coast Guard Agency
ML	Most Likely
MSMS	Marine Safety Management System
nm	Nautical Mile
NRA	Navigation Risk Assessment
PEC	Pilotage Exemption Certificate
PMIS	Port Marine Information Services
PMSC	Port Marine Safety Code
The Port	Belfast Port
SHA	Statutory Harbour Authority
TRA	Towage Risk Assessment
VTS	Vessel Traffic Service
WC	Worst Credible

1 INTRODUCTION

This Towage Risk Assessment (TRA) has been prepared by Marine and Risk Consultants Limited (Marico Marine) for Belfast Harbour Commissioners (BHC), as the Statutory Harbour Authority (SHA), responsible for the safety of navigation, including marine towage operations in Belfast Harbour. Furthermore, this TRA will supplement the existing Belfast Harbour Navigation Risk Assessment (NRA) and will be included as a separate risk register within the Hazman ll database, currently used by BHC as the basis for identification and review of navigation hazards.

1.1 TOWAGE RISK ASSESSMENT

While any contract for the use of tugs is formally for the master of a vessel, the use of harbour tugs is one of the principal and most direct means open to a harbour authority to control risk to vessels. However, it is accepted that towage operations themselves are not without risk to personnel, the environment and property and therefore this risk assessment will identify those hazards pertaining to towage operations and where necessary recommend additional risk control measures.

This TRA will therefore provide input to the decision-making process relating to the safe management of tugs and vessels undertaking towage operations within the port and will also add to the existing Belfast Harbour NRA. It is also intended to enhance the safety of marine towage by ensuring that all towage-related hazards are identified, control measures are in place and hazard risk levels are maintained at acceptable levels.

1.2 BELFAST HARBOUR TOWAGE OPERATIONS MANUAL

The Belfast Harbour Towage Operations Manual (December 2017) approved by Belfast Harbour Commissioners (BHC) in consultation with Belfast Lough Pilotage Services and the current Belfast Harbour towage operators, describes the procedures and policies to promote and improve safety for those responsible when directing tugs during harbour ship towage, barge and dead-ship towage operations. It includes shipboard safety practices and personnel safety issues and forms a body of knowledge with which all those connected with marine towage operations in Belfast Harbour should be familiar.

1.3 THE PORT MARINE SAFETY CODE AND A GUIDE TO GOOD PRACTICE ON PORT MARINE OPERATIONS

The Port Marine Safety Code (PMSC) sets out a national standard for every aspect of port marine safety. Its aim is to enhance safety for everyone who uses or works in the UK port marine environment. It is endorsed by the UK Government, the devolved administrations and representatives from across the maritime sector and, while the PMSC is not mandatory, these bodies have a strong expectation that all harbour authorities will comply.

A "Guide to Good Practice on Port Marine Operations" (GtGP) is intended to supplement the PMSC. It contains useful information and more detailed guidance on many issues relevant to the management of ports and other marine facilities including towage.

With regards to towage the following statements are extracted from Section 10 of the GtGP:

"Procedures for towage in ports, harbours and at terminals need to be developed, managed and regularly reviewed by harbour authorities, tug operators, pilots and ship owners, to ensure a safe and efficient service. Procedures should include responses to emergencies. Effective communication and team work between all parties is essential".

"Berthing and unberthing operations using tugs should be risk assessed by harbour authorities. Based on that risk assessment, the harbour authority in consultation with other stakeholders, should develop specific towage guidelines which should be incorporated into their Safety Management Systems."

1.4 BELFAST HARBOUR TOWAGE INFORMATION & MINIMUM TOWAGE REQUIREMENTS

Belfast Harbour has produced a source of information on tugs and towage procedures for masters of vessels using Belfast Harbour known as: "Belfast Harbour Towage Information" which should be read in conjunction with the Port's "Minimum Towage Requirements" which state the minimum towage requirements for each berth within the port for various vessel sizes and types and the "Navigational Guidelines" within the port.

1.4.1 Belfast Drydock Towage Guidelines

In consultation with Harland & Wolff (H&W) and Belfast Lough Pilotage Services (BLPS) Ltd. BHC have developed towage guidelines for vessels entering and leaving the drydock.

1.5 TOWAGE SIMULATION STUDY AND TOWAGE OPERATIONS MANUAL

BHC considers it important that pilots and tug masters understand their respective concerns when undertaking towage operations and in, supporting the development of the Belfast Harbour Towage Operations Manual (see **Section 1.2**), a real-time bridge navigation simulation workshop was held between 30th October and 3rd November 2017 inclusive. Representatives from BHC, BLPS Ltd, and Belfast Harbour towage operators attended the workshop. The simulator workshops were primarily focussed on themes of operational marine and navigation safety.

Both the simulator workshop and the subsequent compilation of the Towage Operations Manual have played a key part in constructing this risk assessment. This is due to Marico Marine having a clear understanding through previously undertaken consultation with BLPS Ltd and all Belfast harbour towage operators, as well as a practical understanding of towage operations and activities in Belfast Harbour.

1.6 NON-STANDARD MARINE MOVEMENT (SPECIAL CATEGORY MOVEMENTS)

It is recognised that due to the considerable variations in vessel size, shape, condition and degree of capability, certain marine movements may require an individual assessment of the planned movement undertaken. In these cases, a pre-movement planning meeting is to be held between all organisations / individuals who are involved. This is particularly pertinent when a damaged or disabled vessel or unusual floating structure is to be moved within the port.

It should also be noted that there may be other circumstances such as abnormal berthing arrangements or a reduction in available towage assets, which would call for an individual assessment of a proposed shipping movement.

There may be occasions when because of distress or immediate machinery failure (emergencies) that a preplanning meeting cannot be held. On such occasions procedures should be adopted which protects the safety of life, the marine environment and the Port infrastructure.

2 DATA COLLECTION

2.1 TOWAGE MOVEMENTS

In order to understand the level of towage activity in Belfast Harbour the previously undertaken simulation study (see **Section 1.5**) had identified 1,532 vessel movements requiring towage in Belfast Harbour, between September 2015 and September 2017 (Port Marine Information Services (PMIS) database) as detailed below in **Figure 1**.

Key FACTS

	No	%
Total Movements	23343	
Total Movements involving towage	1532	6.56
Light Ship Category (all movements)	3589	15.38
Light Ship Category involving towage	502	32.77

Tugs by NUMBER INC. LIGHT SHIP

Tug	0	1	2	3	4	5	6	Total
01-Sep-2015 - 01-Sep-2017	n/a	962	557	9	1	2	1	**1532**
Percentage	n/a	62.79	36.36	0.59	0.07	0.13	0.07	

Tugs by DRAFT INC. LIGHT SHIP

Draft		1	2	3	4	5	6	Total
0 - 4.99		116	11	0	0	0	0	127
5 - 6.99		380	159	6	1	0	1	547
greater than 7		455	382	3	0	2	0	842
								1516

Tug No by VESSEL TYPE (inc. DRAFT). EXC LIGHT SHIP

Type	Draft	1	2	3	4	5	6	Total
Refined Oil	< 7.00 m	17						17
	>7.00 m	228	11	0	0	0	0	239
Grain/Feeds	>6.20 m	26	136					162
Containers	0 - 4.99	9						9
	5 - 6.99	44	3					47
	greater than 7	87	3					90
Cruise	0 - 6.99m	39	15					54
	greater than 7	39	7	1				47
RoRo	greater than 4.99	95						96
Coal	5 - 6.99	3	2					5
	greater than 7	1	60					65
								831

Key points / data limitations

No Ship length in PMIS (noting this is a parameter in towage guidelines)
Light Ship: When a ship is classified Light Ship this over-rides the underlying vessel/cargo type (and therefore circa 32% of all towage movements are not characterised by vessel/cargo type)
Where multiple tugs are used - the database does not filter by company/tug

Figure 1: Belfast Harbour Towage Movement Data (September 2015 – September 2017)

2.2 INCIDENT ANALYSIS

To support the hazard identification and analysis of the frequency of incidents, a review of Belfast's incident database was conducted. In total, 54 towage related incidents were identified since 2003 and are plotted below in **Figure 2**. On average 3.6 incidents were reported each year, however, a significant spike in 2010 suggests that the rate or format of reporting changed which improved the level of reporting. Between 2010 and 2017, the average number of incidents was 5.6, showing a significant decline over this reporting period.

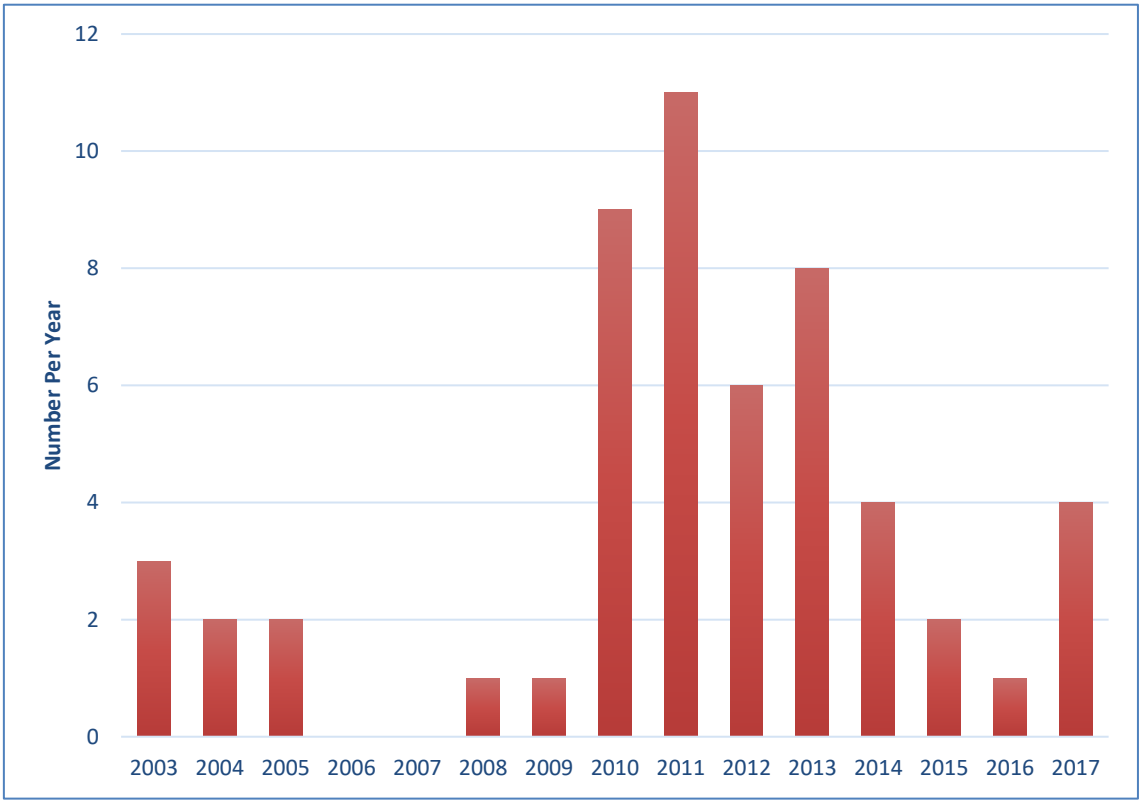


Figure 2: Towage Incidents per Year.

The type of incident recorded in the database is identified in **Figure 3**. The vast majority are either mechanical defects (where the tug loses propulsion or steering) or equipment failures (winch failures or tow line parting) which resulted in the tow being aborted. Four contacts / collisions between a tug and a tow were reported, at a rate of 0.26 per year (once every 4 years). It is recognised that the incident database is likely underreported, with many more near misses or close quarters situations occurring but without being properly reported.

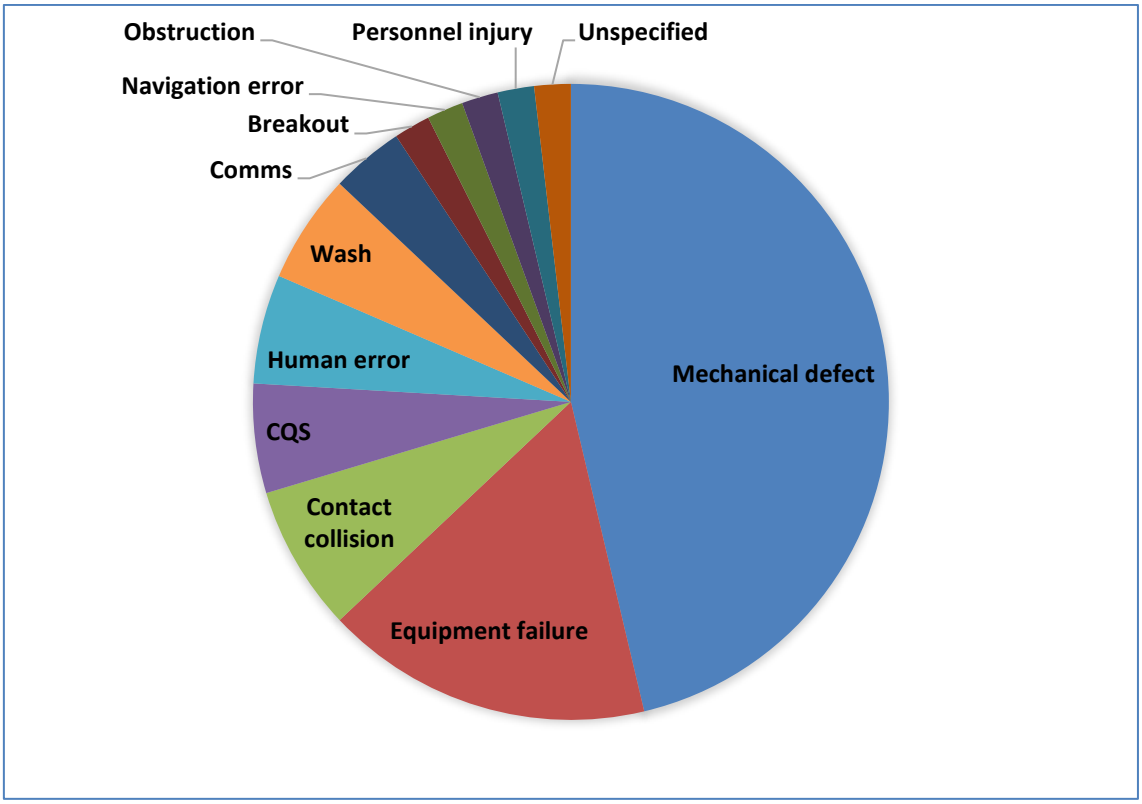


Figure 3: Proportion of Towage Incidents by Type.

2.3 STAKEHOLDER CONSULTATION

Consultation meetings were conducted at BHC on the 23rd and 24th January 2018, the former to identify the hazards and undertake an initial scoring and the latter to review the scores with towage operators:

2.4 HAZARD IDENTIFICATION AND SCORING MEETING (23RD JANUARY)

In attendance:

- Barry Shaughnessy – BHC Deputy Harbour Master;
- Stuart Wilson – BHC Assistant Harbour Master;
- Graham Campbell – Pilot, BLPS Ltd;
- Paul Fuller – Marico Marine; and
- Andrew Rawson – Marico Marine.

An overview of the risk methodology (see **Annex B**) and scoring approach was explained to the pilot Graham Campbell (GC).

Marico Marine had previously constructed a draft hazard risk register (unscored) for discussion at this meeting and for the consultation meeting to be held with the towage operators the following day. A discussion ensued on the merits of each of the individual hazards and they were adjusted, amended and updated accordingly. Scoring for each of the hazards were then agreed and once completed a review of the overall assessment was made in order to ensure it passed the "common sense" test. It was explained to GC that this initial assessment would form the basis for further discussion at the consultation meeting to be held the following day with another pilot in attendance.

The proposed towage assessment proforma form was also discussed with GC (see **Section 2.6**).

2.5 RISK ASSESSMENT WORKSHOP, HAZARD REVIEW AND SCORING (24TH JANUARY)-

The workshop held in BHC training room was attended by:

- Kevin Allen – BHC Harbour Master;
- Barry Shaughnessy – BHC Deputy Harbour Master;
- Stuart Wilson – BHC Assistant Harbour Master;
- Ian Whitlock – SMS Towage Master;
- Scott Tasker – Towage Master, John McLoughlin & Sons;
- Justin Ferran – David Ferran and Sons;
- Connor Ferran – David Ferran and Sons;
- Mark Ewings – Waterfront Services;
- Phil O'Brien –Pilot, BLPS Ltd;
- Paul Fuller – Marico Marine; and
- Andrew Rawson – Marico Marine.

B Shaughnessy (BS) opened the meeting by explaining the purpose and expectations of the workshop.

For clarity P Fuller (PF) explained that to determine towage risk a Formal Safety Assessment (FSA) approach to risk management was used, as defined by the International Maritime Organisation (IMO) guidelines. PF explained that the process started with the identification of all potential towage hazards. It then assessed the likelihood (frequency) of a hazard causing an incident and considers the possible consequences of that incident. This was done in respect of two scenarios, namely the "most likely" and the "worst credible". The quantified values of frequency and consequence are then combined using the Marico HAZMAN software to produce a risk score for each hazard. These are collated into a "Ranked Hazard List" from which the need for possible additional mitigation may be reviewed. The methodology is explained in greater detail in **Section 3**.

A previously constructed hazard risk register was distributed to all and PF explained each of the heading criteria and how they were derived. It was intended for this register that terminology, area and hazard categories are to be consistent with those previously identified in the existing Belfast harbour NRA. A list of existing local mitigation risk controls relative to towage operations were also discussed.

PF emphasised that this TRA does not replace individual operators existing RA's, whether Health and Safety or operational but would serve to complement and determine a common approach to BHC risk managing towage operations. The hazards listed were those considered appropriate when tug(s) were undertaking and / or preparing to undertake a towage operation.

PF explained that a meeting held the previous day with BHC and BLPS Ltd. had identified hazards and determined the scores for each of the hazards. However, it was intended that for each hazard, the attributed scores would be individually discussed, amended and verified as appropriate by all the participants at this workshop. Furthermore, it was envisioned that once finalised the towage risk register would be discussed at all future Towage Sub-Committee meetings as well as following a significant towage related incident and subsequently amended and updated as appropriate.

A list of the 54 towage related incidents (2003 – 2017) received from BHC had been previously analysed (see **Figure 2**). PF explained that it is imperative to share and record and where necessary investigate all marine incidents / accidents as this will undoubtedly assist when reviewing each hazard and their associated risk and if considered necessary introduce additional risk mitigation. It was proposed that BHC adopt a more formal approach to port stakeholders informing them of marine related incidents by producing an incident report form and posting on the BHC marine website.

Each hazard was discussed and to inform the scoring PF stated that any anecdotal recall of incidents i.e. those not identified within the existing towage incident database, should be shared as well as those towage incidents in other ports which when considered could also happen in Belfast.

On completion the hazard risk register was reviewed and it was generally agreed that it represented an accurate reflection on the level of risk in Belfast, both in significance and ranked order.

2.6 TOWAGE ASSESSMENT PROFORMA

The "BHC Minimum Towage Requirements" state in a number of cases the need for the towage requirements for a particular size of vessel bound to and from a berth are required to be "Individually risk assessed". In order to formalise this process BHC wished to promulgate a form which Belfast VTS

in conjunction with BLPS Ltd. would complete and determine the appropriate number of tugs required for that particular operation.

A draft proforma, previously prepared was distributed to the workshop group and discussed accordingly. Several amendments were suggested and agreed and the form was subsequently updated (see **Annex A**). The amendments included:

- Adding vessel minimum manoeuvring speed;
- SWL of towage bitts; and
- Type of mooring lines.

It is envisaged that in order to prevent any future ambiguity when assessing the towage requirements for vessels arriving and departing Belfast harbour and not covered within BHC "Minimum Towage Requirements" document this proforma will be adopted and where necessary adapted accordingly.

3 TOWAGE RISK ASSESSMENT

Belfast Harbour MSMS is underpinned by an effective identification and assessment of navigational hazards. Belfast Harbour use the HAZMAN II system as the basis for initial identification and review of hazards, and to ensure consistent and effective review and implementation of control measures. On completion of the TRA it will be added to the NRA, as a separate risk register, which will be reviewed with the respective key stakeholders on a regular basis or following an incident.

Each of the towage companies operating in Belfast Harbour should have a risk assessment covering all standard towing operations and any unusual or specific operation will require at least a dynamic risk assessment.

3.1 INTRODUCTION

A standard 5x5 risk matrix was used (see **Figure 4**) and each hazard was assessed twice; firstly, to determine the risk associated with the "*most likely*" outcome of the hazard and secondly to determine the risk associated with the "*worst credible*" outcome for each hazard. The results are then combined to give a total risk score for each hazard.

This approach provides a thorough assessment of risk, which reflects reality, in that relatively few incidents result in the "worst credible" outcome.

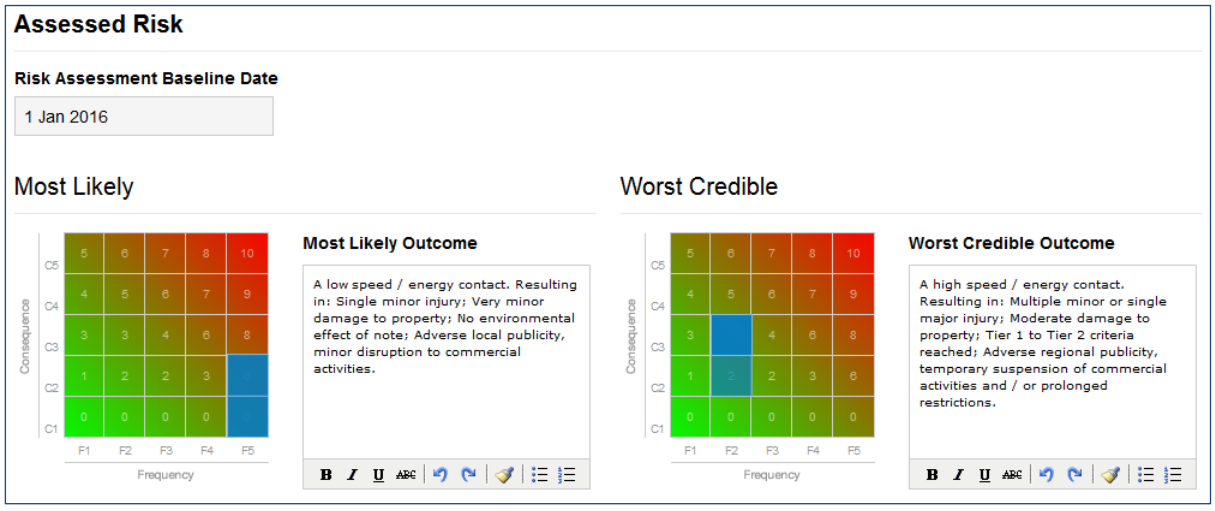


Figure 4: Example Risk Matrix.

3.2 ASSESSMENT OF FREQUENCY AND CONSEQUENCE

The assessment of frequency was made for a notional "*most likely*" and "w*orst credible*" likelihood of occurrence, for each hazard. These were combined with assessments of typical consequences to people, property, environment and business. The frequency and consequence bands used for this TRA are detailed in **Annex B**.

The frequency and consequence assessments were largely based on the data / information collected, and in particular:

- Review of Belfast harbour towage procedures and other documentation / information;
- Towage simulation workshop (November 2017);
- Observation of towage operations;
- Stakeholder consultation meetings;
- Review of the towage related activity; and
- Towage incident database.

This data / information was supplemented by expert judgement and specialist knowledge provided by the assessment team, who have considerable experience in undertaking similar RAs of this type in ports / harbours all around the world.

3.3 HAZARD IDENTIFICATION

The IMO Guidelines defines a hazard as *"something with the potential to cause harm, loss or injury"*, the realisation of which results in an accident. The frequency that the hazard will be realised can be combined with an estimate of the consequence, and this combination is termed "risk". Risk is therefore a measure of the "likelihood" and the "consequence" of a particular hazard occurring.

It is important that the hazard identification process follows a structured and systematic process that is thorough and comprehensive. It must identify common hazards as well as hazards that may never have occurred in the Belfast Harbour in the past, but are nonetheless possible and credible.

Previous identified hazards were discussed and confirmed in consultation with BHC staff, Belfast Lough Services pilots and towage operators across; the areas of the port, vessel type, and towage (push/pull), tug types (conventional and omni-directional tugs) and hazard categories (see **Section 3.4**) previously defined by BHC's navigation risk assessment. The areas under study were as follows:

- Victoria Channel – From buoys No.1 and No.2 to Beach No.15; and

- Dock System – All areas to the south west of Beacon No.15.

Vessel types were summarised into commercial vessels and non-commercial vessels (such as fishing and recreational craft).

3.4 HAZARD CATEGORIES

In order to focus the overall TRA and provide a structured hazard identification process, the following hazard categories were used (**Table 1**). Categorising hazards in this way also helps in the determination of risk control measures pertinent to the category and geographic location of each hazard.

Table 1: Hazard Categories

Hazard Category	Comments
Collision	When two or more vessels impact each other whilst manoeuvring.
Contact	When one or more vessels makes physical contact with a fixed object such as a pier / jetty / dry dock entrance, dock entrance or a mooring buoy. This hazard is sometimes referred to as "allision" when contact is made with a fixed structure, or a "striking" when contact is made with a floating structure (e.g. navigation buoy or anchored or moored ship).
Foundering / Swamping	When the tug fills with water, and when overwhelmed, sinks which could be attributed to girting, sometimes referred to as "girding". This is when a towline under tension exerts a heeling moment which results in excessive heel that could cause the tug to capsize.
Grounding	When a vessel unintentionally makes contact with the seabed.
Personal Injury	For the purposes of this assessment this includes any injury to any person involved directly or indirectly during the towage operation.

3.5 HAZARD RISK REGISTER

All hazards relate to the act of towage activities, hazards involving the movement of tugs around the harbour were not included as they are already covered in BHC's NRA. The following hazards were therefore identified:

Table 2: Identified Hazards.

Hazard ID	Area	Category	Hazard Title	Hazard Detail
1	Victoria Channel and Dock System	Collision	Collision between Tug and Towed Vessel	Whilst towing, tug collides with commercial vessel it is contracted to tow in harbour approaches.
2	Victoria Channel and Dock System	Collision	Collision between Tug/Towed Vessel and a 3rd Party Commercial Vessel	Whilst towing, tug and/or vessel being towed in collision with third party commercial vessel in harbour approaches
3	Victoria Channel and Dock System	Collision	Collision between Tug/Towed Vessel and a 3rd Party Non-Commercial Vessel	Whilst towing, tug and/or non-commercial vessel being towed in collision each other in harbour approaches
4	Victoria Channel	Grounding	Tug (push/pull mode) and/or towed vessel grounding	Tug (push/pull mode) and/or vessel towed grounds during towing operations.
5	Dock System	Grounding	Tug (push/pull mode) and/or towed vessel grounding	Tug (push/pull mode) and/or vessel towed grounds during towing operations.
6	Dock System	Contact	Contact with moored 3rd party commercial vessel	Whilst under tow, tug and/or vessel being towed/pushed contacts 3rd party commercial vessel on adjacent berth.
7	Dock System	Contact	Contact with moored 3rd party non-commercial vessel	Whilst under tow, tug and/or vessel being towed/pushed contacts 3rd party non-commercial vessel on adjacent berth/mooring.
8	Dock System	Contact	Contact with infrastructure	Whilst under tow, tug and/or vessel being towed/pushed contacts berth / (dry) dock entrance/ infrastructure.
9	Victoria Channel	Contact	Contact with Navigation Aid	Whilst under tow, tug and/or vessel being towed/push contacts floating navigation aid.
10	Victoria Channel and Dock System	Swamping & Foundering	Tug Capsize/ Swamping	Whilst undertaking towage operations conventional tug capsizes.
11	Victoria Channel and Dock System	Personal Injury (crew safety)	Personal injury to crew member(s) during towage operations.	Man over-board; Tow-line parts; Towline incident during connection/ disconnection.

The identified hazards shown above in **Table 2** were reviewed and scored at the stakeholder meetings held in BHC offices on 23rd and 24th January 2018,with input from towage operators, pilots and harbour staff (see **Section 2.3**). Each hazard was discussed in turn and the circumstances and frequency of previous incidents were discussed to inform the assessment of likelihood. On completion of the assessment, the ranking of hazards was reviewed and discussed to determine whether they were an accurate reflection on the level of risk for towage operations in Belfast Harbour, both in significance and order.

3.6 RISK CONTROLS

There are a number of over-arching merchant shipping regulations that apply in all ports / harbours in the UK, and the most applicable include (but are not limited to):

- International Convention for the Safety of Life at Sea (SOLAS), 1974 (and amendments);
- The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (or STCW), 1978 (and amendments);
- The International Regulations for Preventing Collisions at Sea (COLREGs);
- IMO Resolution A765 (18) Guidelines on the Safety of Towed Ships and other Floating Objects;
- IMO MSC Circular 1175 Guidance on Shipboard Towing and Mooring Equipment;
- MGN 308 (M+F) Mooring, Towing or Hauling Equipment on all Vessels – Safe Installation and Safe Operation;
- MGN 468 M Voluntary Towage Endorsement Scheme;
- MGN 199 (M+F) Dangers of Interaction;
- MSN 1752 (M) The Merchant Shipping (Load Line) Regulations 1998, as amended by the Merchant Shipping (Load Line) (Amendment) Regulations 2000, Schedule 2;
- MCA: Instructions to Surveyors, Load Line Instruction (MSIS 1) Part 8, Section 8.11 Tugs and Section 8.12 Safety of Towed Ships and Other Floating Objects;
- MCA: The Safety of Small Workboats and Pilot Boats – a Code of Practice (the 'Workboat Code') particularly part 11.7 Stability of Vessels Engaged in Towing and 25.2 Vessels Engaged in Towing; and
- MCA Code of Safe Working Practices for Merchant Seafarers (CSWP).

3.6.1 Existing Risk Controls

Ship towage operations have inherent risks and these risks can largely be mitigated by good communications with open reporting, dialogue and regular liaison.

The data gathering exercise and stakeholder consultation meetings sought to identify all risk control measures applicable to towage operations and currently in place within Belfast Harbour and these are listed below in **Table 3**.

Table 3: Risk Control List.

ID	Risk Control
1	BHC "Minimum Towage Requirements" document.
2	BHC Navigational Guidelines.
3	BHC MSMS including navigation risk assessment.
4	Towage operator SMS/ISM, including risk assessment and standard operating practices.
5	Adequate passage planning.
6	Tug master qualification, training and experience.
7	Pilot authorisation (including PEC holders), training and experience.
8	Vessel traffic monitoring through a 24-hour VTS.
9	Communication (ship master/pilot and tug master/pilot exchange of information).
10	Assessing the size and type of vessel or barge to be towed and any limitations of the tow.
11	Tow wire and towing equipment is suitable (inspected and tested).
12	Adequate manoeuvring space.
13	Appropriate speeds agreed during; connection, under tow and disconnection.
14	Tug maintenance.
15	Emergency contingency plans.

The towage risk assessment also considered the vessel, when under tow, in relation to the existing:

- Port geography;
- Tug power / bollard pull;
- Berth facilities, length, fendering, bollard strength, gangway positions;
- Wind strength and direction;
- Tidal current rates, and ship handling windows;
- Tidal heights and under keel clearances in channel and in berth;
- Mooring arrangements and the extent of berth overhangs;
- The effect on vessels on other berths;
- The effect on other vessels using the harbour channels or swing basin including interaction effects;
- Day / night manoeuvres;
- Vessel beam in relation to berth pocket width;

- Vessel displacement in relation to tug power;
- Vessel engine power in relation to displacement;
- Vessel handling characteristics;
- Vessel manoeuvring aids;
- Vessel turning circle diameter and stopping distance;
- Vessel windage area; and
- Visibility from the bridge.

3.7 RESULTS

The ranked hazard list is shown below in **Table 4**. "*Contact with infrastructure*" was identified as the most significant hazard, falling within ALARP. All other hazards scored as "Low Risk".

It should be noted that several hazards score "people" at 6 and 7, reflecting the possible threat to life during towage operations requiring the possible introduction of additional risk control measures.

Table 4: Hazard Summary.

Rank	Hazard Ref.	Affected Areas	Accident Category	Hazard Title	Risk by Consequence Category								Risk Overall
					ML				WC				
					Environment	People	Property	Stakeholders	Environment	People	Property	Stakeholders	
1	8	Dock System	Contact	Contact with infrastructure	0	6	6	6	3	5	4	4	4.87
2	1	Dock System, Victoria Channel	Collision	Collision between Tug and Towed Vessel	0	3	0	0	5	6	5	5	3.85
3	2	Dock System, Victoria Channel	Collision	Collision between Tug/Towed Vessel and a 3rd Party Commercial Vessel	0	2	2	2	5	6	5	5	3.82
4	3	Dock System, Victoria Channel	Collision	Collision between Tug/Towed Vessel and a 3rd Party Non-Commercial Vessel	0	4	0	2	2	5	3	5	3.69
5	4	Victoria Channel	Grounding	Tug (push/pull mode) and/or towed vessel grounding	0	2	2	0	5	6	5	5	3.67
6	11	Dock System, Victoria Channel	Personal Injury	Personal injury to crew member(s) during towage operations.	0	3	0	0	0	6	0	6	3.31
7	10	Dock System, Victoria Channel	Swamping & Foundering	Tug Capsize/ Swamping	0	0	0	0	6	7	6	6	3.3

Rank	Hazard Ref.	Affected Areas	Accident Category	Hazard Title	Risk by Consequence Category								Risk Overall
					ML				WC				
					Environment	People	Property	Stakeholders	Environment	People	Property	Stakeholders	
8	5	Dock System	Grounding	Tug (push/pull mode) and/or towed vessel grounding	0	0	0	0	5	6	5	5	2.76
9	9	Victoria Channel	Contact	Contact with Nav Aid	0	0	3	0	2	2	3	2	2.53
10	6	Dock System	Contact	Contact with moored 3rd party commercial vessel	0	0	0	0	3	5	5	5	2.34
11	7	Dock System	Contact	Contact with moored 3rd party non-commercial vessel	0	0	0	0	2	5	3	5	2.15

3.8 ADDITIONAL RISK CONTROLS

All the hazards identified and scored for this risk assessment fell into the ALARP (1 hazard) or low (10 hazards) categories of risk, as such the current towage activities are deemed to be largely acceptable.

This does not, however, mean that further mitigation risk control measures for the hazard assessed as ALARP should not be considered. There is a rationale underlying any risk assessments that no matter how low the risk, there remains, no matter how small, a possibility that accidents or incidents may still occur. There are also underlying principles of the PMSC which encourage port authorities and operators to operate as safely as possible and to implement a coherent and clear MSMS.

Notwithstanding that the vast majority of hazards fell within the "low risk" region, a number of additional risk control measures and recommendations, which would contribute to safe and efficient operations within the harbour towage activities, were identified during the course of this TRA, these are listed below for BHC consideration.

Table 5: Additional Risk Controls and recommendations for consideration

ID	Additional Risk Control
1	In conjunction with a Notice to Mariners introduce an online incident and near-miss reporting system, including feedback and lessons learnt.
2	Although the pilots accompany tug masters on tug operations during initial training this should continue thereafter on an agreed periodical re-familiarisation basis.
3	Tug masters to accompany pilots on the same basis as above.
4	Introduce an integrated approach to the training of tug masters and pilots where appropriate (through simulation, if required).

ID	Additional Risk Control
5	Implement the Voluntary Marine Services Licencing regime at the earliest opportunity.
6	Ensure any towage related incidents are discussed at the Towage Sub-Committee meetings.
7	The towage risk assessment should be reviewed on an annual basis with appropriate stakeholders (i.e. at the Towage Sub-Committee meetings) as well as following a serious reported incident.
8	In conjunction with the towage operators and BLPS Ltd. undertake regular reviews and update the recently introduced Towage Operations Manual.
9	Update the BHC "Minimum Towage Requirements" and the Towage Operations Manual with the "Towage Assessment Proforma".
10	Update the BHC "Towage Information" document with up to date information such as current tug info.
11	Update BHC "Minimum Towage Requirements" by removing the term "individually *risk* assessed" stated and replacing with "individually assessed".
12	Introduce an annual emergency response exercise programme with BHC, BLPS Ltd. and towage operator participation.
13	Any unusual or specific operation (non-standard marine movement) will require a dynamic risk assessment.

3.9 "PEOPLE" CONSEQUENCE CATEGORY

It should be noted that several hazards (Hazard Reference Nos: 1, 2, 4, 5, 10 and 11) within the "people" (personal injury) consequence category fall in the 6 and 7 scoring band (see **Section 3.7**).

Effective mitigation will rely on safe working practices, appropriate crew competence and the provision of appropriate personal protection equipment. The proximity of appropriate response resources will also help to reduce the seriousness of any accident.

It is therefore essential that BHC ensure, through inspection, that personal safety mitigation measures, Company safe systems of work as well as industry standards are adhered to and if considered appropriate the introduction of a more robust and effective safety inspection regime.

4 CONCLUSIONS AND RECOMMENDATIONS

Projects previously undertaken by Marico Marine including several PMSC related audits, a NRA, towage simulator workshops and the compilation of the recently adopted Towage Operations Manual have assisted in having a clear understanding of marine activities within Belfast Harbour.

A total of 54 towage related incidents were recorded between 2003 and 2017 with on average 3.6 incidents reported per year. Of the recorded incidents "mechanical breakdown" and "equipment failure (i.e. tow line, winch failure)" were the highest category accounting for 46% and 17% respectively.

Previously analysed vessel movement data showed that between 2015 and 2017 there were 23,343 recorded vessel movements of which 1,532 (6.5%) required the use of towage assistance.

The TRA identified a total of 11 hazards for those towage operations being undertaken within the BHC SHA area.

The TRA and associated risk controls to be included in the BHC Hazman ll Navigation Risk Assessment as a separate risk register.

The risk of contact with a berth, (dry) dock entrance and or port infrastructure whilst a commercial vessel is under tow or being pushed by either a conventional or omni-directional tug in the dock system was assessed to be the highest ranked hazard, with risk score of 4.87 i.e. within the ALARP band.

The other towage-related hazards were assessed to be in the "low risk" category, and thus no additional risk control measures are necessarily required. Notwithstanding this, a number of additional risk control measures and associated recommendations were identified during the course of this TRA, as listed in **Section 3.8**.

Several hazards within the "people" (personal injury) consequence category fell within the 6 and 7 scoring band.

It is concluded that there are a number of reasons why the identified hazards are generally at a low risk:

- Existing national / international shipping regulations as well as BHC minimum towage requirements and navigation guidelines are in place ensure that when commercial vessels are under towage they operate in a regulated safe and efficient manner;
- Monitoring and responding to the level of commercial traffic interaction is well within the control and capabilities of Belfast Harbour VTS;

- The combination of clearly defined local marine traffic regulations, active VTS, professional piloting and the existing ship towage resources contribute to the safe running of the harbour; and
- Belfast Harbour is not a particularly busy area for recreational activities.

As part of the Belfast Harbour MSMS the identified hazards and associated risk control measures should be regularly reviewed, in conjunction with BLPS Ltd. and the towage operators.

A "Towage Assessment Proforma" (see **Annex A**) is to be introduced to clarify and document all future requirements for vessels requiring towage (or *not* as the case maybe). These are classed as movements that are currently required to be "individually risk assessed", as detailed in the Belfast Harbour "Minimum Towage Requirements" document.

In conclusion the risks associated with towage operations in BHC are considered largely acceptable and therefore safe. However, it is recommended that BHC consider implementing the additional risk control measures and recommendations as listed in **Section 3.8**.

Annex A Towage Assessment Form

Belfast Harbour	TOWAGE ASSESSMENT FORM

Section A – Vessel Details			
Name of Vessel:		Cargo Type:	
Agent:		DWT:	
Length Overall(m):		Beam (m):	
Max Draft (m):		Air Draft (m):	

Section B – Manoeuvring Equipment (complete as appropriate)						
Propulsion:	No. of (CPP/FP) propellers/			Min Manoeuvring speed./		
Rudder Type:						
Thrusters (power):	Bow	No.	Power	Stern	No.	Power
Towing Arrangements:	SWL Bitts			Type of ropes		
Other relevant info						
Known Vessel Defects:						

Section C – Planned Movement					
From:		To:		Side to Quay:	
Date:		Time:			

Section D - Checklist	
1. Have vessel displacement and longitudinal windage area been assessed using recognised criteria?	YES/NO
2. Have typical turning circle diameters and stopping distances for vessels of this type been assessed?	YES/NO
3. Does the vessel have unusual pilot boarding arrangements which would affect the operation? *(If yes, please quantify)*	YES/NO
4. Has the presence of vessels on adjacent berths been assessed and are there additional precautions required? *(If yes, please quantify)*	YES/NO
5. Does Port operations have special towage requirements for this move? E.g. If Dry-Dock Intermediate Gate in place. (*If yes, please quantify*	YES/NO
6. Are there additional precautions or remarks associated with this vessel? E.g. Comments based on prior experience or experience from sister vessels.	YES/NO

Section D - Checklist	
If yes to 6., please quantify:	

Section E- Towage Assessment								
Is towage required for this vessel?								YES/NO
If yes, insert number:	>10T		>20T		>25T		>40T	
Does towage differ for outward movement?								YES/NO
If yes, please quantify:								

Section F - Wind Speed Limit for which this assessment is valid	
Average wind speed <20 knots, max gust < 50% of average wind speed.	YES/NO
Other: *(Please quantify)*	

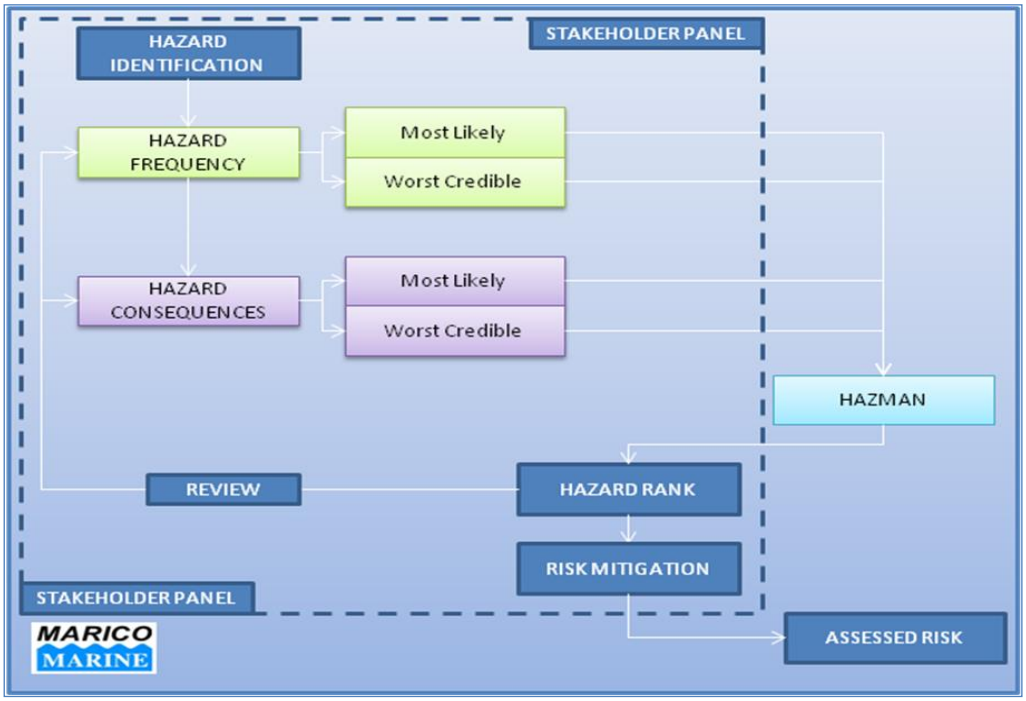
Section G – Sign Off			
Pilot completing assessment:		Date:	
Harbour Master confirming assessment:		Date:	

Please use this space for sketches or calculations used to guide this assessment:

Annex B Risk Assessment Methodology

Methodology

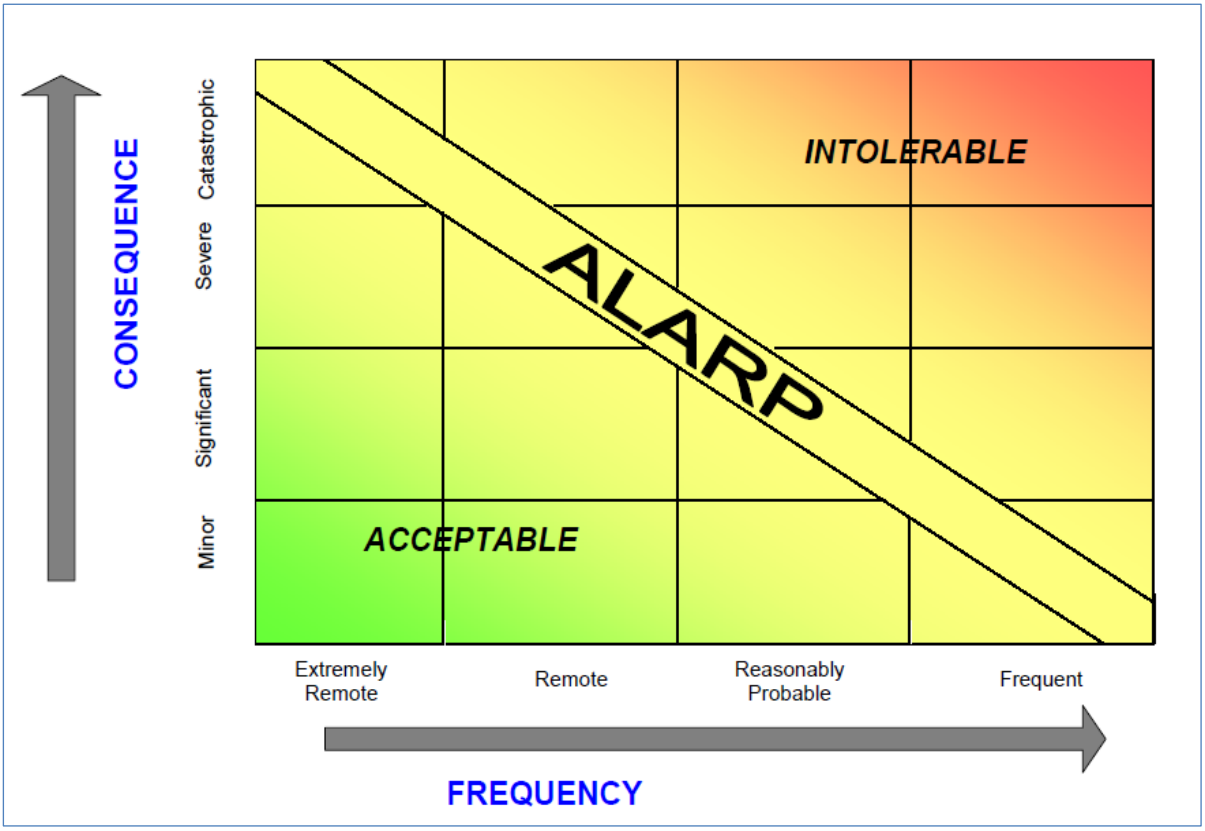
The TRA is limited to identifying and quantifying any additional or increased towage risk resulting from the project. It subsequently identifies possible mitigation measures where appropriate and makes recommendations. The process starts with the identification of all potential towage hazards. It then assesses the likelihood (frequency) of a hazard causing an incident and considers the possible consequences of that incident. It does so in respect of two scenarios, namely the "most likely" and the "worst credible". The quantified values of frequency and consequence are then combined using the Marico HAZMAN software to produce a "Risk Score" for each hazard. These are collated into a "Ranked Hazard List" from which the need for possible additional mitigation may be reviewed.



Marico Marine Risk Assessment Methodology.

Criteria for Towage Risk Assessment

Risk is the product of a combination of consequence of an event and the frequency with which it might be expected to occur. In order to determine towage risk a Formal Safety Assessment (FSA) approach to risk management is used. International Maritime Organisation (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.



General risk matrix.

The combination of consequence and frequency of occurrence of a hazard is combined using a risk matrix which enables hazards to be ranked and a risk score assigned. The resulting scale can be divided into three general categories:

- Acceptable;
- As Low As Reasonable Practicable (ALARP); and
- Intolerable.

At the low end of the scale, frequency is extremely remote and consequence minor, and as such the risk can be said to be "acceptable", whilst at the high end of the matrix, where hazards are defined as frequent and the consequence catastrophic, then risk is termed "intolerable". Every effort should be made to mitigate all risks such that they lie in the "acceptable" range. Where this is not possible, they should be reduced to the level where further reduction is not practicable. This region, at the centre of the matrix is described as the ALARP region. It is possible that some risks will lie in the "intolerable" region, but can be mitigated by measures, which reduce their risk score and move them into the ALARP region, where they can be tolerated, albeit efforts should continue to be made when opportunity presents itself to further reduce their risk score.

The FSA methodology used in this TRA, determines where to prioritise risk control options for the towage. The outcome of this risk assessment process should then act as the basis for a Navigation Safety Management System, which can be used to manage navigational risk.

Hazard Identification

Hazard identification is the first and fundamental step in the risk assessment process. It was undertaken for this project by Marico Marine specialists using the results of the analysis, recently undertaken simulator workshops with towage operator and pilot input, and feedback from local stakeholders during this and previous consultation periods.

In order to ensure that the process was both structured and comprehensive, potential hazards were reviewed under the following headings:

- Incident category;
- Geographical area; and
- Vessel type.

The five incident categories identified as being relevant to this study are:

- Collision;
- Contact;
- Foundering / swamping;
- Grounding; and
- Personnel injury.

It the content of this study, foundering, defined as “filling from above the waterline and sinking” and pollution have been treated as possible consequences of the above accident categories. The geographical areas used for the study were:

- Victoria Channel – From buoys No.1 and No.2 to Beach No.15; and
- Dock System – All areas to the south west of Beacon No.15.

The vessel types considered were:

- Commercial; and
- Non-commercial vessel (e.g. fishing, recreational etc.).

Risk Matrix Criteria

As indicated earlier, frequency of occurrence and likely consequence were both assessed for the “most likely” and “worst credible” scenario. Frequencies were assessed according to the levels set out below.

Frequency criteria.

Scale	Description	Definition	Operational Interpretation
F5	Frequent	An event occurring in the range once a week to once an operating year.	One or more times in 1 year
F4	Likely	An event occurring in the range once a year to once every 10 operating years.	One or more times in 10 years 1 - 9 years
F3	Possible	An event occurring in the range once every 10 operating years to once in 100 operating years.	One or more times in 100 years 10 – 99 years
F2	Unlikely	An event occurring in the range less than once in 100 operating years.	One or more times in 1,000 years 100 – 999 years
F1	Remote	Considered to occur less than once in 1,000 operating years (e.g. it may have occurred at a similar site, elsewhere in the world).	Less than once in 1,000 years >1,000 years

Using the assessed notional frequency for the “most likely” and “worst credible” scenarios for each hazard, the probable consequences associated with each were assessed in terms of damage to:

- People - Personal injury, fatality etc.;
- Property – To vessels/infrastructure;
- Environment - Oil pollution etc.; and
- Business - Reputation, economic loss, public relations etc.

The magnitude of each was then assessed using the consequence categories given below. These have been set such that the consequences in respect of property, environment and business have similar monetary outcomes.

Consequence categories and criteria.

Cat.	People	Property	Environment	Business
C1	**Negligible** Possible very minor injury (e.g. bruising)	**Negligible** Costs <£10k	**Negligible** No effect of note. Tier1 may be declared but criteria not necessarily met. Costs <£10k	**Negligible** Costs <£10k
C2	**Minor** (single minor injury)	**Minor** Minor damage Costs £10k – £100k	**Minor** Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity Costs £10K–£100k	**Minor** Bad local publicity and/or short-term loss of revenue Costs £10k – £100k
C3	**Moderate** Multiple minor or single major injury	**Moderate** Moderate damage Costs £100k - £1M	**Moderate** Tier 2 spill criteria reached but capable of being limited to immediate area within site Costs £100k -£1M	**Moderate** Bad widespread publicity Temporary suspension of operations or prolonged restrictions at port Costs £100k - £1M
C4	**Major** Multiple major injuries or single fatality	**Major** Major damage Costs £1M -£10M	**Major** Tier 3 criteria reached with pollution requiring national support. Chemical spillage or small gas release Costs £1M - £10M	**Major** National publicity, Temporary closure or prolonged restrictions on port operations Costs £1M -£10M
C5	**Catastrophic** Multiple fatalities	**Catastrophic** Catastrophic damage Costs >£10M	**Catastrophic** Tier 3 oil spill criteria reached. International support required. Widespread shoreline contamination. Serious chemical or gas release. Significant threat to environmental amenity. Costs >£10M	**Catastrophic** International media publicity. Port closes. Operations and revenue seriously disrupted for more than two days. Ensuing loss of revenue. Costs >£10M

Hazard Data Review Process

Frequency and consequence data was assessed for each hazard drawing initially on the knowledge and expertise of the Marico Marine specialists. This was subsequently influenced by the views and experience of the many stakeholders, whose contribution was greatly appreciated, as well as historic incident where available. It should be noted that the hazards were scored on the basis of the "status quo" i.e. with all existing mitigation measures taken into consideration. The outcome of this process was then checked for consistency against the assessments made in previous and similar risk assessments.

Having decided in respect of each hazard which frequency and consequence criteria are appropriate for the four consequence categories in both the "most likely" and "worst credible" scenarios, eight risk scores were obtained using the following matrix.

Risk factor matrix used for hazard assessment.

Consequences	Cat 5	5	6	7	8	10
	Cat 4	4	5	6	7	9
	Cat 3	3	3	4	6	8
	Cat 2	1	2	2	3	6
	Cat 1	0	0	0	0	0
	Frequency	**>1,000 years**	**100-1,000 years**	**10-100 years**	**1 to 10 years**	**Yearly**

Where:

Risk Number	*Risk*
0 to 1.9	*Negligible*
2 to 3.9	*Low Risk*
4 to 6.9	*As Low as Reasonably Practical*
7 to 8.9	*Significant Risk*
9 to 10.0	*High Risk*

It should be noted that occasionally, a "most likely" scenario will generate a higher risk score than the equivalent "worst credible" scenario; this is due to the increased frequency often associated with a "most likely" event. For example, in the case of a large number of small contact events, the total damage might be of greater significance than a single heavy contact at a much lesser frequency.

Hazard Ranking

The risk scores obtained from the above process were then analysed further to obtain four indices for each hazard as follows:

- The average risk score of the four categories in the "most likely" set;
- The average risk score of the four categories in the "worst credible" set;
- The maximum risk score of the four categories in the "most likely" set; and
- The maximum risk score of the four categories in the "worst credible" set.

These scores were then combined in Marico Marine's hazard management software "HAZMAN" to produce a single numeric value representing each 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" with the highest risk hazards prioritised at the top.

Mitigation

Mitigation measures that could be employed to reduce the likelihood or consequence of the hazards occurring are then identified.

Annex C Hazard Logs

Hazard ID	Area	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely					Worst Credible					Overall Risk
								People	Property	Environment	Stakeholders	Frequency	People	Property	Environment	Stakeholders	Frequency	
1	Victoria Channel and Dock System	Collision	Collision between Tug and Towed Vessel	Whilst towing, tug collides with commercial vessel it is contracted to tow in harbour approaches.	Pilot/Master/tug skipper error; Poor visibility; Adverse weather; Mechanical failure; Equipment failure.	Minor damage to one or both vessels. Minor Injury	One or more vessel hull breached and water ingress; Possible loss of vessel(s); Fire; Multiple Fatalities; Loss of revenue; Pollution.	2	1	1	1	4	5	4	4	4	2	3.85
2	Victoria Channel and Dock System	Collision	Collision between Tug/Towed Vessel and a 3rd Party Commercial Vessel	Whilst towing, tug and/or vessel being towed in collision with third party commercial vessel in harbour approaches	Pilot/Master/tug skipper error; Inappropriate speed; Poor visibility; Adverse weather; Mechanical failure; Equipment failure.	Minor damage to commercial vessel; Minor injuries.	Commercial vessel hull breached and water ingress; Moderate damage to tug and/or vessel being towed; Possible loss of vessel; Multiple Fatality; Serious injuries; Loss of revenue; Pollution.	2	2	1	2	3	5	4	4	4	2	3.82
3	Victoria Channel and Dock System	Collision	Collision between Tug/Towed Vessel and a 3rd Party Non-Commercial Vessel	Whilst towing, tug and/or non-commercial vessel being towed in collision each other in harbour approaches	Pilot/Master/tug/yacht skipper error; Inappropriate speed; Poor visibility; Adverse weather; Mechanical failure; Equipment failure.	Minor damage to non-commercial vessel; Minor injuries.	Non-commercial vessel hull breached and water ingress; Moderate damage to tug and/or vessel being towed; Possible loss of vessel; Fatality; Serious injuries; Loss of revenue; Pollution.	3	1	1	2	3	4	3	2	4	2	3.69
4	Victoria Channel	Grounding	Tug (push/pull mode) and/or towed vessel grounding	Tug (push/pull mode) and/or vessel towed grounds during towing operations.	Navigational error Inappropriate speed; Failure to monitor navigational warnings; Mechanical defect tug or vessel; Inaccurate charts; Heavy weather Underwater obstruction	Tug and/or vessel refloated with minor damage	Damage to rudders / propellers. Hull breach and water ingress. Tug and/or vessel stranded Pollution Loss of revenue Possible multiple injuries	2	2	1	1	3	5	4	4	4	2	3.67
5	Dock System	Grounding	Tug (push/pull mode) and/or towed vessel grounding	Tug (push/pull mode) and/or vessel towed grounds during towing operations.	Navigational error Inappropriate speed; Failure to monitor navigational warnings; Mechanical defect tug or vessel; Inaccurate charts; Heavy weather Underwater obstruction	Tug and/or vessel refloated with minor damage	Damage to rudders / propellers. Hull breach and water ingress. Tug and/or vessel stranded Pollution Loss of revenue Possible multiple injuries	1	1	1	1	4	5	4	4	4	2	2.76
6	Dock System	Contact	Contact with moored 3rd party commercial vessel	Whilst under tow, tug and/or vessel being towed/pushed contacts 3rd party commercial vessel on adjacent berth.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor hull damage to one or more vessels.	Vessel(s) hull breached and water ingress; Possible loss of vessel(s); Possible serious injuries; Loss of revenue; Pollution.	1	1	1	1	4	4	4	3	4	2	2.34

Hazard ID	Area	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely					Worst Credible					Overall Risk
								People	Property	Environment	Stakeholders	Frequency	People	Property	Environment	Stakeholders	Frequency	
7	Dock System	Contact	Contact with moored 3rd party non-commercial vessel	Whilst under tow, tug and/or vessel being towed/pushed contacts 3rd party non-commercial vessel on adjacent berth/mooring.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor hull damage to both non-commercial vessel.	Non-commercial vessel hull breached and water ingress; Possible loss of non-commercial vessel; Moderate damage to tug / vessel being towed/pushed; Possible serious injuries; Loss of revenue; Pollution.	1	1	1	1	3	4	3	2	4	2	2.15
8	Dock System	Contact	Contact with infrastructure	Whilst under tow, tug and/or vessel being towed/pushed contacts berth / (dry) dock entrance/ infrastructure.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor hull damage to both tug and/or vessel being towed/pushed. Damage to infrastructure or fendering;	Tug / vessel hull breached and water ingress; Major damage to tug/vessel being towed/pushed; Possible serious injuries; Loss of revenue; Pollution.	2	2	1	2	5	5	4	3	4	1	4.87
9	Victoria Channel	Contact	Contact with Nav Aid	Whilst under tow, tug and/or vessel being towed/push contacts floating nav/aid.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor damage to nav/aid	Major damage to nav/aid; Minor damage to tug and/or vessel being towed.	1	2	1	1	4	2	3	2	2	2	2.53
10	Victoria Channel and Dock System	Swamping & Foundering	Tug Capsize/ Swamping	Whilst undertaking towage operations conventional tug capsizes.	Pilot/Master/tug skipper error; Girding/ girting; ER doors open; Inappropriate speed Equipment failure; Inappropriate setting of engine room valves.	Quick release gear activated successfully; Minor damage to vessel/equipment; Minor injuries.	Quick release gear fails to operate; Loss of tug; Loss of major items of equipment; Crew injuries or fatalities; Loss of revenue.	1	1	1	1	4	5	4	4	4	3	3.30
11	All	Personal Injury (crew safety)	Personal injury to crew member(s) during towage operations.	Man over-board; Tow-line parts; Towline incident during connection/ disconnection.	Pilot/Master/tug skipper error; Vessel movement; Heavy weather; Lack of PPE Safety equipment failure.	Minor injury.	Major Injury or fatality.	2	1	1	1	4	4	1	1	4	3	3.31

Rank	Hazard Ref.	Affected Areas	Accident Category	Hazard Title	Hazard Detail	Possible Causes	Consequence Descriptions		Risk By Consequence Category								Risk Overall
									ML				WC				
							Most Likely (ML)	Worst Credible (WC)	Environment	People	Property	Stakeholders	Environment	People	Property	Stakeholders	
1	8	Dock System	Contact	Contact with infrastructure	Whilst under tow, tug and/or vessel being towed/pushed contacts berth / (dry) dock entrance/ infrastructure.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor hull damage to both tug and/or vessel being towed/pushed. Damage to infrastructure or fendering;	Tug / vessel hull breached and water ingress; Major damage to tug/vessel being towed/pushed; Possible serious injuries; Loss of revenue; Pollution.	0	6	6	6	3	5	4	4	4.87
2	1	Dock System, Victoria Channel	Collision	Collision between Tug and Towed Vessel	Whilst towing, tug collides with commercial vessel it is contracted to tow in harbour approaches.	Pilot/Master/tug skipper error; Poor visibility; Adverse weather; Mechanical failure; Equipment failure.	Minor damage to one or both vessels. Minor Injury	One or more vessel hull breached and water ingress; Possible loss of vessel(s); Fire; Multiple Fatalities; Loss of revenue; Pollution.	0	3	0	0	5	6	5	5	3.85
3	2	Dock System, Victoria Channel	Collision	Collision between Tug/Towed Vessel and a 3rd Party Commercial Vessel	Whilst towing, tug and/or vessel being towed in collision with third party commercial vessel in harbour approaches	Pilot/Master/tug skipper error; Inappropriate speed; Poor visibility; Adverse weather; Mechanical failure; Equipment failure.	Minor damage to commercial vessel; Minor injuries.	Commercial vessel hull breached and water ingress; Moderate damage to tug and/or vessel being towed; Possible loss of vessel; Multiple Fatality; Serious injuries; Loss of revenue; Pollution.	0	2	2	2	5	6	5	5	3.82
4	3	Dock System, Victoria Channel	Collision	Collision between Tug/Towed Vessel and a 3rd Party Non-Commercial Vessel	Whilst towing, tug and/or non-commercial vessel being towed in collision each other in harbour approaches	Pilot/Master/tug/yacht skipper error; Inappropriate speed; Poor visibility; Adverse weather; Mechanical failure; Equipment failure.	Minor damage to non-commercial vessel; Minor injuries.	Non-commercial vessel hull breached and water ingress; Moderate damage to tug and/or vessel being towed; Possible loss of vessel; Fatality; Serious injuries; Loss of revenue; Pollution.	0	4	0	2	2	5	3	5	3.69
5	4	Victoria Channel	Grounding	Tug (push/pull mode) and/or towed vessel grounding	Tug (push/pull mode) and/or vessel towed grounds during towing operations.	Navigational error Inappropriate speed; Failure to monitor navigational warnings; Mechanical defect tug or vessel; Inaccurate charts; Heavy weather Underwater obstruction	Tug and/or vessel refloated with minor damage	Damage to rudders / propellers. Hull breach and water ingress. Tug and/or vessel stranded Pollution Loss of revenue Possible multiple injuries	0	2	2	0	5	6	5	5	3.67
6	11	Dock System, Victoria Channel	Personal Injury	Personal injury to crew member(s) during towage operations.	Man over-board; Tow-line parts; Towline incident during connection/ disconnection.	Pilot/Master/tug skipper error; Vessel movement; Heavy weather; Lack of PPE Safety equipment failure.	Minor injury.	Major Injury or fatality.	0	3	0	0	0	6	0	6	3.31
7	10	Dock System, Victoria Channel	Swamping & Foundering	Tug Capsize/ Swamping	Whilst undertaking towage operations conventional tug capsizes.	Pilot/Master/tug skipper error; Girding/ girting; ER doors open; Inappropriate speed Equipment failure; Inappropriate setting of engine room valves.	Quick release gear activated successfully; Minor damage to vessel/equipment; Minor injuries.	Quick release gear fails to operate; Loss of tug; Loss of major items of equipment; Crew injuries or fatalities; Loss of revenue.	0	0	0	0	6	7	6	6	3.3
8	5	Dock System	Grounding	Tug (push/pull mode) and/or towed vessel grounding	Tug (push/pull mode) and/or vessel towed grounds during towing operations.	Navigational error Inappropriate speed; Failure to monitor navigational warnings; Mechanical defect tug or vessel; Inaccurate charts; Heavy weather Underwater obstruction	Tug and/or vessel refloated with minor damage	Damage to rudders / propellers. Hull breach and water ingress. Tug and/or vessel stranded Pollution Loss of revenue Possible multiple injuries	0	0	0	0	5	6	5	5	2.76
9	9	Victoria Channel	Contact	Contact with Nav Aid	Whilst under tow, tug and/or vessel being towed/push contacts floating nav/aid.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor damage to nav/aid	Major damage to nav/aid; Minor damage to tug and/or vessel being towed.	0	0	3	0	2	2	3	2	2.53

Rank	Hazard Ref.	Affected Areas	Accident Category	Hazard Title	Hazard Detail	Possible Causes	Consequence Descriptions		Risk By Consequence Category								Risk Overall
									ML				WC				
							Most Likely (ML)	Worst Credible (WC)	Environment	People	Property	Stakeholders	Environment	People	Property	Stakeholders	
10	6	Dock System	Contact	Contact with moored 3rd party commercial vessel	Whilst under tow, tug and/or vessel being towed/pushed contacts 3rd party commercial vessel on adjacent berth.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor hull damage to one or more vessels.	Vessel(s) hull breached and water ingress; Possible loss of vessel(s); Possible serious injuries; Loss of revenue; Pollution.	0	0	0	0	3	5	5	5	2.34
11	7	Dock System	Contact	Contact with moored 3rd party non-commercial vessel	Whilst under tow, tug and/or vessel being towed/pushed contacts 3rd party non-commercial vessel on adjacent berth/mooring.	Mechanical failure; leading to loss of control; Inappropriate speed; Pilot/Master/tug skipper error; Adverse weather; Navigational error.	Minor hull damage to both non-commercial vessel.	Non-commercial vessel hull breached and water ingress; Possible loss of non-commercial vessel; Moderate damage to tug / vessel being towed/pushed; Possible serious injuries; Loss of revenue; Pollution.	0	0	0	0	2	5	3	5	2.15