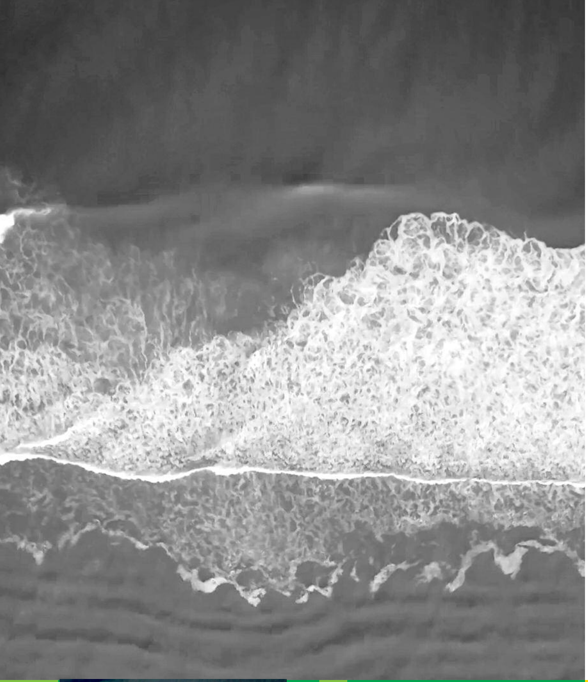

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Greater Tortue / Ahmeyim
Phase 1 Gas Production Project

Environmental and Social Impact Assessment

Consolidated Final Report Including Regulatory Reviews from Mauritania and Senegal

June 2019

Volume 3 of 7

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The report on the environmental and social impact assessment for the Greater Tortue/Ahmeyim Phase 1 Gas Production Project is divided into 7 volumes as follows:

Volume 1: The Non-Technical Summary, the list of Main Contributors to the ESIA, the Table of Contents, the list of Abbreviations and Acronyms, as well as Chapters 1 to 6

Volume 2: Chapter 7

Volume 3: Chapters 8 to 11 as well as the Bibliography and References

Volume 4: Appendices A to J

Volume 5: Appendices K to O

Volume 6: Appendices P to R

Volume 7: Appendices S to Y

The present document is **Volume 3** which contains:

- Chapter 8 - Risk Study and Occupational Risk Assessment
- Chapter 9 - Environmental and Social Management Plan
- Chapter 10 - Surveillance and Monitoring Plan
- Chapter 11 - Conclusion
- Bibliography and References

CHAPTER 8: RISK STUDY AND OCCUPATIONAL RISK ASSESSMENT

8.0 RISK STUDY AND OCCUPATIONAL RISK ASSESSMENT

8.1 Introduction and Approach

8.1.1 Background, Purpose and Scope

As part of the scope of the Environmental and Social Impact Assessment (ESIA) for the Greater Tortue/Ahmeyim Phase 1 (GTA Phase 1) Project, a Risk Study and Occupational Risk Assessment (*Étude de danger (EDD) et analyse des risques professionnels*) was conducted to identify and assess health, safety, security and environmental (HSSE) accident hazards and associated risks. The Risk Study and Occupational Risk Assessment forms an integral part of the ESIA, in accordance with the approved terms of reference provided in Appendix A, and in accordance with the Republic of Senegal (2005) Risk Study Guide (République du Sénégal Guide d'étude de danger,) While Mauritania has no such guide, the Risk Study in this chapter fully considers potential risks in both countries.

The purpose of the Risk Study and Occupational Risk Assessment is to:

- Detail the studies undertaken by the operator to:
  - o Identify and assess the accident hazards and risks associated with the GTA Phase 1 Project facilities and operations. Sources of accident hazards may be located within or outside boundary limits of the Project facilities.
  - o Evaluate the extent and severity of consequences associated with identified major accidents.
  - o Provide basis and justification for in-place, or to-be-implemented technical safety barriers and equipment designed to reduce the level of risks for people and the environment.
- Where relevant, identify additional measures and improvements for prevention, control and mitigation of accidents to reduce risk.
- Inform facilities personnel and other stakeholders of the main accident hazards and risks, along with the means through which they are managed.
- Provide a basis to define safe zoning areas around facilities. Within these areas, future third party development and activities shall be managed to minimise the effects and risk associated with major accidents

The Risk Study and Occupational Risk Assessment is an important part of the process for understanding and managing accident hazards and risks associated with GTA Phase 1 Project facilities and operations. However, in addition to the Risk Study and Occupational Risk Assessment, and its supporting analyses, further detailed assessment of facilities accident hazards and risks is ongoing as part of the GTA Phase 1Project design process. These assessments, along with the development of an overarching HSSE Case will provide input and justification for design safety requirements and major accident event design accidental loads (DAL). Risk assessment and management activities undertaken during the design process also provide early input into facilities layout and design, and are an integral part of ensuring risks are reduced to as low as reasonably practicable (ALARP). Reducing risks to ALARP involves balancing reduction in risk against the time, trouble, difficulty and cost of achieving it. In any assessment of whether risks are ALARP, measures to reduce risk can only be ruled out if the sacrifice involved in taking them is grossly disproportionate to the benefits of risk reduction.

The operations and facilities included within the scope of the Risk Study and Occupational Risk Assessment comprise:

- Development well drilling and completion with the Ensco Drillship DS-12 drillship, or similar drillship
- Subsea production facilities and gas pipeline
- Gas pre-processing at a floating production, storage and offloading facility (FPSO)

- Liquefied natural gas (LNG) production at the Near Shore Hub/Terminal including the breakwater, a riser platform and trestle structure, floating liquefied natural gas production and storage facility (the FLNG), a quarters utility (QU) platform, a liquefied natural gas carrier (LNGC) berth and associated offloading facilities, and crew boat landing dock
- Support operations areas (supply bases in the Port of Dakar and the Port of Nouakchott).

A significant focus for the Risk Study and Occupational Risk Assessment is major hazards; specifically process safety hazards (i.e., hazards involving significant quantities of flammable or explosive materials, and/or acutely toxic inventories); hazardous events with the potential for multiple fatality; significant spills; and/or far field effects.

However, it also addresses occupational health and safety hazards and risks; specifically, personal safety hazards and hazardous events with the potential for injury, illness and/or limited localised fatality. This includes risks during offshore construction, installation, and decommissioning.

With respect to the Ensco DS-12, the drillship has a Health, Safety and Environment (HSE) Case (Atwood Oceanics. 2016), developed in accordance with International Association of Drilling Contractors (IADC. 2010) HSE Case Guidelines. These guidelines include the requirement for detailed assessment of all HSE hazards and risks. As a result, the HSE Case and supporting studies were used as a basis for the assessment of drillship related accident hazards and risks.

The Risk Study and Occupational Risk Assessment is supported by two appendices comprising key supporting documentation as follows:

- Appendix N-2
  - GTA Phase 1 Project Consequence Modelling Report
- Appendix O
  - A register of products that will be handled during the project, and the associated hazards – Hazardous Substance and Materials Register
  - Analysis and risk ranking of potential major accident hazards and risks – Preliminary Risk Analysis Worksheets
  - Bowtie analysis for major accident events with severity ranking Critical (4) in the preliminary risk analysis – Bowtie Diagrams (Severity Ranking 4)
  - Analysis and risk ranking for occupational hazards and risks – Occupational Risk Analysis Worksheets
  - Example Bowtie diagram with fault tree and event tree logic built into the branches – Fault/Event Tree Bowtie Approach Example (D-01 Blowout or Well Release)

8.1.2 Approach in Assessing Hazards and Risks

The overall approach followed in the Risk Study and Occupational Risk Assessment in assessing accident hazards and risks is illustrated by Figure 8-1. It follows accepted industry practice and standards, including:

- Republic of Senegal (2005) Risk Study Guide
- European Union (EU) rules for onshore and offshore hazard assessment (EU, 2012), (EU. 2013)
- International Standards Organisation (ISO) guidelines for major accident hazard management during the design of new installations (ISO. 2016)
- IADC (2010) HSE Case Guidelines

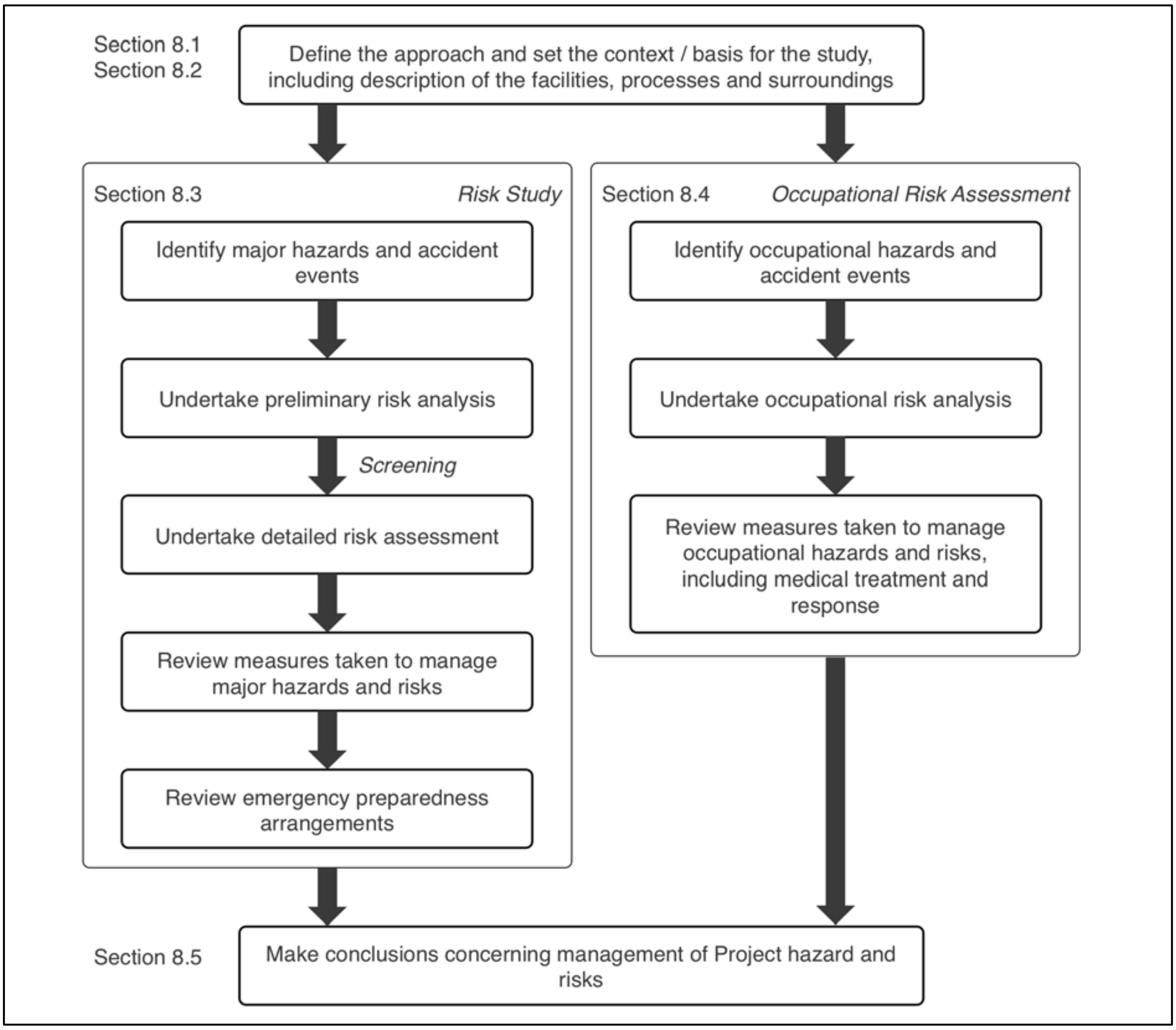


Figure 8-1. Risk Study and Occupational Risk Assessment Approach.

8.1.2.1 Set Context

The context for the Risk Study and Occupational Risk Assessment involved the review and understanding of GTA Phase 1 Project key requirements and information including:

- Mauritania and Senegal regulatory requirements, expectation and guidelines
- BP corporate requirements
- Relevant and accepted codes, standards, and industry good practice
- Facilities location, layout and design aspects, operations and HSSE design philosophies
- The host environment

The context was used to develop detailed requirements and work scopes for the Risk Study and Occupational Risk Assessment.

8.1.2.2 Risk Study

8.1.2.2.1 Identification of Major Hazards

The foundation for assessing GTA Phase 1 Project major hazards and risks involved a thorough and systematic process to identify major hazards and associated accident events. This was achieved through review of past major accident and incidents, review of project hazard identification workshops (BP. 2017a), (BP, KBR. 2017a), (BP, KBR. 2017b), (KBR. 2016), review of hazards on similar facilities, identification of major hazard inventories, and use of industry standard hazard checklists (ISO. 2016).

Identified major hazards and accident events were recorded in a Hazard Register (Goddard. 2018a).

8.1.2.2.2 Preliminary Risk Analysis

Following hazard identification, a preliminary risk analysis was undertaken. This was used to:

- Provide an initial qualitative estimate of major hazard risk levels
- Screen and define the listing of major accident events requiring further detailed analysis, specifically quantification of consequences and risks

Analysis and ranking of major accident event risk in the preliminary risk analysis was based on the risk matrix given in the Republic of Senegal (2005) Risk Study Guide.

8.1.2.2.3 Detailed Risk Analysis

Following on from the preliminary risk analysis, more detailed analysis of major accident events was then undertaken through assessment of specific consequence effect distances, Bowtie analysis, and calculation of risk levels.

For accident events involving major hazard inventories, detailed release, dispersion, fire and explosion modelling was performed to determine likely and realistic worst-case consequence effects. Modelling utilised Senegal (République du Sénégal. 2005) and other industry established and accepted threshold values for consequence effects (Oil and Gas Producers (OGP). 2010).

Bowtie analysis was then undertaken to assess and verify that suitable and sufficient prevention, control and mitigation measures are in place (or are planned) to manage major accident event risk.

Finally, risks were quantified and assessed against industry established and accepted risk tolerability criteria (UK HSE. 2001), (UK HSE. 2014), (New South Wales (NSW) Government Planning and Infrastructure, 2011), (European Maritime Safety Agency. 2013).

8.1.2.2.4 Measures Taken to Manage Major Hazards and Risks

Following detailed analysis of major hazard risk, review and documentation of key hazard management processes and facilities, including key design engineering and operational controls, was undertaken. This included:

- Major hazard management requirements and processes through the Preparation phase of the project
- Operational safety and environmental management systems
- Management of safety and environmental critical equipment
- Specific control and mitigation measures

8.1.2.2.5 Emergency Preparedness Arrangements

In addition to the review of measures taken to manage major hazards, review and documentation of emergency preparedness in the unlikely event a major accident were to occur, was undertaken. This included documentation of the overall organisational structure in place to respond to the emergency, as well key plans, requirements, and response activities.

8.1.2.3 Occupational Risk Assessment

8.1.2.3.1 Identification of Occupational Hazards

The foundation for assessing GTA Phase 1 Project occupational hazards and risks involved a thorough and systematic process to identify facilities occupational hazards and associated accident events. This was achieved through review of project hazard identification workshops (KBR. 2016), (BP, KBR. 2017a), (BP, KBR. 2017b), review of hazards on similar facilities, identification of products that will be handled during the project and associated hazards, and use of industry standard hazard checklists.

Identified occupational hazards and accident events were recorded in a Hazard Register (Goddard. 2018a).

8.1.2.3.2 Occupational Risk Analysis

Following hazard identification, an occupational risk analysis was undertaken. The focus of this analysis was occupational health and safety hazards, and associated accident events. The occupational risk analysis was used to:

- Provide a qualitative estimate of occupational risk levels
- Assess and verify that suitable and sufficient prevention, control and mitigation measures are in place (or are planned) to manage personal safety risk

The Republic of Senegal (2005) Risk Study Guide contains a risk matrix whose consequence categories are focused towards significant/major hazards in line with the scope and objectives of the guide. As a result, a different matrix was used for risk ranking was specifically focused on occupational type hazards and risks (Caisse Régionale d'Assurance Maladie des Pays de la Loire, les Services de Santé au Travail du Maine-et-Loire. 2002).

8.1.2.3.3 Measures Taken to Manage Occupational Hazards and Risks

Following analysis of occupational hazard risks, review and documentation of key hazard management processes and facilities, including key design engineering and operational controls, was undertaken. This included:

- Activities undertaken as part of the GTA Phase 1 Project design process to manage occupational hazards and risks during operations
- Management of occupational hazards and risks during operations
- Management occupational hazards and risks during offshore construction and installation
- Emergency preparedness in the event of occupational health and safety illness or injury

8.1.2.4 Conclusions and Recommendations

The final part of the Risk Study and Occupational Risk Assessment details overall conclusions and recommendations. This includes a summary of the main accidental event effects and impacts, along with the main means through the through which hazards and risks are managed.

8.2 Description of Facilities, Processes and Surroundings

8.2.1 Introduction

Section 8.2 provides a description of the facilities, their processes, and the surroundings. These form the basis for the identification hazards and assessment of risk. GTA Phase 1 Project facilities and their operating environment are described in detail in other Chapters of the ESIA, specifically:

- Chapter 2: Description and Justification of the Project
- Chapter 4: Description of the Host Environment

Therefore, to avoid significant repetition, a detailed description of the project facilities and host environment is not repeated. However, a summary of facilities and environmental factors is provided, largely relevant to the general understanding of facilities hazards and risks. This includes:

1) The offshore field layout, main facilities, locations and activities
2) Supply bases
3) Surrounding populations
4) Significant and sensitive ecological areas

8.2.2 Offshore Field Layout, Main Facilities, Locations and Activities

The overall development layout and facilities locations is shown in Figure 8-2. Drilling activities take place approximately 125 km offshore in water depths of approximately 2,700 to 2,800 m. The FPSO is located approximately 40 km offshore in water depths of about 120 m. The Near Shore Hub/Terminal is located approximately 10 km offshore in water depths of about 33 m. Facilities are generally located along with Mauritania Senegal maritime boarder.

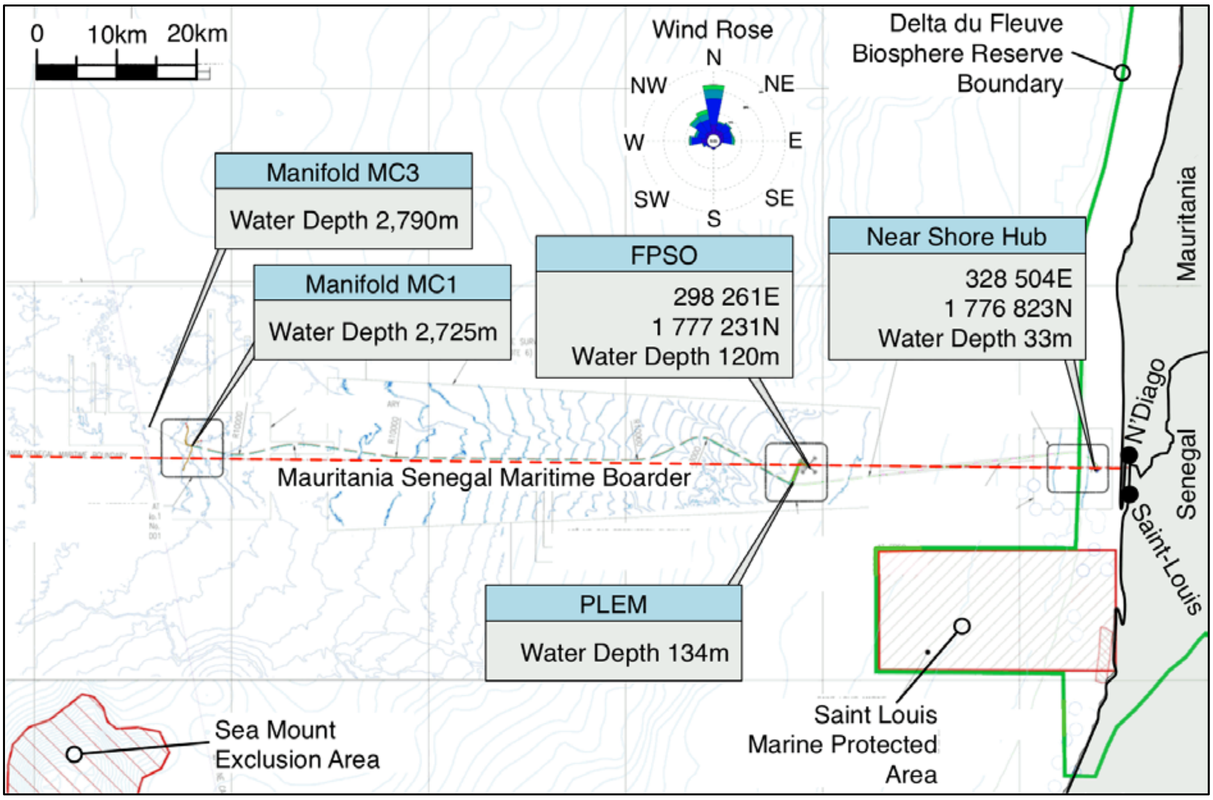


Figure 8-2. Development Layout and Facilities Locations.

Generally, wind speeds are high between November and February and June and August. Winds are lower between March and May and September and October with monthly differences being minor. From January through December 2016, monthly average winds speeds varied from approximately 0.24 m s^{-1} in October to greater than 5 m s^{-1} in December.

In Senegal, the mean temperature along the Grande Côte ranges from 25 °C in Dakar to 27.5 °C in Saint-Louis. Mean temperature in N'Diago in Mauritania is similar to mean temperature in Saint-Louis.

Sea water temperatures are the coolest during March and April due to strong upwelling events. Sea surface temperatures are regionally consistent and highest during August through October ranging from approximately 18 °C to nearly 30 °C.

Waves are predominately from the north and north east with significant wave heights rarely exceeding 3 m.

Ocean currents are predominately west to southwestward movement, due to the influence of the Azores and Canary Current. Based on the HYbrid Coordinate Ocean Model (HYCOM) global circulation model, average monthly surface current velocities are between 0.12 m s^{-1} and 0.27 m s^{-1} with maximum near-surface values of 0.40 m s^{-1}.

8.2.2.1 Overall Production Facilities and Process Flow

Production is from 12 subsea wells tied back to two manifold centres (MC1 and MC3). From the subsea production facilities (Offshore Area), wellfluids are routed to the FPSO for pre-processing. The FPSO separates water, condensate, and gas from the wellfluids. It also recovers monoethylene glycol (MEG) injected at the wellheads.

Condensate is stored in the FPSO hull tanks prior to export via offtake tanker. Gas (primarily methane) is exported from the FPSO to the Near Shore Hub/Terminal via subsea pipeline. Produced water is treated to meet the required standards and disposed of to sea.

At the Near Shore Hub/Terminal, gas is processed by the FLNG, to remove impurities including carbon dioxide (CO_2) and residual water, before being liquefied into LNG. LNG is stored in the FLNG Moss type hull tanks prior to export via LNGC. Fuel gas is taken from the incoming gas supply at the riser platform and used for power generation at the QU platform. The overall process block flow is shown in Figure 8-3.

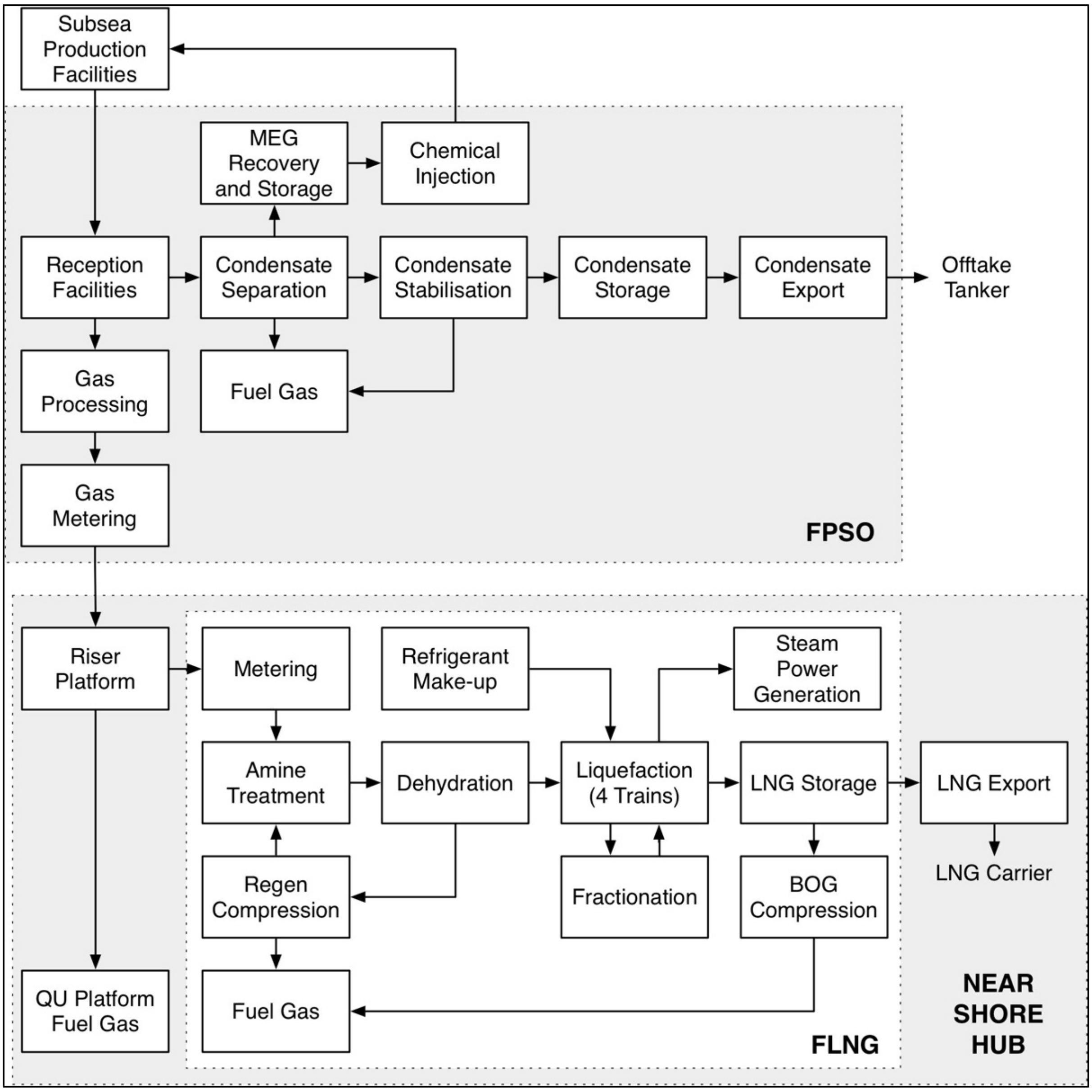


Figure 8-3. Overall Process Block Flow.

Figure 8-4, Figure 8-5, Figure 8-6 and Figure 8-7 then provide a simplified process flow from production wells through LNG export.

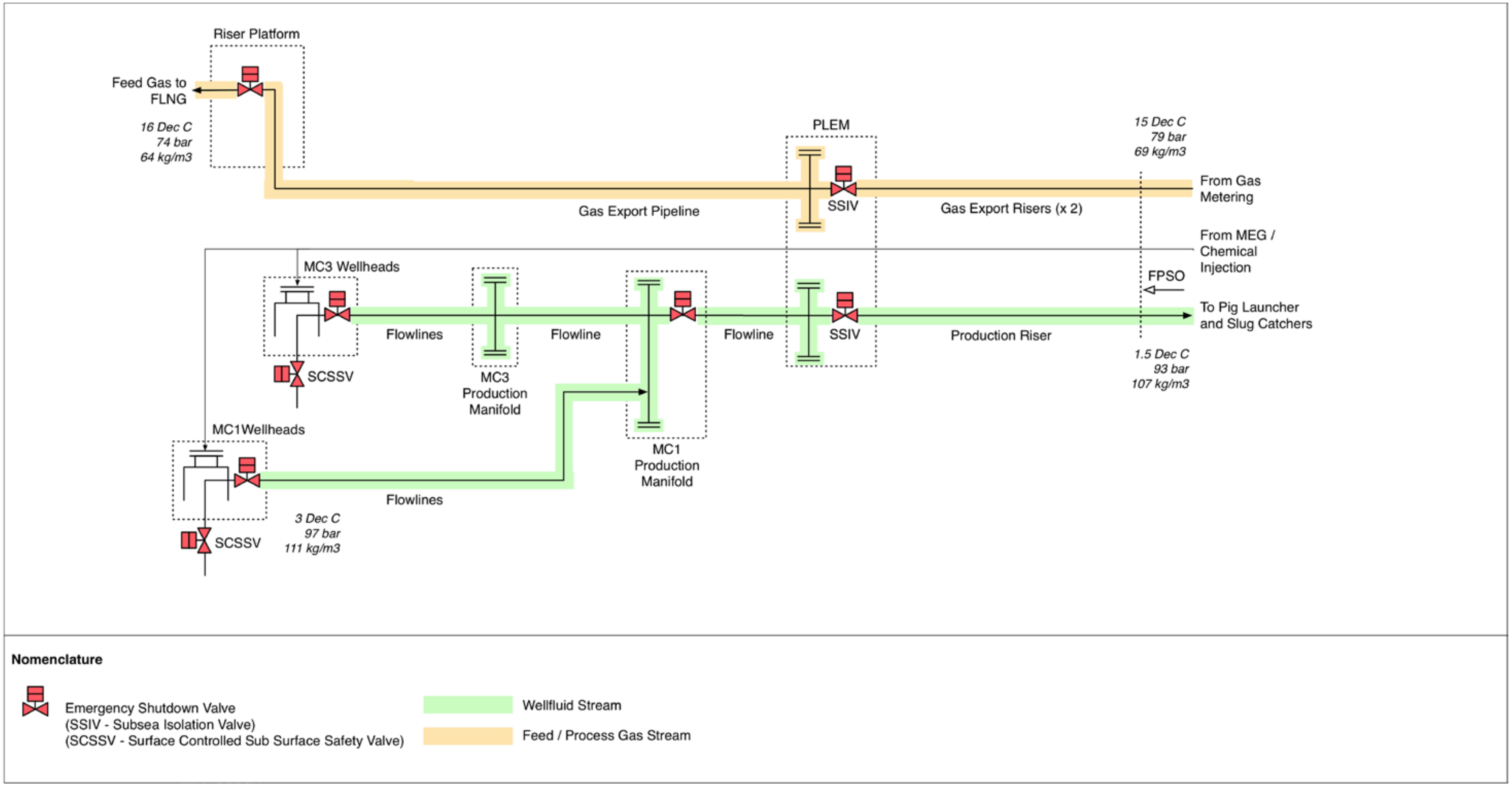


Figure 8-4. Subsea – Simplified Process Flow.

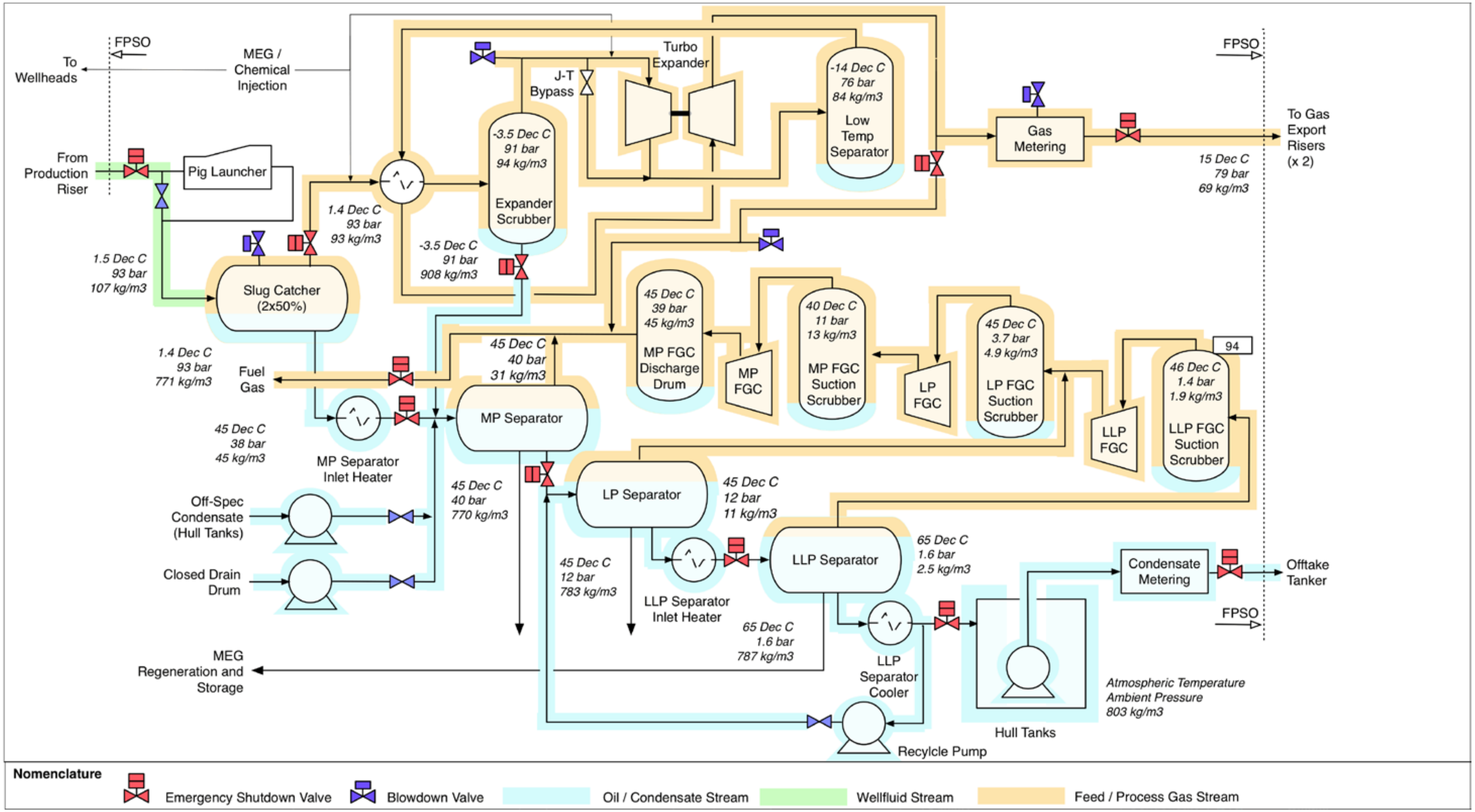


Figure 8-5. FPSO – Simplified Process Flow.

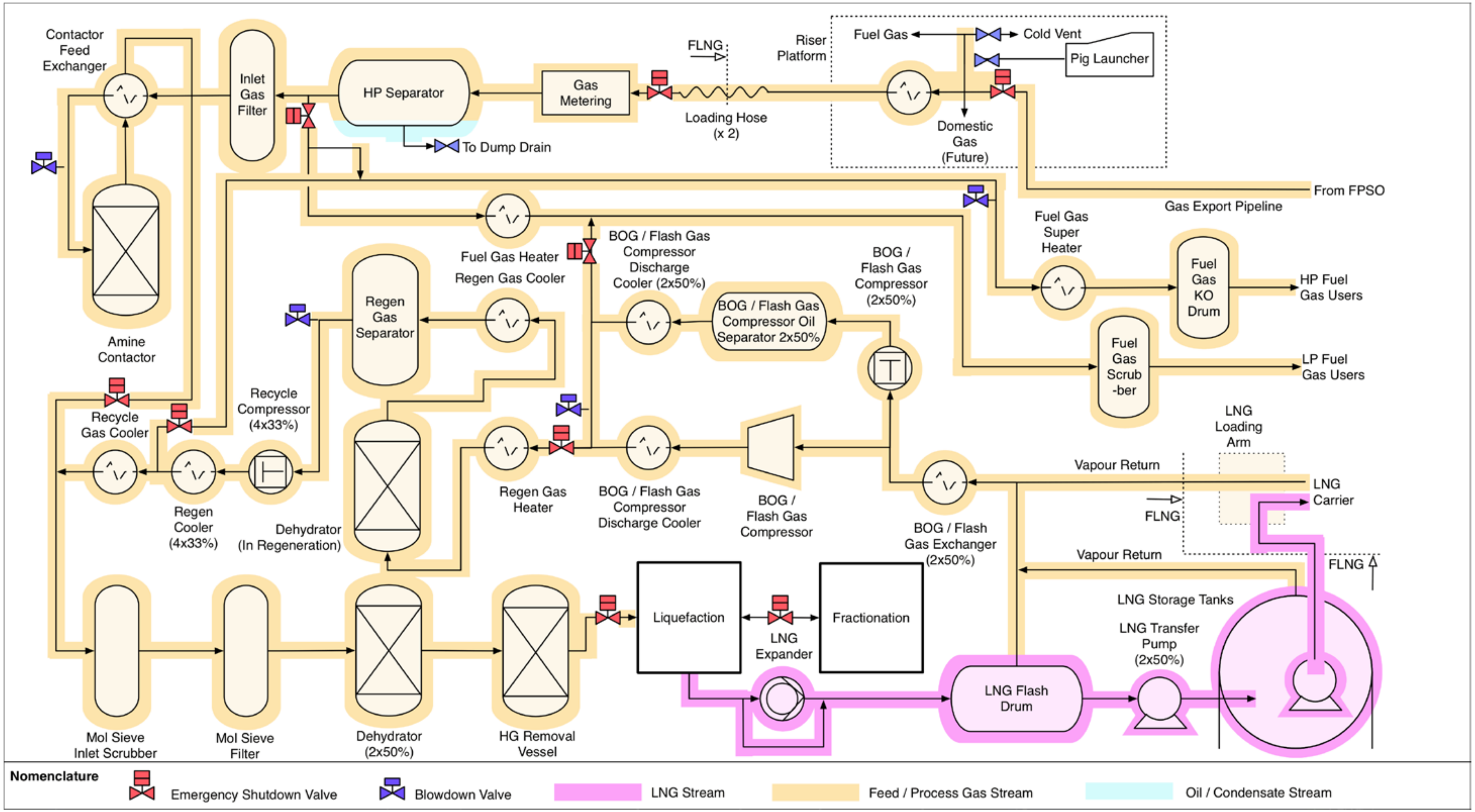


Figure 8-6. FLNG – Simplified Overall Process Flow.

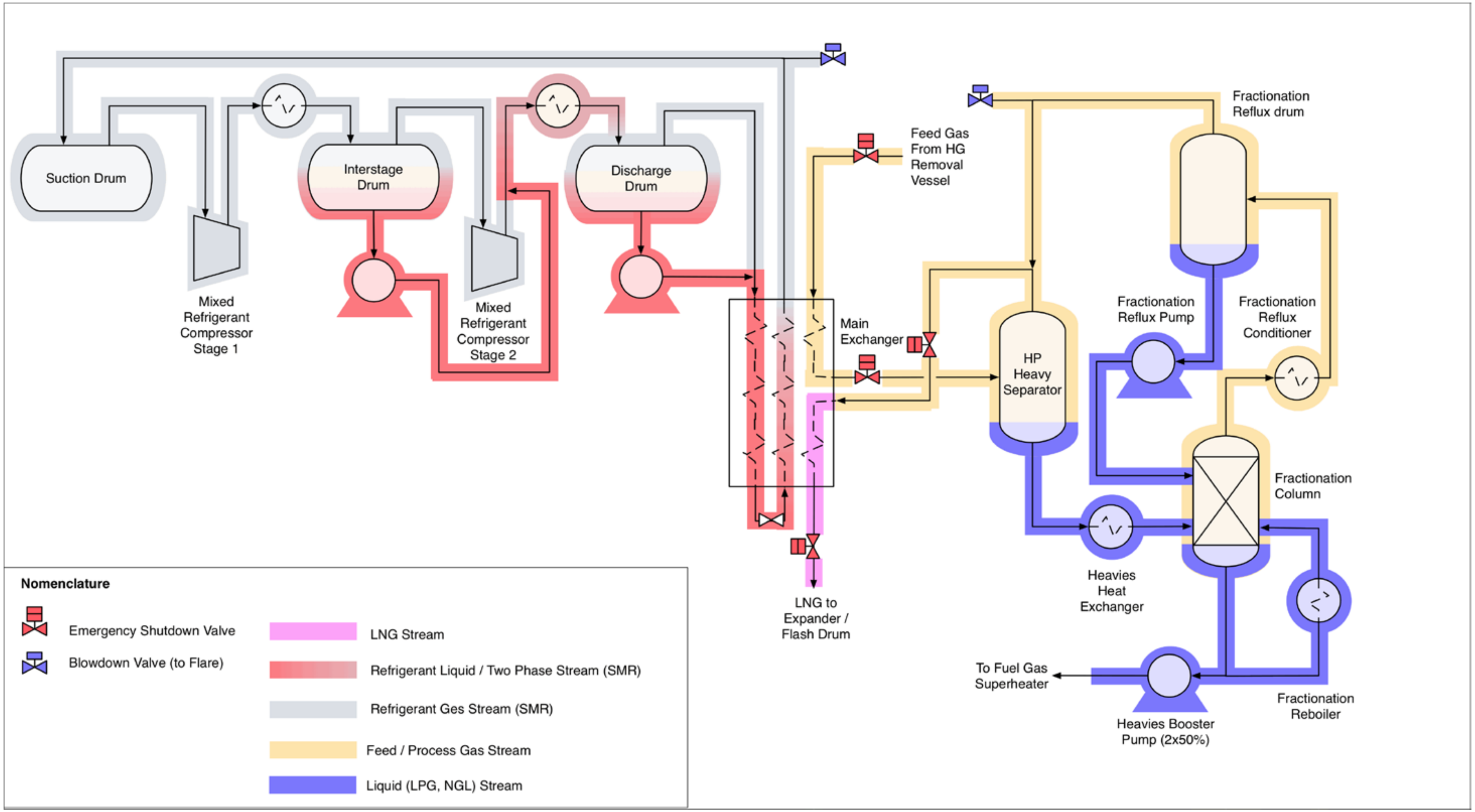


Figure 8-7. FLNG – LNG Liquefaction Simplified Process Flow.

8.2.2.2 Development Drilling and Well Completion

Development drilling and well completion operations for the subsea wells is to be carried out by the Ensco DS-12 drillship, or similar drillship. The Ensco DS-12 is an ultra-deepwater dynamically positioned (DP) drillship, built in 2013 with a 25-year design life. The drillship can operate in water depths up to 12,000 ft (approximately 3,700 m), drilling to a depth of 40,000 ft (approximately 12,000 m). The drillship is capable of exploration, development drilling and work-over operations world-wide.

The vessel is equipped with a 1,250 ton top drive, crown mounted compensator and draw works and four mud pumps. It has dual blowout preventers (BOPs) rated to 15k psi (approximately 1,030 bar) which include two annulars and seven rams each. The BOPs have upgraded capabilities for shearing and subsea intervention.

The drillship is designed for a maximum Personnel on Board (POB) of 200 with typical operating POB of 100 (Atwood Oceanics. 2014a).

The overall layout of the drillship is given in Figure 8-8.

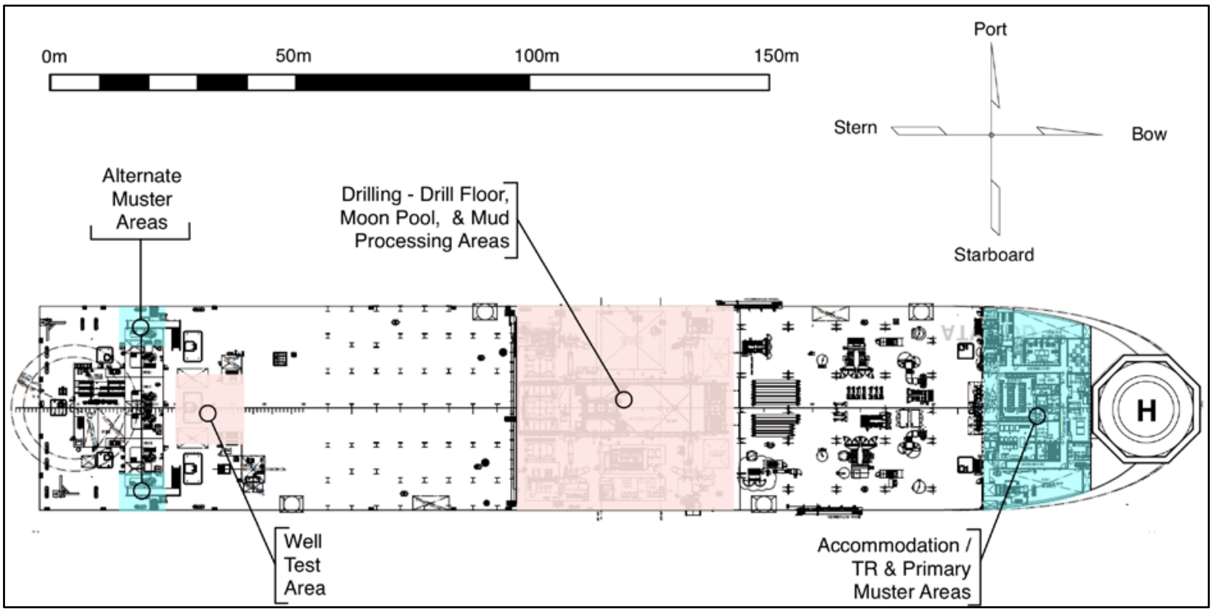


Figure 8-8. Drillship Layout (Typical).

8.2.2.3 Subsea Facilities

The peak wellfluid production rate of 505 million standard cubic feet per day (MMSCFD) comes from 12 subsea wells at two manifold centres.

Wellfluids are routed to the FPSO via 16” production flowline, a pipeline end manifold (PLEM), and 16” flexible riser. Subsea facilities also include:

- MEG injection at the wellheads from the FPSO, via 6” flowline, to prevent wellheads/pipeline hydrate formation
- Subsea pig launchers
- Fibre optic communication lines

Conditioned gas from the FPSO is exported to the Near Shore Hub/Terminal via two 18” flexible risers, the PLEM and a 30” feed gas export pipeline.

Subsea isolation valves (SSIV) are located at the PLEM to provide isolation of flow to the production import riser and two export gas risers on the FPSO. These limit flow and released inventory in case of a major riser leak. The downstream end of the 30” export pipeline at the Near Shore Hub/Terminal is also isolated by a riser boarding valve at the Near Shore Hub/Terminal riser platform.

Fishing/over-trawl protection is provided on all subsea facilities up to a nominal water depth of 1,000 m. This prevents damage from demersal (bottom fishing) commercial trawl gear and typically comprises options of concrete weight coating, trenching and burial, placement of mattresses and/or rock dump. Protection against damage from fishing activities includes subsea structures. These structures are designed to withstand impacts and over-trawl loads from trawl gear and are over-trawlable. Fishing/over-trawl protection also reduces the risk of damage to fishing vessels due to snagging trawl gear.

8.2.2.4 FPSO and Condensate Export Facilities

The FPSO design is based upon a Very Large Crude Carrier (VLCC), double hull, designed for a full-field life of 30 years, and permanently spread moored with a northerly heading.

The living quarters (LQ) onboard the FPSO is sized for a POB of 100 during normal operations, with the capability of being increased to 150 during maintenance periods.

The FPSO topside facilities provide:

- Gas/liquid separation
- Gas conditioning, metering and export
- Condensate processing, stabilisation, storage, metering and export
- Chemical injection
- Water treatment
- MEG recovery and storage

Condensate is stored in hull tanks, with total capacity of 1,020,000 bbls (162,167 m^3) at 98% volume fill levels. The condensate offtake system is located at the bow of the FPSO with the LQ aft (predominately upwind of the process and storage). Mooring with the offtake tanker is carried out with a separation distance of approximately 150 m. Offtakes are carried out via a double carcass floating hose with marine dry breakaway couplings and hose end valve in a tandem mooring arrangement with the offtake tanker. Between one and three tug boats will assist the offtake tanker in maneuvering, hook-up and disconnection during offloading.

The condensate offtake system can offload the total parcel size of approximately 733,000 bbls (116,538 m^3) within 24 hours. Cargo offloads will occur every 65-70 days.

The overall layout of the FPSO is given in Figure 8-9.

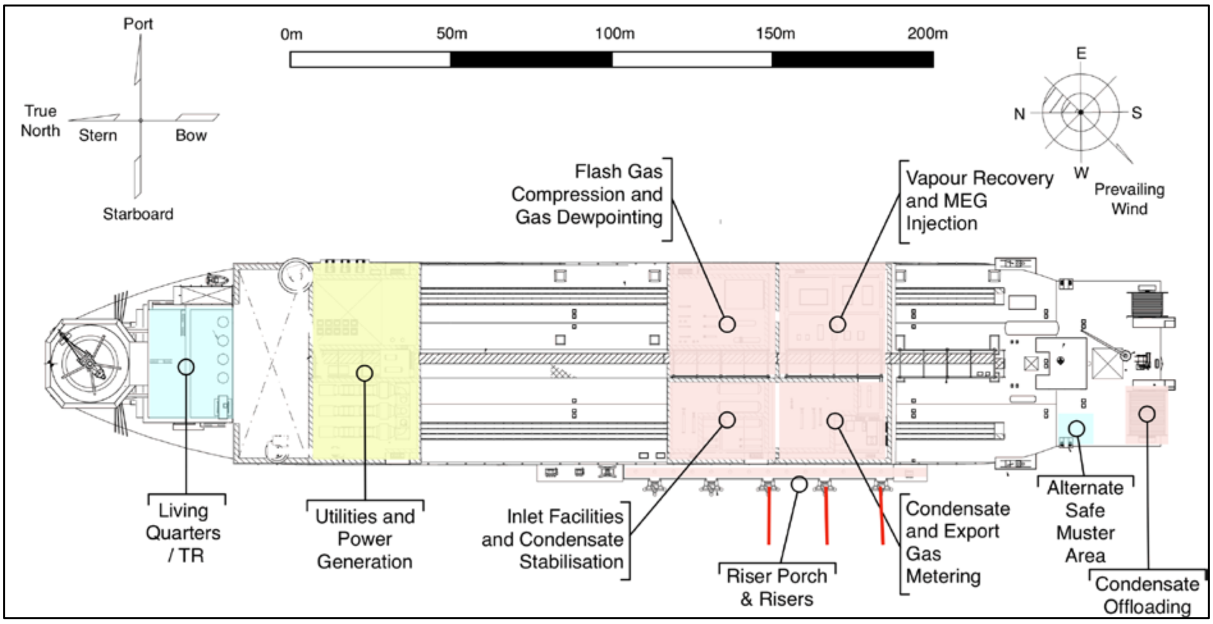


Figure 8-9. FPSO Layout (Typical).

8.2.2.5 Near Shore Hub/Terminal Facilities

8.2.2.5.1 Overall Layout

Near shore LNG processing facilities are situated at a man-made Near Shore Hub/Terminal with a protected breakwater approximately 10 km from shore. Primary facilities include:

- Breakwater (approximately 1,000 m long)
- FLNG vessel
- QU platform
- Hub trestle structure
- LNGC mooring and transfer arrangements
- Riser platform
- Tug boat mooring
- Crew boat mooring and transfer dock

The overall layout of the Near Shore Hub/Terminal is given in Figure 8-10.

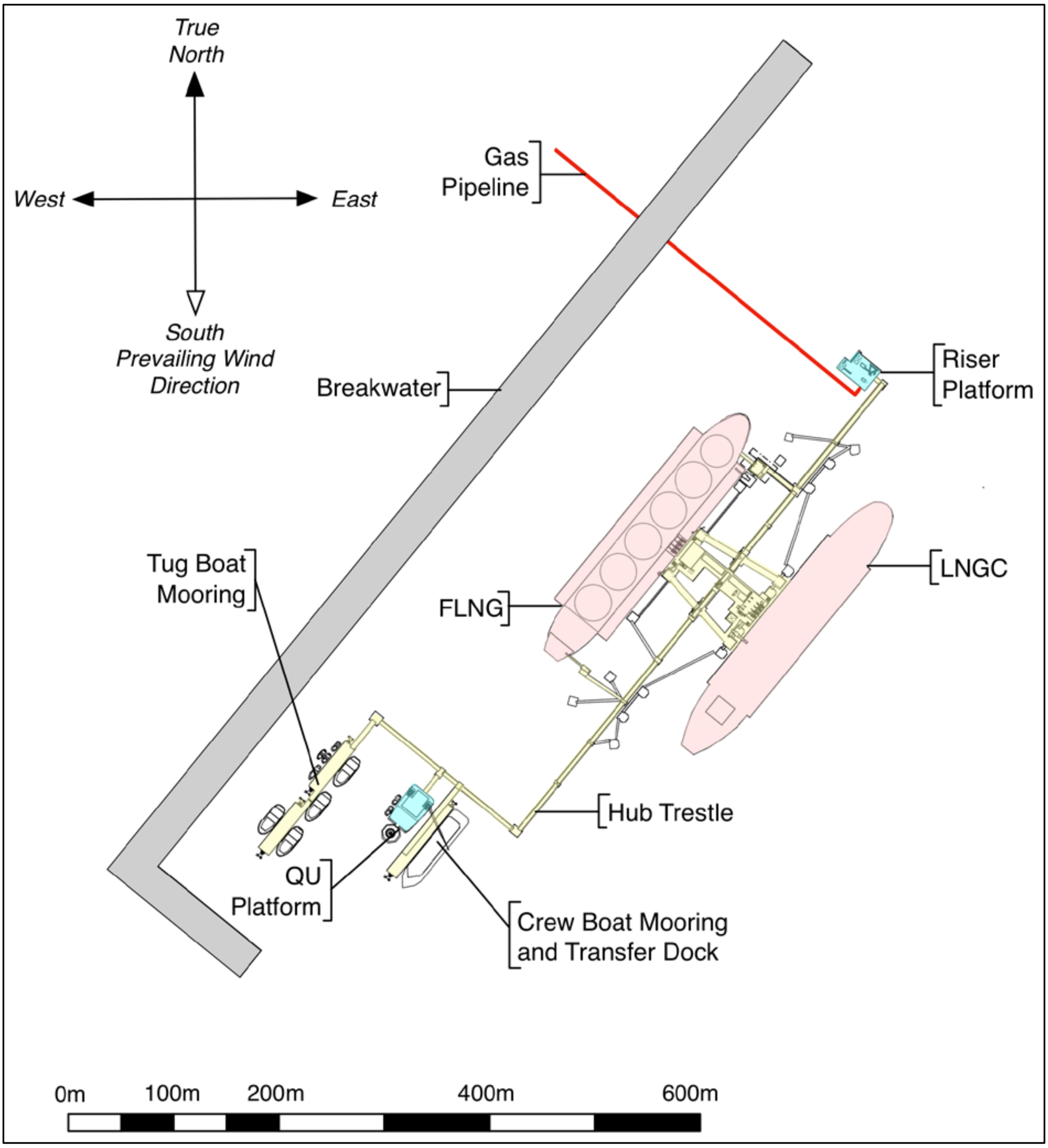


Figure 8-10. Near Shore Hub/Terminal Layout.

8.2.2.5.2 Floating LNG and LNG Carrier

The FLNG is a converted Moss Tanker design with approximately net LNG production capacity (excluding fuel gas and flare consumption) of 2.5 million tons per year.

The FLNG has a crew POB of 50. Crew accommodations are on the QU Platform.

The FLNG topside facilities provide:

- Feed gas metering
- Amine gas treatment
- Fractionation
- Liquefaction (using the PRICO® Single Mixed Refrigerant (SMR) technology)
- Waste heat recovery for FLNG power generation
- LNG export metering

LNG is stored in six Moss spherical hull storage tanks, with total capacity 125,000 m^3 for export via LNGC. The LNGC enters the Near Shore Hub/Terminal under assistance from four tug boats. Once moored, LNG will be exported across the hub trestle via cryogenic pipework and marine loading arms. The LNG export parcel size is expected to be between 125,000 – 180,000 m^3 requiring the LNGC to make two entries to complete loading.

The overall layout of the FLNG is given in Figure 8-11.

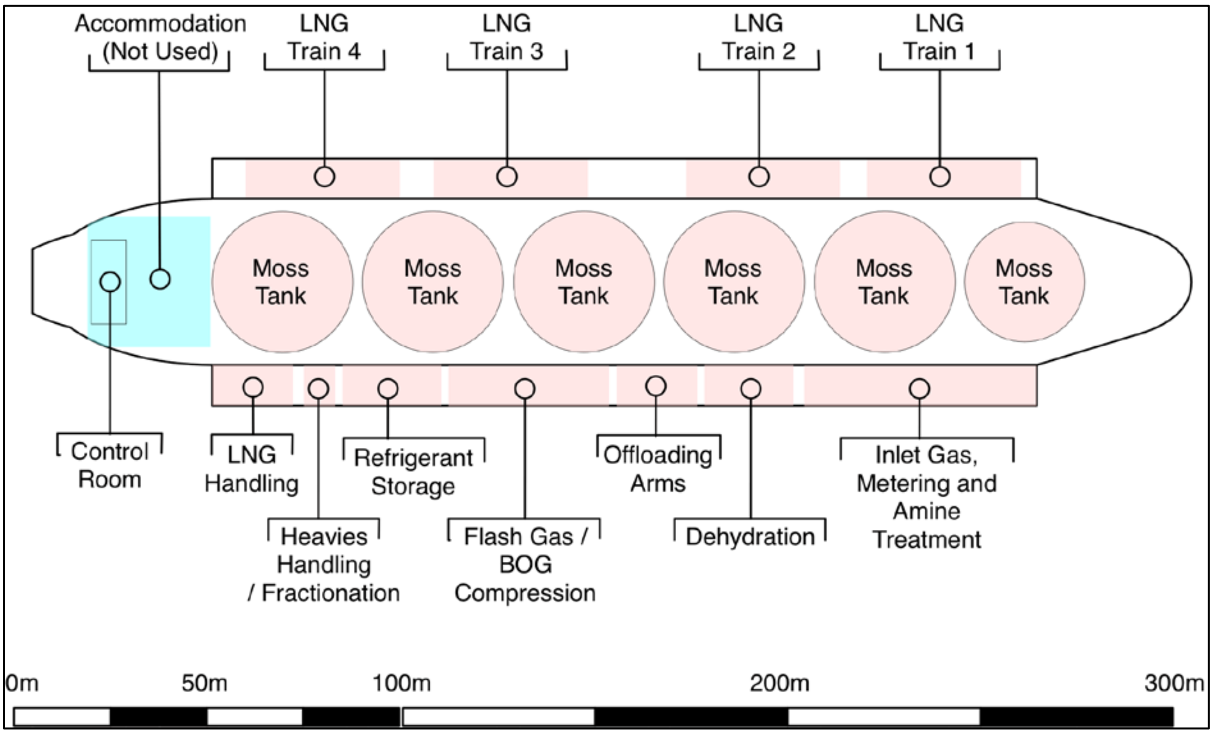


Figure 8-11. FLNG Layout (Typical).

8.2.2.5.3 Quarters Utilities Platform

The QU platform provides the main accommodation for approximately 160 crew working at the Near Shore Hub/Terminal (excluding tug boats and support vessels, where crew will reside onboard) and integrates a combined living quarters, control room and offices; with functional utilities.

Utilities systems include:

- Diesel fuel storage for tugs
- Firewater pumps for Near Shore Hub/Terminal active firewater protection systems
- Power generation (using feed gas taken off at the riser platform)
- Instrument air
- Nitrogen generation
- Potable water
- Seawater cooling

8.2.2.5.4 Riser Platform

Gas exported from the FPSO is routed to the (normally unmanned) riser platform connected to the northeast end of the hub trestle.

The riser platform main equipment and facilities include:

- Cold vent and drum
- Pressure control valve (PCV)
- Inlet heaters
- Emergency shutdown valve (ESDV)
- Fuel gas heaters and filters
- Gas pipeline pigging

8.2.2.6 Crew Transfer and Rotation

Crew transfer to and from the supply bases, and the FPSO and Near Shore Hub/Terminal is by fast crew boat. To facilitate safe transfer, boot mooring and transfer docks with articulated gangways are provided at the supply bases and Near Shore Hub/Terminal. Crew transfer at the FPSO will be achieved by a 10-person FROG, lifted by a suitably certified crane on the FPSO to/from a crew boat.

Crew transfer to and from the drillship is by helicopter from Dakar and/or Nouakchott airports.

While the FPSO, FLNG and QU platform are equipped with helidecks, helicopters will only be used in emergency or time sensitive situations such as medivac.

Crew working onboard the drillship, FPSO, and at the Near Shore Hub/Terminal nominally work a 4 week on/4 week off rotation.

8.2.3 Supply Bases

It is anticipated that supply bases will be provided in Dakar and/or Nouakchott within existing port facilities, the main purpose being to:

- Provide short-term transit and cross-over facilities for the arriving and departing personnel working at the FPSO and Near Shore Hub/Terminal. Crew transfers will take place two or three times per week, with a maximum of 60 persons per trip.
- Store equipment and materials.
- Provide operations and maintenance.

Facilities include an access trestle; a quay/jetty for embarkation and disembarkation of personnel (floating or fixed); wave protection for berth, depending on location; a reserved area on quay/jetty for a 2-tonne crane to load/unload vessel and space for truck; a security hut; a storage area for light goods in transit; vehicle parking (for base vehicles, cars etc.); and a waiting room.

8.2.4 Surrounding Populations

The closest communities from the Near Shore Hub/Terminal are N'Diago in Mauritania and Saint-Louis in Senegal.

The *commune* of N'Diago, which includes the coastal village of N'Diago and several other coastal and inland villages, counts approximately 6,100 people (2013). The village of N'Diago, which is inhabited by a fishing community, is located about 16 km from the Near Shore Hub/Terminal. Details on the population of the commune of N'Diago are provided in Section 4.6.3.

The *commune* of Saint-Louis counts approximately 230,000 people (2015). It includes four neighborhoods directly on the coast which are inhabited by fishing communities. Saint-Louis is located about 13 km from the Near Shore Hub/Terminal. Details on the population of the commune of Saint-Louis are provided in Section 4.7.3

Waters surrounding the GTA Phase 1 Project facilities support industrial and artisanal fishing. Location of industrial fishing boats in Mauritania and Senegal is illustrated in Figure 4-26 in Section 4.6.6.2, and Figure 4-32 in Section 4.7.6.2. These figures show that industrial fishing occurs on the Mauritania and Senegal maritime border and can potentially occur near the offshore field and the FPSO facilities.

Artisanal fishing is conducted closer to shore than industrial fishing, in water depths generally between 20 and 200 m. The Mauritanian pirogue fleet counts over 6,000 units (in 2016). The Senegalese counts over 19,000 units (in 2015), including more than 3,000 in Saint-Louis alone (in 2016).

Artisanal fishing could potentially occur in the surroundings of the FPSO facilities. Additionally, an important concentration of pirogues operates in coastal waters in the surroundings of the Near Shore Hub/Terminal, as shown on Figure 4-34 in Section 4.7.6.3.

8.2.5 Significant and Sensitive Ecological Areas

There are seven protected areas and two important bird and biodiversity areas that are either within or adjacent to the core or extended study areas of the ESIA. These areas are described in detail in Section 4.5.9. The closest protected areas are the following:

In Mauritania:

- Diawling National Park (4 km from the Near Shore Hub/Terminal Area)
- Chatt Tboul Reserve (48 km from the Near Shore Hub/Terminal Area)

In Senegal:

- Saint-Louis Marine Protected Area (5 km from the Near Shore Hub/Terminal Area)
- Langue-de-Barbarie National Park (15 km from the Near Shore Hub/Terminal Area).

Additionally, the United Nations Educational, Scientific and Cultural Organization (UNESCO) Senegal River Delta Transboundary Biosphere Reserve includes areas in both Mauritania and Senegal and it encompasses approximately 6,420 km^2 of land and water centered on the Senegal River. Its boundaries are shown on Figure 4-20 and the Reserve is discussed in Section 4.5.9.3.

8.3 Risk Study

8.3.1 Introduction

Section 8.3 of the Risk Study and Occupational Risk Assessment details the assessment of major hazards and risks. Major hazards comprise:

- Process safety hazards (i.e., hazards involving significant quantities of flammable or explosive materials, and/or acutely toxic inventories)
- Hazardous events with the potential for multiple fatalities; significant spills, and/or far field effects.

Workplaces and work activities addressed as part of the Risk Study comprise:

- The drillship; the FPSO and subsea facilities; the Near Shore Hub/Terminal and associated facilities; and support vessels
- Normal drilling and production operations, including all support and ancillary activities such as inspection, testing and maintenance

The assessment of major hazards and risks comprises five main parts:

1) Identification of major hazards.
2) Preliminary risk analysis. Based on the results of the preliminary risk analysis, major hazards and associated accident events are carried forward for further detailed analysis.
3) Detailed risk analysis, including quantification of effect distances and Bowtie analysis.
4) Review of measures taken to manage major hazards and risks.
5) Review of emergency preparedness arrangements.

8.3.2 Identification of Major Hazards

A thorough and systematic approach to hazard identification forms the basis for the assessment of GTA Phase 1 Project major hazards and risks. The hazard identification section of the Risk Study addresses the process by which hazards are identified and associated accident events defined. It comprised the following key aspects:

1) Review of past major accidents and incidents relevant to the facilities (the accidentology).
2) Review and summary of major hazards based on:
    - Facilities environment, design and operational aspects.
    - The Ensco DS-12 HSE Case (Atwood Oceanics. 2016) and supporting major hazard studies (Atwood Oceanics. 2014a), (Atwood Oceanics. 2014b).

- ○ Hazards identified during project specific hazard identification workshops. These workshops comprised multidiscipline teams of personnel familiar with the facilities design and operation (BP. 2017a), (BP, KBR. 2017a), (BP, KBR. 2017b), (KBR. 2016).
- ○ Hazards from other similar facilities.

3) Major hazard categories and checklists adopted from the ISO 17776: major accident hazard management during the design of new offshore installations (ISO. 2016), with the development of a Hazard Register (Goddard. 2018a), and documentation of major hazards.

8.3.2.1 Accidentology

One of the basic inputs to hazard identification is the review of historical accidents that have occurred in relevant offshore oil and gas, LNG and tanker shipping operations. For the purposes of the accidentology, the focus on such accidents is primarily limited to those that have led to multiple deaths, significant spills, total loss of the facility and/or significant far field effects. The accidentology also considers accident causes, reviewing data from 1944 through 2016 (where available).

It should be noted however, that when reviewing data, more recent accidents provide the best representation of current operating practices and standards. These practices and standards have largely incorporated the lessons learned from previous major accidents.

In developing the accidentology, a review of relevant historical major accidents was undertaken using a variety of data sources including BP reports and accident learnings, the World Wide Offshore Accident Database (WOAD), 1970 – 2012 (WOAD. 2017), Scandinavian Foundation for Scientific and Industrial Research (SINTEF) (2017a), (Scandpower. 2010), (Expro. 2017), the International Association of Oil and Gas Producers (IOGP) (2017), the United Kingdom Health and Safety Executive (UK HSE) (2017), the United States Bureau of Safety and Environmental Enforcement (BSEE) (2017), and the United States Bureau of Ocean Energy Management, Regulation and Enforcement (BOEM - formally the Minerals Management Service) (2017).

With respect to FLNG facilities, operations and technology are relatively new with major oil and gas companies still researching and considering FLNG development. Petronas' PFLNG Satu, the world's first floating LNG production facility, commenced operation in December 2016. Petronas is also building another FLNG unit, the PFLNG2. Exmar's Caribbean FLNG unit produced its first LNG in 2016 (albeit during tests in a shipyard) with the unit not currently operational. Eni has approved investment plans for the Coral FLNG project in Mozambique while London-based Ophir Energy is moving forward with its Fortuna FLNG project off the coast of Equatorial Guinea. LNG shipper Golar LNG expects to deploy its FLNG Hilli offshore Cameroon late 2017. The Golar design forms the basis for the GTA Phase 1 Project FLNG. The largest of all the FLNG facilities in operation or development, Shell's Prelude FLNG, should start production offshore Australia some time in 2018.

To date, no FLNG major accident has occurred, which is hardly surprising given the very limited operational history. However, the LNG industry has been operating since the late 1930's. As a result, accidents from LNG shipping, onshore LNG facilities, and floating storage and regasification units (FRSUs – the first unit became operational in 2009) are reviewed.

The accidentology comprises the following main sections:

- Review of WOAD. The GTA Phase 1 Project comprises multiple facilities and facility types. As a result, a high-level review of all WOAD data was initially undertaken.
- Review of drillship and drilling related major accidents.
- Review of FPSO related major accidents. Given the limited number of accidents, this review also covered other types of offshore oil and gas production facilities.
- Review of LNG related accidents and incidents.

- Review of transportation major accidents.
- Conclusions to the review.

8.3.2.1.1 Worldwide Offshore Accident Database

The WOAD database is one of the most reliable and complete global databases of failures, incidents and accidents in the offshore oil and gas industry. However, there are certain shortcomings with the WOAD data as follows:

- Reporting is voluntary and the content of the database is based on the information collected and compiled by a third party. As a result, it is not an authoritative register of incidents and accidents.
- Given the voluntary character of WOAD, reporting from areas such as the Gulf of Mexico and the North Sea dominate, compared to other regions of the world. North and west African countries have significantly fewer accident records in WOAD because of lower reporting and availability of public information in these areas.
- WOAD does not contain information relating to total facility numbers and operating durations, only the count of unit types which have experienced recordable events.

Within WOAD, records are classified as one of four significance categories:

- Insignificant events
- Near-misses
- Incidents/hazardous situations
- Accidents

Accidents represent the most significant events including all events causing fatalities and severe injuries.

Records in WOAD start from 1970, with a smaller number of records in the earlier years due to limited information sources. The number of recorded events peaks in 1999 and 2005. In 1999, a large increase in records due to new regulations for the Norwegian Continental Shelf that required reporting of all events (including near misses). From the 381 events recorded in 1999, only 8 were characterized as accidents and none resulted in serious damage to the environment, significant material loss or interruption of production. Another large increase in records occurred in 2005. This is the year of the hurricanes Katrina and Rita in USA with 341 of 484 records from the US Continental Shelf.

From WOAD, the number of accident types relevant to GTA Phase 1 Project facilities is given in Table 8-1.

Table 8-1. Number of Accident Types per Type of Unit (Worldwide).

Type of Unit	Accidents	Incidents/Hazardous Situations	Near miss	Insignificant	Total
Artificial Island	2	1	0	0	**3**
Drill Ship	95	75	3	4	**177**
FPSO/Floating Storage Unit (FSU)	25	102	9	32	**168**
Helicopter (Offshore Duty)	243	19	13	3	**278**
Jacket	746	916	128	259	**2049**
Loading Buoy	13	19	2	5	**39**
Pipeline	145	115	1	4	**265**
Total	**1,269**	**1,247**	**156**	**307**	**2,979**

As can be seen from the above table, jacket units dominate, comprising over 60% of entries. However, these entries generally relate to production facilities and include platforms that are not-normally manned. Direct comparison with the GTA Phase 1 Project QU platform is therefore difficult as relevant hazards are different. Helicopter accidents are also a significant contributor, comprising over 20% of accident records.

Accidents are also categorized according to two schemes: one reports the “Main Event”, while the other reports all the “Events in Chain”. For example, a blowout can lead to an explosion and then to a fire. In this case, all three events are coded as Events in Chain. The Events in Chain, together with the operating function where they occurred (i.e., construction, drilling, production, etc.) are presented in Table 8-2.

Table 8-2. Accidental Events in Chain by Operating Function.

Events in Chain	Operating Function					
	Construction	Drilling	Operating	Production	Support	Transfer
Anchor/Mooring Failure	21	117	27	13	9	8
Blowout	0	228	86	43	0	0
Breakage or Fatigue	32	141	98	379	9	70
Capsizing, Overturn, Toppling	12	44	18	156	1	43
Collision, Offshore Units	21	130	18	98	12	35
Crane Accident	29	302	54	251	2	4
Explosion	11	49	16	98	1	4
Falling Load/Dropped Object	38	509	127	403	3	14
Fire	27	195	51	678	21	10
Grounding	11	18	4	1	1	40
Helicopter Accident	1	14	2	38	2	0
Leakage into Hull	11	17	3	6	4	31
List, Uncontrolled Inclination	10	37	32	9	1	20
Loss of Buoyancy or Sinking	20	36	18	27	0	45
Machinery/Propulsion Failure	1	9	0	0	3	14
Out of Position, Adrift	16	87	16	4	3	103
Release of Fluid or Gas	11	240	107	1499	3	4
Towline Failure/Rupture	3	1	4	0	0	102

Records in Table 8-1 and Table 8-2 are dominated by accidental release of fluid or gas during production; fire during production; and falling load/dropped object during drilling and production.

Figure 8-12 presents the occurrence of accidental Events in Chain by percentage. One notable anomaly is Helicopter Accident as in Table 8.1, Helicopter (Offshore Duty) are a significant contributor, comprising over 20% of accidents. This anomaly is likely due to helicopter accidents being categorised by other means in the Events in Chain, for example, Breakage or Fatigue, and Fire.

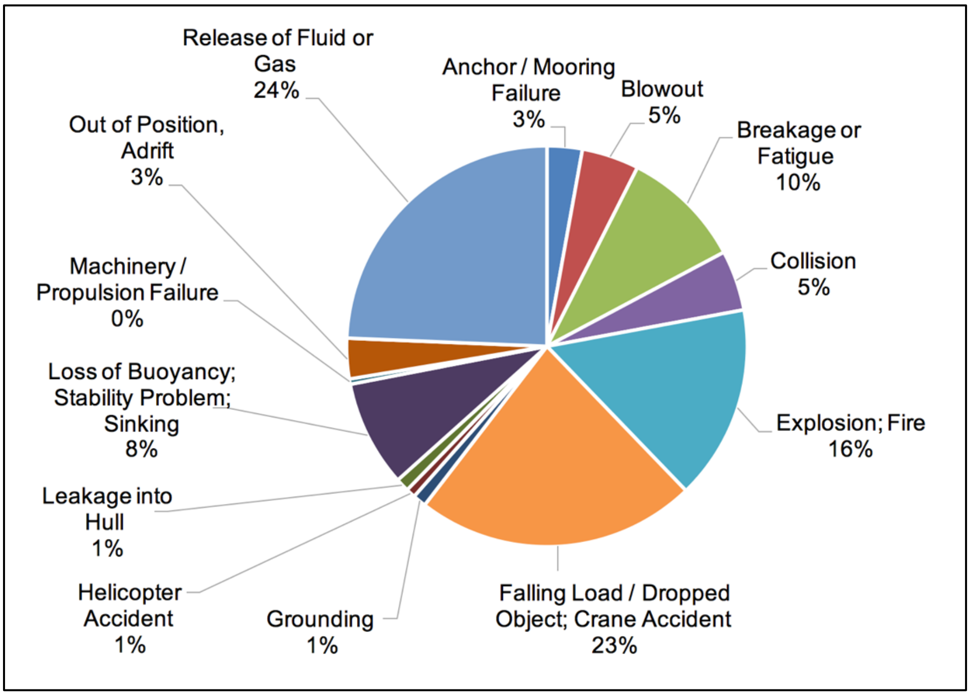


Figure 8-12. Accidental Events in Chain % Occurrence.

When considering accident causes, WOAD includes categories for human and equipment related. The distribution of causes is summarised in Table 8-3.

Table 8-3. Human and Equipment Related Accident Causes (All Accident Types).

Human Related		Equipment Related	
3rd Party Error	9%	3rd Party Equipment Failure	5%
Act of War/During War	<1%	Earthquake, Volcanic Eruption	<1%
Sabotage	<1%	All Equipment Malfunction	34%
Improper Design	8%	Foundation and Structural Failure	8%
Unsafe Act/No procedure	44%	Ignition	26%
Unsafe Procedure	37%	Safety System Malfunction	<1%
Other	1%	Weather	25%
		Other	2%

From Table 8-3, unsafe acts/no procedure and unsafe procedure dominate human related accident causes. Equipment malfunction, ignition and weather dominate equipment related causes.

8.3.2.1.2 Drilling Related Major Accidents

Major accidents involving drillships have been relatively rare. Only two were identified in the review:

- In 1983, in a tropical storm, the Glomar drillship capsized and sank with all 81 crew onboard. The severe environmental conditions and poorly secured cargo which shifted, resulted in a substantial list that affected the rig's stability and watertight integrity.

- In 1989, in Typhoon Gay, the Seacrest drillship capsized with 91 fatalities, two people survived. Warnings of the typhoon were largely ignored as the rig kept operating.

Drillships represent approximately 10% of the current offshore drilling fleet. Since 1955, they accounted for slightly less than 4% of the major offshore drilling accidents, and 20% of 997 reported drilling-related deaths. This high ratio of fatalities to accidents is largely due to the two capsize events described above.

Considering all types of offshore drilling rigs, types of accident and their distribution are given in Figure 8-13.

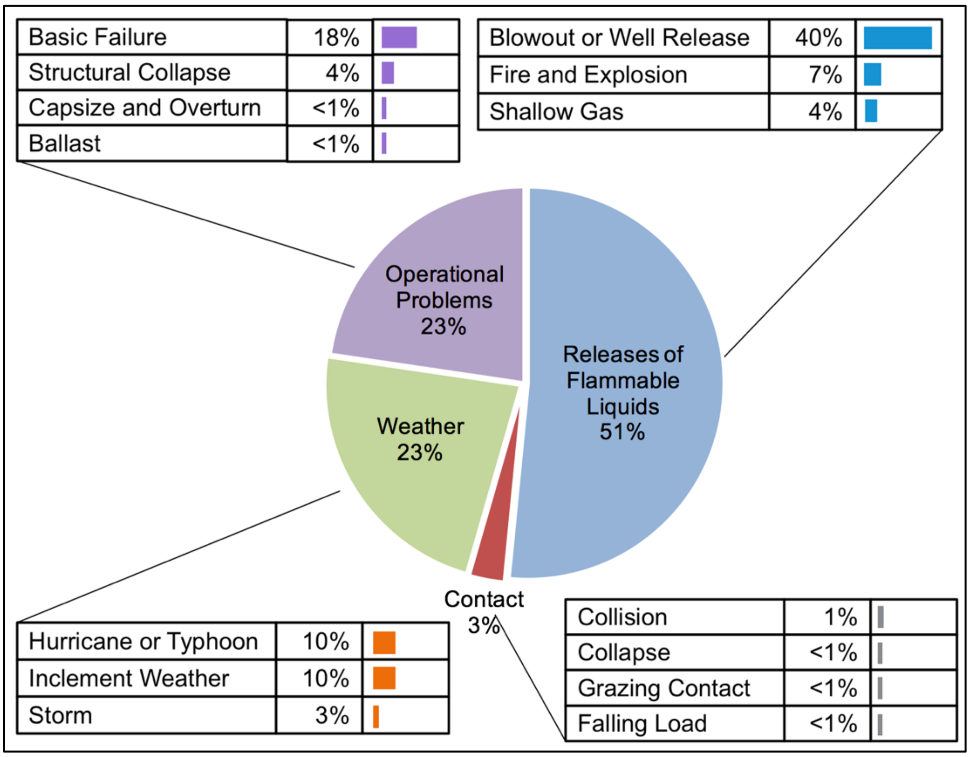


Figure 8-13. Offshore Drilling Major Accident Type and Distribution (1955-2013).

Blowout or well releases (loss of well control incidents) are by far the most common drilling major accident (40% of all events), with the distribution blowouts to well releases approximately equal. A blowout is an incident where formations fluid flows out of the well, or between formation layers, after all the technical well barriers have failed. A well release is an incident where hydrocarbons flow from the well at some point where flow was not intended and the flow was stopped by use of the well barrier system.

Considering the US Gulf of Mexico (GOM) and regulated areas (UK, Norway, Netherlands, Canada East Coast, Australia, US Pacific Outer Continental Shelf (OCS), Denmark and Brazil), a total of 13 fatalities resulted from 117 loss of well control incidents for the period 2000 - 2015. One major accident (the Deepwater Horizon blowout in 2010) resulted in 11 of these fatalities. The two other fatalities resulted from two separate major accidents.

In the period 1980–1999, 186 loss of well control incidents occurred resulting in 58 fatalities. One major accident (the Enchova blowout in 1984) resulted in 42 fatalities. These fatalities occurred during evacuation, when a cable for the lifeboat snapped. The remaining 16 fatalities occurred in eight separate major accidents.

Loss of well control incidents, specifically blowouts, have also resulted in several significant oil spills, most notably:

- In 1979, a blowout occurred on the Sedco 135 drilling semi-submersible. The Ixtoc I well was brought under control some nine months later, spilling 3.3 million bbls of oil. The accident was attributed to a kick following removal of drill pipe after circulation had been lost, and drill collars preventing closure of the BOP.
- In 1980, blowout occurred on the Funiwa No. 5 Well. The well flowed for three days before it bridged, spilling some 200,000 bbls of oil. No specific data could be found on the accident cause.
- In 2009, a blowout occurred on the Montara wellhead platform and continued for almost three months before the well was capped, spilling some 225,000 bbls of oil. The accident was attributed to failure of a cemented casing shoe.
- In 2010, a blowout occurred on the Deepwater Horizon semi-submersible and continued for 5 months spilling some 4.9 million bbls of oil before relief wells sealed the well. The accident was attributed to many causes including equipment failures (the cement job, mud/gas separator, fire and gas system, and seabed blowout preventer); pressure test results interpreted incorrectly; failures in regulatory oversight; failures in management and communication; and failure to adequately identify or address risks.

The above events represent the worst-case. Based on industry data from 1996 through 2015, a significant proportion of loss of well control incidents were of short duration, with 32 of 40 well release events lasting less than 10 minutes, and 22 of 52 blowout events lasting less than 2 days. The historical distribution of loss of well control durations, and oil spill size, is given in Figure 8-14 and Figure 8-15 (2000–2015) respectively.

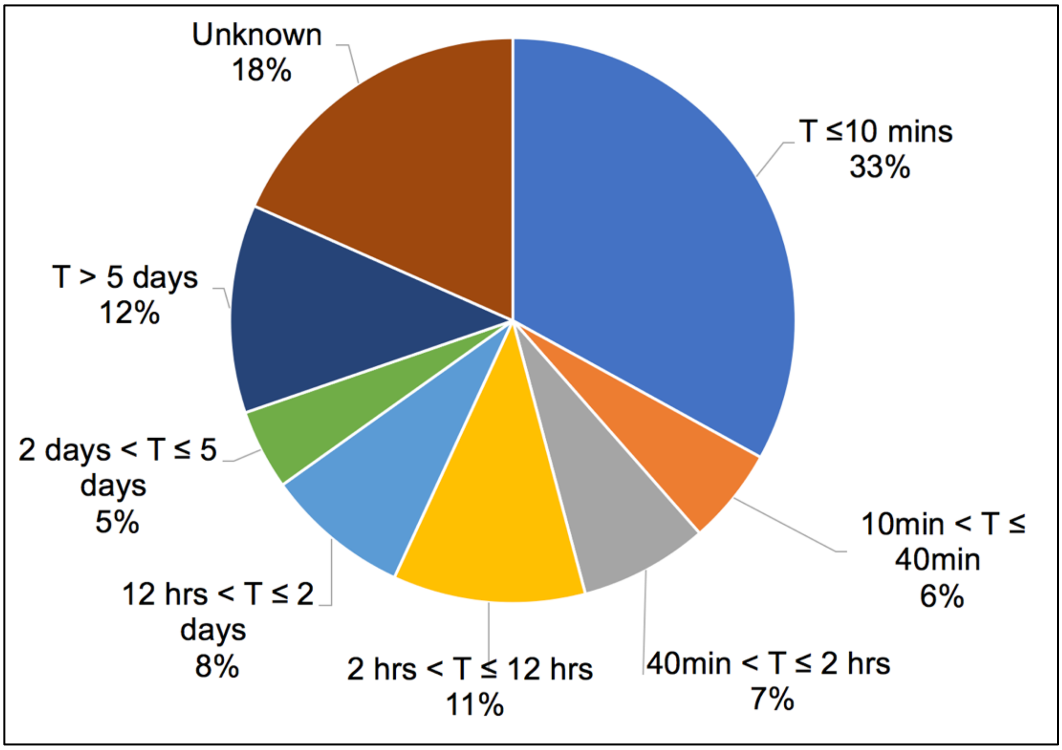


Figure 8-14. Duration Distribution for Loss of Well Control Incidents.

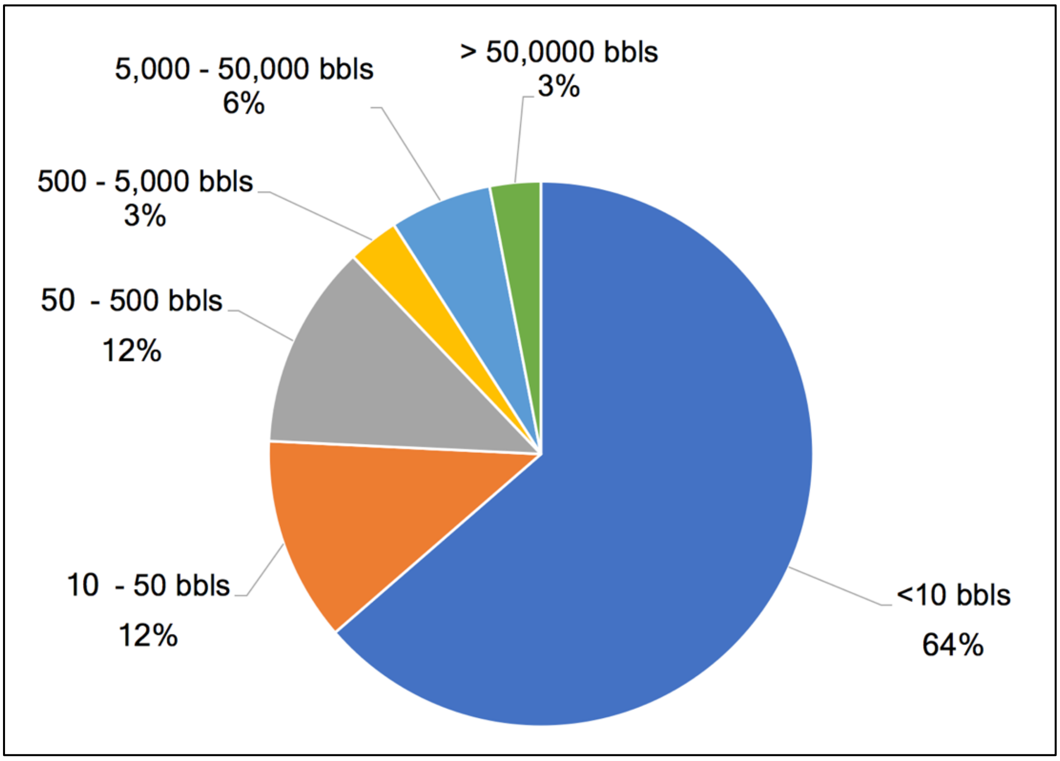


Figure 8-15. Oil Spill Size Distribution for Loss of Well Control Incidents.

8.3.2.1.3 FPSO Related Major Accidents

The review identified one recent major accidents involving an FPSO, out of a total of 25 FPSO related accident records (hazardous situation which have developed into an accidental situation, including all situations/events causing fatalities and severe injuries).

The one FPSO major accident occurred in 2015 onboard the Cidade de Sao Mateus FPSO, offshore Brazil. A gas leak within the pump room resulted in an explosion and a fire that led to 9 fatalities. The accident was attributed to breaches of safe operating procedures, installation of a blind in a pipe with inadequate change management and technical specification, and safety procedure violations.

Six other significant major accidents were identified in the review of all oil and gas production facilities, one of which was a floating semi-submersible facility, the other five events involved fixed jacket platforms. The six major accidents are summarized as follows:

- In 1984, a blowout occurred on the Enchova Central platform, followed by an explosion and fire. A total of 42 fatalities resulted, largely during the evacuation process where the davit system on a loaded lifeboat failed, plunging it into the sea. The accident was attributed to the initial blowout and mechanical failure of lifeboat lowering mechanism.
- In 1988, an explosion and subsequence catastrophic fire involving the facility risers occurred on the Piper Alpha platform resulting in 167 fatalities. The immediate cause was failure of the permit to work system with the accident occurring after shift change when a condensate pump was wrongly started having been disconnected for maintenance by the previous shift. The accident was attributed to failure of the permit to work system; lack of regulatory oversight; poor safety culture; poor design; and failure to assess, understand and mitigate risks.
- 1995, an explosion and fire occurred on the Ubit platform resulting in 10 fatalities. No further detail could be found for this accident.

- In 2001, the Petrobras P-36 sank after a series of explosion resulting in 11 fatalities. The accident was attributed to poor design, including design errors; a lack of training and communication between crew that led to mass confusion; economic factors with focus on cost cutting to make operations as profitable as possible; accepted engineering, inspections and quality requirements not followed; and lack of regulatory oversight.

- In 2005, multi-purpose support vessel collided with the Mumbai High North production platform, rupturing an oil riser resulting in a fire, total loss of the platform and 11 fatalities. The accident was attributed (in addition to the loss of control of the supply vessel) to poor design and lack of safe operating procedures.

- In 2015, a gas leak occurred from a rarely used gas fuel line on the Abkatun A-Permanente Platform. This resulted in an explosion that led to 7 fatalities. The accident was attributed to an unusual kind of accelerated corrosion due to the presence of micro-organisms and sulfuric acid within the gas.

No significant oil spills were identified for FPSO and associated offtake tanker operations. However, review of general tanker operations from 1960 onwards shows almost 50 major oil spills with a range of 50,000 to almost 300,000 tons of oil spilt. While there are notable differences between FPSO and general tanker operations (with the FPSO spread moored and processing hydrocarbons), some causes can be considered relevant to the FPSO such as fire/explosion, collision, structural failure and mechanical failure. The main causes of oil tanker spills are shown in Figure 8-16.

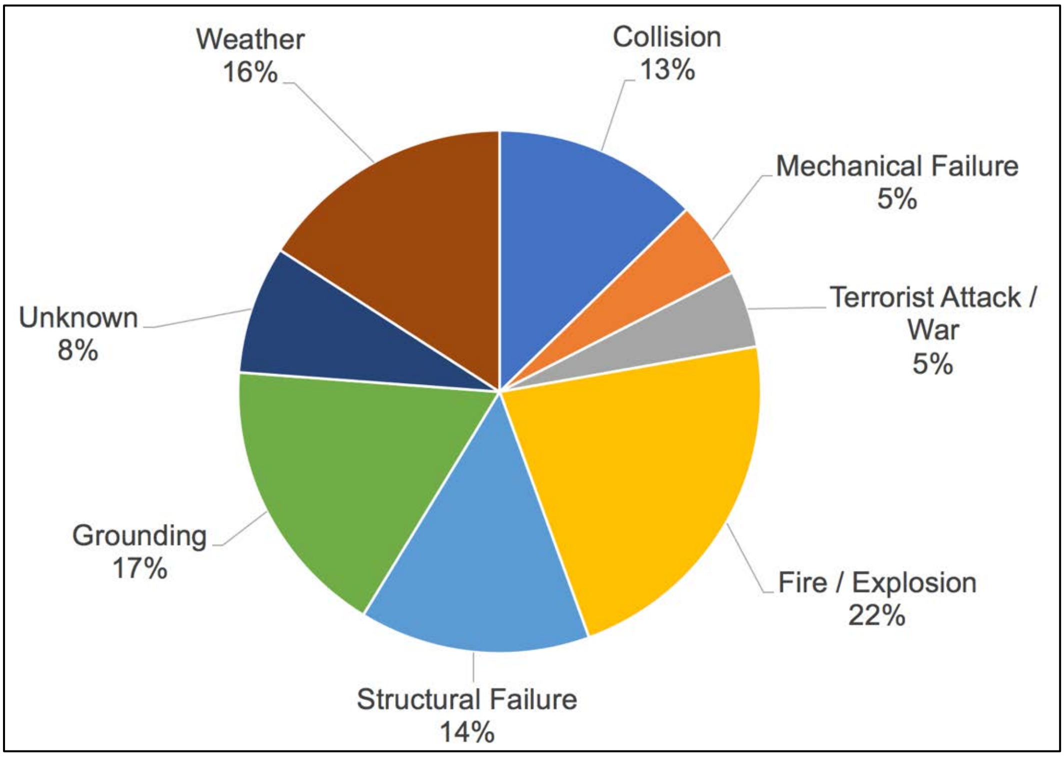


Figure 8-16. Oil Tanker Operations – Main (Immediate) Causes of Oil Spill.

8.3.2.1.4 LNG Related Major Accidents

As discussed in the introduction, FLNG production operations and technology are relatively new and no FLNG major accident has occurred. However, the LNG industry has been operating since the late 1930's and therefore accidents from LNG shipping (including FRSUs), and onshore LNG facilities were reviewed.

The LNG shipping industry has an excellent safety record in terms of cargo loss with no shipboard LNG related deaths. To date, there have been close to 90,000 loaded port transits with no loss of containment failure. There have been two serious groundings, both in the late 1970s, but neither of these resulted in cargo loss:

- In 1979, the LNGC El Paso Paul Kayser ran aground at while manoeuvring to avoid another vessel in the Strait of Gibraltar. The hull was extensively damaged but the vessel was refloated and the cargo transferred to the sister ship.
- In 1980, the LNGC Taurus ran aground in heavy weather at the Mutsure Anchorage, Tobata, Japan. This resulted in extensive hull damage and flooding of the ballast tanks.

In addition, two collisions during berthing were also identified in the review:

- In 1997, the LNGC Capricorn struck a mooring dolphin at a pier near the Senboku LNG Terminal in Japan. This resulted in some damage to hull, but no ingress of water. No cargo was released.
- In 1999, the LNGC Methane Polar struck and damaged a pier when the engine failed during approach to Atlantic LNG jetty in Trinidad and Tobago. No damage to the hull was reported and no cargo was released.

There were no incidents involving FLNGs or FSRUs and no further detail on causes for the above accidents could be found.

Accidents and incidents at LNG handling facilities were also reviewed, those considered noteworthy are summarised as follows:

- In 1944, a tank failure at the East Ohio LNG peak shaving facility, Cleveland, USA, resulted in a spillage of LNG into the street and storm sewer system. The resulting explosion and fire killed 128 people. The tank was built with a steel alloy that had low-nickel content, which made the alloy brittle when exposed to the extreme cold of LNG.
- In 1968, an explosion occurred in an LNG tank at the Portland LNG peak shaving facility, Oregon, USA. The explosion killed 4 construction workers and occurred in an LNG tank under construction. The explosion was attributed to the accidental removal of blinds from natural gas pipelines which were connected to the tank. This led to flow of natural gas into the tank while it was being built.
- In 1973, foam insulation inside an LNG tank at the Staten Island peak shaving facility, New York, USA, caught fire. The rapid rise in temperature caused a corresponding rise in pressure inside the tank which lifted the tank's concrete dome. The dome then collapsed killing the 40 construction workers inside. The fire was attributed to the incorrect use of non-explosion proof irons and vacuum cleaners used for sealing the liner and cleaning insulation debris.
- In 1977, a worker was frozen to death at the LNG export facility, Arzew, Algeria, when he was sprayed with LNG from a ruptured valve body on top of an in-ground storage tank. Approximately 1,500 to 2,000 m^3 of LNG were released, but the resulting vapour cloud did not ignite. The valve body that ruptured was constructed of cast aluminium, a practice no longer used.
- In 1983, a main liquefaction column at the LNG export facility, Bontang, Indonesia ruptured. Debris and coil sections were projected some 50 meters away, hitting and killing three workers, and resulting in a fire. The accident was attributed to a blind flange left in a pressure relief line during start-up.

- In 1988, approximately 30,000 gallons of LNG were spilled through blown flange gaskets during LNG transfer at the Everett LNG import terminal, Massachusetts, USA. The spill was contained in a small area as designed for, and the still night helped prevent dispersion of the vapour cloud. The accident was attributed to condensation induced water hammer.
- In 1992, a relief valve on LNG piping at the Baltimore LNG peak shaving facility, Maryland, USA, failed open and released over 25,000 gallons of LNG into the tank containment area. The LNG also impinged on the LNG tank causing embrittlement fractures on the outer shell. No ignition occurred.
- In 2004, a steam boiler at the Skikda LNG liquefaction and export facility exploded, triggering a second, more massive vapour-cloud explosion and fire. The explosions and fire destroyed a portion of the LNG plant and resulted in 27 fatalities along with material damage outside the plant's boundaries. The initial boiler explosion was attributed to a leak in the hydrocarbon refrigerant system with vapour drawn into the inlet of the steam boiler. The severe consequences of the accident were attributed to poor design with a lack of standard gas detection and automatic of boiler air intakes.
- In 2014, shrapnel from an explosion at the Plymouth LNG peak shaving plant, Washington, USA, caused the slow leak of LNG from a storage tank. People were evacuated for 2 miles around facility. Highway and rail line traffic were also shut down near the Columbia River. The initial explosion was attributed to auto-ignition of a gas-air mixture left in piping (improper purging) prior to liquefaction start-up.

8.3.2.1.5 Transportation Related Major Accidents

Transportation major accidents are dominated by helicopter incidents and no record of a crew boat major accident could be found. Considering all offshore major accidents, helicopter crashes are by far the most common, and typically dominate the risk profile for offshore workers. Of 50 offshore oil and gas major accidents reviewed in detail, helicopter crashes accounted for 29 of the records.

The safety record of offshore helicopter travel is comparable with other some forms of common land-based transport, as summarised in Table 8-4 (Oil and Gas UK. 2011). Main causes of helicopter transportation accidents are summarised in Figure 8-17. Causes of helicopter accidents are dominated by pilot errors, and mechanical failure of rotors, engines and gearboxes.

Table 8-4. Comparison of Average Passenger Fatality Rates (UK).

Transport Mode	Average Fatality Rate
Commercial Airline Operations	0.003
Rail	0.3
Car	2.6
Two Wheeled Motor Vehicle	106.7
Pedal Cycle	34.6
Pedestrian	43.3
Offshore Helicopter	13.8
Fatality rates per billion passenger kilometres	

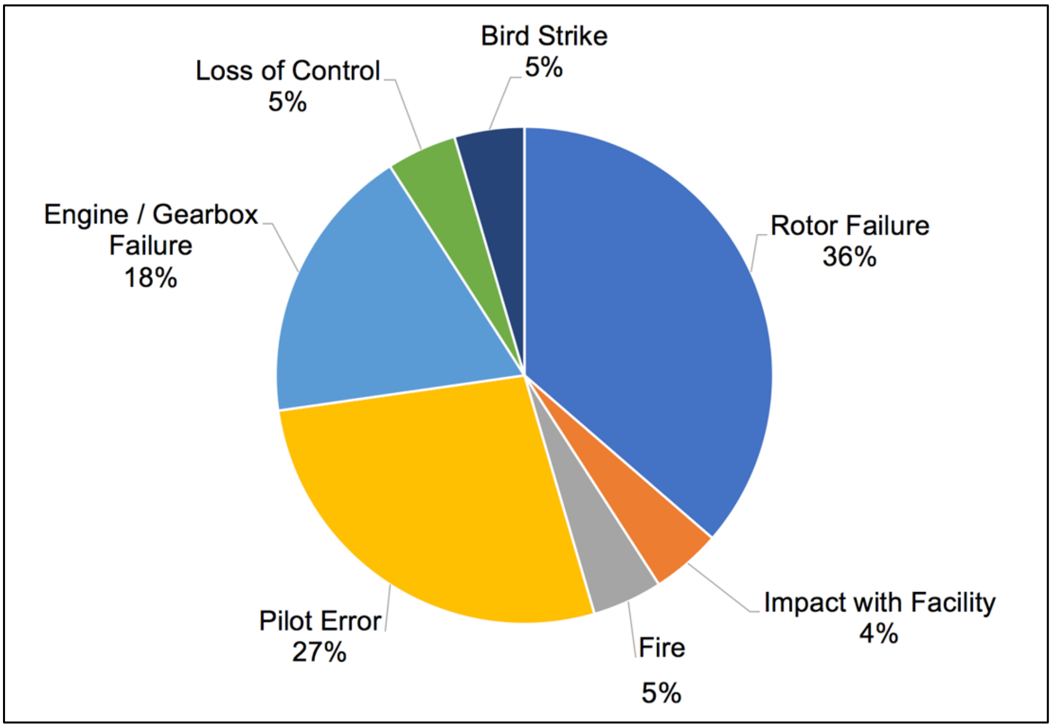


Figure 8-17. Main (Immediate) Causes of Helicopter Transportation Major Accidents.

8.3.2.1.6 Conclusions

A review of historical incidents and accidents has been undertaken to identify incidents relevant to the GTA Phase 1 Project facilities and operations. Given the limited history of FLNG production operations, this review has included incidents associated with LNG shipping (including FRSUs) and onshore LNG facilities.

From the review, the following potential major accidents are identified as relevant to the GTA Phase 1 Project.

- Drilling or completion blowout
- Hydrocarbon releases from risers, and fire on the FPSO, or Near Shore Hub/Terminal riser platform
- Hydrocarbon releases from process, and fire or explosion on the FPSO or FLNG
- Drillship, FPSO or FLNG loss of stability/foundering
- LNGC collision with berth leading to damage to the hull and release of LNG
- Fire or explosion in a facility pump room/engine room/machinery space
- Helicopter crash

Regarding causation factors, there is a significant amount of information available, and general agreement, about the immediate and underlying causes of major accidents (UK HSE, 2006), (Kletz, T. 2001). The evidence comes from extensive and detailed investigations, along with the analysis of smaller scale incidents to look for common causes. Many major accidents have been analysed, and re-analysed by researchers and are presented as case studies for model accident causation theories, and to develop investigation approaches.

The information collated from the review of accidents, along with other relevant literature, shows that the underlying causes of accidents are generally similar across the different facilities and operations considered. For most major accidents, there is a complex chain of events, including organisational policies and decisions, individual behaviours and mechanical or technological failures that, when combined, resulted in the accident. While individual behaviours and specific failures are wide and varied, they all relate to human and organisational factors, and many are symptomatic of a poor safety culture.

Further, the regulatory framework itself has been identified in several major accidents as an underlying factor, specifically:

- The 1988 Piper Alpha disaster in the UK which resulted in 167 fatalities and total loss of the platform.
- The 2010 Deepwater horizon disaster in the USA which resulted in 11 fatalities, 4.9 million bbls of oil spilt, and total loss of the rig.

Both these accidents resulted in significant changes to regulatory regimes, moving towards performance based from prescription. Other specific factors contributing to major accidents include:

- Poor management practices (e.g. inadequate supervision)
- Pressure to meet production targets
- Inadequate safety and environmental management systems
- Failure to learn lessons from previous accidents and incidents
- Communication issues (e.g. between shifts, between personnel and management, etc.)
- Complacency and violations/non-compliance behaviours
- Inadequate training (e.g. emergency response, fire and safety)
- Lack of competency
- Excessive working hours resulting in mental fatigue
- Poor/inadequate procedures
- Failure to identify hazards and understand risks
- Poor design, often related to failure to identify hazards and understand risks
- Failure of change management processes
- Inadequate/insufficient maintenance, including maintenance errors

8.3.2.2 Review and Summary of Relevant Hazards

Following the accidentology, review of GTA Phase 1 Project facilities, their operating environment, and specific production and support operations was undertaken to understand and document relevant major hazards. Potential major hazards were documented with consideration to the surrounding environment, the facilities and their operations, as summarised in Table 8-5.

Table 8-5. Potential Major Hazards: Relevant Environment, Facilities and Operations.

Hazards Relating to		Major Hazard	(Occupational Hazard)
The Environment and Surrounding Conditions (Section 8.3.2.2.1)	Ocean Currents	X	
	Waves and Swells	X	(See Sect. 8.4)
	Winds and Severe Weather	X	(See Sect. 8.4)
	Lightning	X	(See Sect. 8.4)
	Rainfall or Fog	X	(See Sect. 8.4)
	Earthquakes	X	
	Air Traffic Activity (Excluding Facility Related Helicopter Operations)	X	
	Marine Traffic Activity (Not Related to Facility Attendant Vessels)	X	
	Security	X	
Offshore Oil and Gas Production (General) (Section 8.3.2.2.2)	Process Hydrocarbons	X	
	Attendant Vessels	X	(See Sect. 8.4)
	Stability	X	
	Structural Integrity	X	
	Crew Transportation	X	(See Sect. 8.4)
	Materials Handling and Lifting	X	(See Sect. 8.4)
	Accommodation Spaces	X	(See Sect. 8.4)
	Diesel Fuel Transfer and Storage	X	
	Engine Rooms, Machinery Spaces and Utilities Areas	X	(See Sect. 8.4)
	Chemical Injection	X	
	Compressed Gases		(See Sect. 8.4)
	Hydrogen Sulphide	X	(See Sect. 8.4)
	Inspection, Testing and Maintenance	X	(See Sect. 8.4)
	Offshore Construction and Installation		(See Sect. 8.4)
Drillship Drilling Operations (Section 8.3.2.2.3)	Use of Explosives	X	
	Well Control	X	
	Mud Returns and Processing	X	
	Well Testing or Clean-up	X	
	Operational Baskets		(See Sect. 8.4)
	Helicopter Refueling	X	
	Drilling Equipment Handling and Lifting		(See Sect. 8.4)
	Simultaneous Operations	X	
FPSO Hydrocarbon Processing (Section 8.3.2.2.4)	Subsea Production Facilities, Risers and Pipeline	X	
	Processing	X	
	Condensate Storage	X	
	Condensate Offloading	X	

Hazards Relating to		Major Hazard	(Occupational Hazard)
Near Shore Hub/Terminal LNG Processing (Section 8.3.2.2.5)	Feed Gas Pipeline and Riser	X	
	LNG Processing	X	(See Sect. 8.4)
	LNG Storage	X	
	LNG Offloading	X	
The Supply Bases			(See Sect. 8.4)
Product Used, Stored or Produced (Section 8.3.2.2.6)		X	(See Sect. 8.4)
Note: 'X' denotes a major hazard present for the category			

8.3.2.2.1 Hazards Relating to the Environment and Surrounding Conditions

8.3.2.2.1.1 Ocean Currents

Around GTA Phase 1 Project facilities, surface currents are variable, but tend to exhibit predominantly west to southwestward movement, due to the influence of the Azores and Canary Current. Maximum near surface current speeds are of the order of 0.40 m/s.

High currents may exert significant forces on facilities and their mooring. They may also impact condensate and LNG offtake operations. This includes loss of position of the condensate offtake tanker or LNG carrier, and drillship DP failures. However, ocean currents are very low speed and well within safe design limits of all facilities. Near Shore Hub/Terminal facilities are also protected by the breakwater.

8.3.2.2.1.2 Waves and Swells

Waves result from deformation of the surface of the sea due to the wind. A swell is an undulating movement of the sea caused by a series of waves generated over distances of tens or even hundreds of kilometres. Waves and swells (the peak swell period is December-April) may present a hazard for marine activities. Any unusual force and/or height of the waves may destabilise floating facilities.

The drillship was specifically designed for deep-water offshore drilling activities, and wave and swell conditions are well within safe design and operating limits. Further, the FPSO design takes account of anticipated wave and swell conditions and the Near Shore Hub/Terminal breakwater is designed to wave and swell conditions have minimal impact on LNG production and offtake operations.

8.3.2.2.1.3 Winds and Severe Weather

Maritime trade winds, trade winds (or harmattan), winds of the Intertropical Convergence Zone (ITCZ) and/or cyclones of nontropical origin may bring wind and severe weather. Winds and severe weather can cause waves and swells as discussed in the previous section.

Maritime tradewinds have mean velocities of 6 to 8 m/s, and maximum speeds of 15 m/s. Such winds are well within safe design and operating limits of all facilities. Further, all facilities are designed for anticipated severe weather and storm conditions, which are very rare in the area. However, wind and storms may increase risks associated with other major hazards and accident events such as:

- Collision between vessels
- Helicopter crash

The drillship was specifically designed for deep-water offshore drilling activities, and winds and severe weather conditions are well within safe design limits. At risk operations such as supply vessel operations and helicopter transportation also have clearly defined safe operating limits for winds and severe weather. Further, the FPSO design takes account of anticipated wind and severe weather conditions and the Near Shore Hub/Terminal breakwater is designed to help ensure wind, and wave and swell conditions resulting from severe weather, have minimal impact on LNG production and offtake operations.

8.3.2.2.1.4 Lightning

Lightning presents several risks. It may strike persons outside and exposed, it may result in transient voltage surges damaging equipment, it may damage aircraft (helicopters), and it can present a source of ignition for flammable materials.

Facilities are designed for direct lightning strikes with the appropriate conductors and earthing.

8.3.2.2.1.5 Rainfall or Fog

Heavy rainfall or fog may result in a significant reduction in visibility, with an increased risk associated with vessel collision, and helicopter crash. As with other adverse environmental conditions, at risk operations have clearly defined safe operating limits for visibility and vessels are aware of the facilities locations (e.g., notice to mariners and navigation charts) and equipped with navigation aids (including radar reflectors and radar systems) to reduce the likelihood of vessel collision events.

8.3.2.2.1.6 Earthquakes

Earthquakes result from the sudden release of energy in the Earth's lithosphere that creates seismic waves. This may impact facilities structures, piles and moorings directly, or can give rise to a tsunami (a series of waves in a water body caused by the displacement of a large volume of water by seismic activity).

Mauritania and Senegal are in a relatively stable continental area in which seismic activity is almost nil. If relevant as part of design codes and standards, facilities will be designed for any anticipated seismic loads. With respect to tsunamis, waves may travel thousands of kilometres from their source, however, wave activity is generally imperceptible in the open ocean. As the wave nears the coastline, and moves into shallower water, it usually slows down and builds up. Tsunami hazards exist in all oceans and basins, but occur most frequently in the Pacific Ocean. Coastal Mauritania and coastal Senegal are in an area of very low tsunami risk. Given the location of the facilities and the associated water depths (>33m), tsunamis should not pose a significant threat.

8.3.2.2.1.7 Air Traffic Activity (Other than Facility Related Helicopter Operations)

There is limited commercial air traffic activity above the area the facilities are located. In general, flights in and out of Dakar-Senegal to and from the north may fly over the general development area, specifically, Nouakchott-Mauritania (Mauritanian Airlines and Turkish Airlines), Paris-France (Air France), Brussels-Belgium (Brussels Airlines), Barcelona-Spain (Iberian), Casablanca-Morocco (Royal Air Maroc), and Lisbon-Portugal (Tap Portugal). Each airline offers limited services with typically one or two return flights a day.

Flights to the south in and out of Nouakchott-Mauritania may fly over the general development area, specifically Dakar-Senegal (Mauritanian Airlines and Turkish Airlines), and Conakry-Guinea (Air France – although flights may pass inland to the east).

Nouakchott airport is located some 200 km to the north north east of the Near Shore Hub/Terminal development area. Dakar airport is located some 150 km to the south west of Near Shore Hub/Terminal development area. At these distances, aircraft may have started on approach to the airport but should still be at significant elevation (>6,000 m). For departures, aircraft should also be expected to be above 6,000 m over the development area.

At their tallest, facilities may be up to 120 m above sea level (the height of the drillship derrick is 120 m).

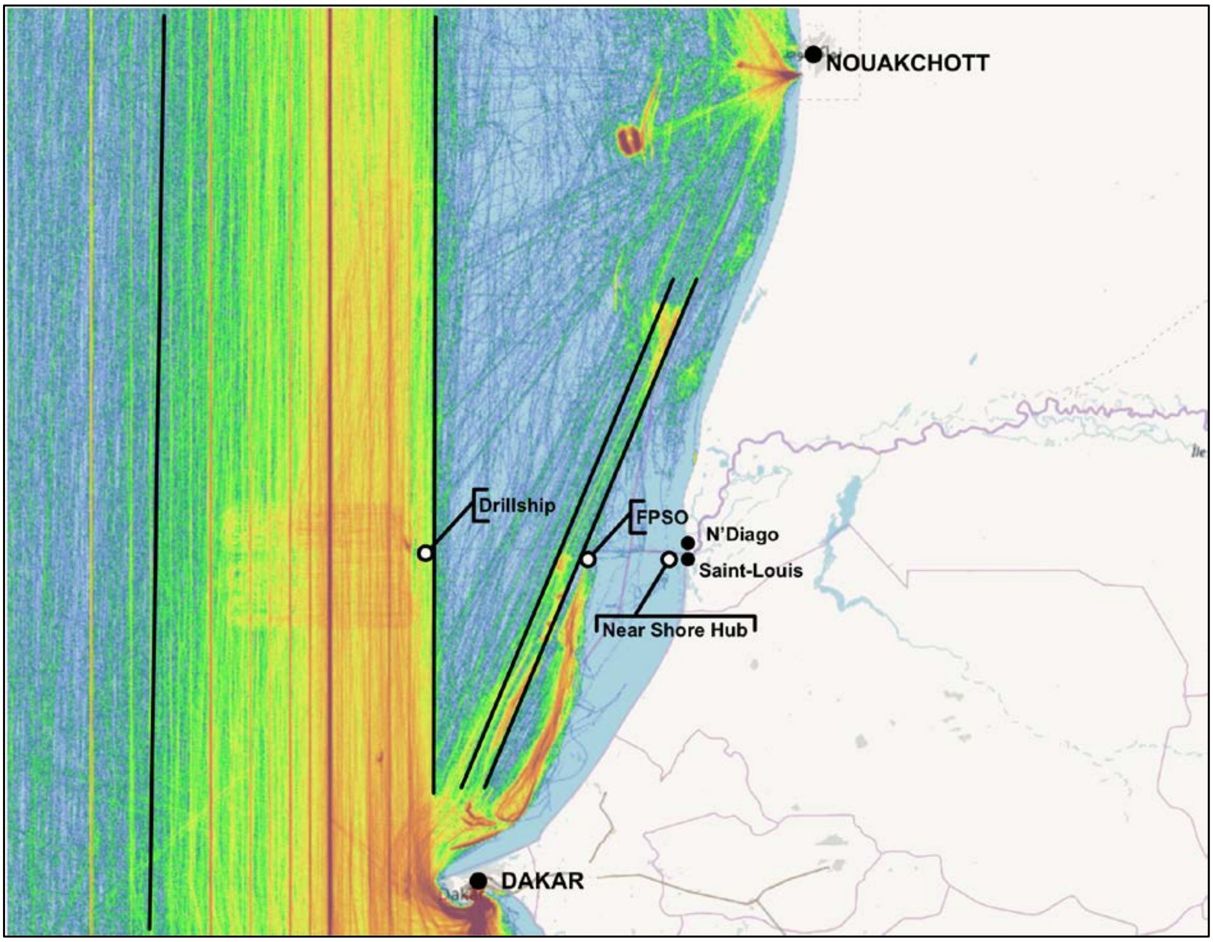
Commercial airlines have some of the best safety records of any industry, and the hazards and risks to the project facilities associated with such activities are considered negligible.

8.3.2.2.1.8 Marine Traffic Activity (Other than Facility Related Attendant Vessels)

Marine traffic refers to everything that is the subject of, or that is associated with, the maritime transport of goods or persons. The hazard associated with vessel traffic near the facilities arises from the risk of collision which could result in structural failure/loss of stability and/or large release of condensate or LNG from hull storage tanks. Collision risks specifically arise from vessel passing nearby the facilities en-route to another destination.

Passing vessel traffic density is illustrated by Figure 8-18. Two primary shipping lanes are identified near the facilities based upon the vessel traffic densities:

- Lane 1, located approximately 70 km to the west of the FPSO location travelled by approximately 14,600 vessels a year, primarily cargo vessels with some tankers and fishing vessels. Note that the drillship is located on the edge of Lane 1
- Lane 2, located approximately 5.5 km to the west of the FPSO location travelled by approximately 1,100 vessels a year, primarily fishing vessels with some cargo vessels and tankers



Source: Goddard. 2018c.

Figure 8-18. Passing Vessel Traffic.

Collision risks are assessed as part of a specific ship collision hazard analysis (Goddard. 2018c) and the likelihood of a marine traffic collision is considered very low. However, should one occur, consequences may be catastrophic with structural failure/loss of buoyancy and/or large spill of condensate or LNG cargo possible.

Passing vessel risks are managed through various safeguards and controls including a 500 m safety zones around the drillship and FPSO, and 500-600 m safety zone around the Near Shore Hub/Terminal; notice to mariners; facilities being clearly marked on navigation charts; provision of navigation aids; and monitoring of vessel traffic near the facilities with emergency response plans and procedures in place to deal with errant vessels.

Further, Near Shore Hub/Terminal facilities are located a significant distance from any recognised shipping lane with negligible risk from collision.

8.3.2.2.1.9 Security

Security hazards refer to any act of piracy, theft, murder, kidnapping, and/or sabotage that is committed at a port or at sea. Since the start of the 21st century, security threats have increased substantially in various parts of the world. In Africa, piracy occurs primarily in the Gulf of Guinea, the Red Sea, the Gulf of Aden, and off the coast of Somalia. Offshore facilities, because they often belong to multinational corporations (with substantial financial resources), are the target of pirates who rely on demands for ransom. This partly explains the current scale of piracy associated with oil and gas facilities in Nigeria.

Offshore oil exploration is a relatively new activity in Mauritania and Senegal, and the area in which project facilities are located is a stable one. Security in Mauritania and Senegal is generally good. However, the threat of regional terrorism in West Africa has raised the threat level for Mauritania and Senegal, partly because of their accessible borders. The presence of the terrorist groups known as Al Qaeda in the Islamic Maghreb (AQMI) and Ansar Dine in the region, may be cause for concern.

Security risks are managed through various safeguards and controls including design of facilities to prevent unauthorised access; and safe operating plans and procedures, including security plans that comply with the International Maritime Organisation (IMO) International Ship and Port Security (ISPS) Code (IMO. 2012).

8.3.2.2.2 Hazards Relating to Offshore Oil and Gas Production (General)

8.3.2.2.2.1 Process Hydrocarbons

Oil and gas development operations involve the production and processing of large volumes of hydrocarbons. The nature of these flammable hydrocarbons could result in various types of hazardous event should an accidental release occur. If a hydrocarbon release is ignited, fire and explosion may occur. The characteristic of these fires and explosions depends on the type of material, the rate and nature of the release, the time at which it is ignited and the nature of the surrounding equipment, process and structures. These outcomes can be characterised by:

- Jet fire – a burning jet of gas or spray of atomised liquid released from high-pressure equipment. This may be very damaging to equipment within or near the fire, and lethal to personnel some distance from it.
- Pool fire – a burning pool of hydrocarbon liquid. This may be very damaging to equipment, and lethal to personnel, within or near the fire.
- Flash fire – a fire that propagates through a cloud of gas in an open, uncongested region. This may be lethal for anyone within it, but is unlikely to be damaging to equipment or facilities.
- Explosion – combustion of a gas cloud causing a rapid increase in pressure (overpressure). The severity of an explosion depends on how fast the flame propagates and how the pressure can expand away from the gas cloud. This may be very damaging to equipment and facilities, and lethal for personnel, some distance from it.
- Fireball - a spherical fire resulting from the sudden explosive release of pressurised liquid or gas that is immediately ignited. Although it may only last a few seconds, associated thermal radiations may be damaging to some unprotected equipment and facilities, and lethal for personnel, some distance from it.

Explosions and jet fires may be particularly damaging to facilities structures, other process equipment, and key safety and emergency systems. Pool fires may result in significant smoke that can reduce visibility, be toxic and ingress into areas required for safe muster and evacuation.

Process hydrocarbon risks are managed through various safeguards and controls (as applicable to the relevant facility) including appropriate layout and design of process systems; integrity management programs, including inspection, testing, and maintenance of equipment; provision of process safeguarding systems such as instrumentation, overpressure protection, emergency shutdown, and relief and blowdown); along with other safety systems such as fire and gas detection, active and passive fire protection, and explosion rated walls and barriers. In addition, as part of the design process, facilities process safety hazards are assessed in detail with facilities designed for anticipated fire and explosion DALs.

Further, equipment will be selected appropriate to the hazardous area zone where it is located.

8.3.2.2.2.2 Attendant Vessels

Several vessels assist with, and attend to the offshore operations. These include supply vessels, guard vessels, tugs to assist with LNGC berthing and fast crew boats. Given the number and frequency of these operations, there is the risk of collision of attendant vessel with other facilities.

Attendant vessel servicing GTA Phase 1 Project facilities may be quite large, specifically supply vessels, the security vessel and tugs with a deadweight tonnage of up to 7,500 tons. Depending upon vessel speed, collision energies and damage from these vessels en route to facilities, or during maneuvering may be relatively high. This may result in damage to the attendant vessel and/or the other facility involved in the collision (for example, QU platform jacket structure, loss of containment from risers, and damage to FLNG, LNGC or FPSO hull).

Supply vessel collision energies however, are generally insufficient to result in significant damage to jacket structures or other vessel hulls.

Attendant vessel collision risks are managed through various safeguards and controls including inspections and maintenance to help ensure seaworthiness of vessels; crew training and competence assurance; navigation aids and weather forecasting; and safe operating procedures including berthing, approach and maneuvering, clearly defined environmental limits, and use of appropriate lifesaving facilities and appliances. The FPSO and the FLNG are double hull designs should be able to withstand high impact energies without loss of storage tank integrity. In addition, where collision risk to risers exists, they are provided with impact protection.

8.3.2.2.2.3 Stability

Loss of stability presents a hazard for all floating facilities. Vessel stability may be impacted by several factors including:

- Ballasting system failures and errors
- Deck loading distribution
- Tank filling/offloading and distribution
- Hull fatigue
- Dropped object
- Corrosion
- Loss of mooring
- Adverse weather
- Other major accident event (e.g. topsides fire or explosion, vessel collision)

Loss of stability has potentially catastrophic consequences with the vessel foundering. This can result in multiple loss of life and spill from loss of cargo and/or fuel oil.

Stability related risks are managed through various safeguards and controls including rigorous risk assessment, such as failure modes and effects (FMEA) analysis, as part of vessel ballast system design; redundant ballast pumps with critical valves failing in their safe position (open or closed as relevant); and ballast operator training and competence assurance. In addition, marine operating procedures and vessel management systems (VMS) address stability calculations and requirements for ballast operations and deck/tank loading, including adverse weather conditions. Vessel hulls are also designed for expected environmental conditions and fatigue life, and are provided with the appropriate corrosion protection systems (including coatings and cathodic protection). Hulls are inspected and maintained, and certified by independent third party as part of ongoing class requirements.

Redundancy is provided in the mooring systems for the FPSO and FLNG, and moorings are designed for anticipated environmental conditions, inspected and maintained.

8.3.2.2.2.4 Structural Integrity

Loss of structural integrity presents a hazard for the QU platform. Structural failures may also impact any load bearing structures including the drillship derrick, cranes and process skid structural supports. Structural integrity may be impacted by several factors including:

- Deck loading distribution
- Fatigue
- Corrosion
- Adverse weather
- Other major accident event (e.g. topsides fire or explosion, vessel collision)

Loss of structural integrity has potentially catastrophic consequences with the QU platform collapsing. Structural related risks are managed through various safeguards and controls including design of facilities for anticipated loads, including weather, with the relevant safety factors in line with accepted codes and standards, and good practice; seabed surveys prior to suction pile installation; and provision of the appropriate corrosion protection systems (including coatings and cathodic protection). Critical structural members and nodes are also identified within structural integrity management programs which are then subject to the appropriate inspection and maintenance.

8.3.2.2.2.5 Crew Transportation

Personnel are transported to and from the offshore facilities using helicopter (for the drillship) and fast crew boat (for the FPSO and Near Shore Hub/Terminal). The FLNG, QU platform and FPSO are also equipped with helidecks but these will only be used in an emergency, not for crew transfer.

Helicopter transport is via Dakar or Nouakchott using AgustaWestland AW139 aircraft with capacity to carry up to 10 passengers and 3 crew.

Helicopter accidents can occur during take-off, landing or during flight. During take-off/landing there is the potential for a crash onto the facility, however, the potential for escalation is limited as helicopters approach in designated clear sectors and land on the appropriately designed helideck. Any crash on the facility should likely be near the helideck. Helidecks are remote from any process and drilling equipment, and critical structural member of the drillship, FLNG, FPSO and QU platform. For crashes into sea, passengers and crew may be able to escape from the helicopter. Water temperatures offshore Mauritania and Senegal are relatively warm with low current speeds, as a result, chances of rescue and recovery are high if personnel survive the initial crash.

Helicopter transportation risks are managed through various safeguards and controls including inspection, testing and maintenance of aircraft; aircraft onboard monitoring systems; crew and passenger training and competency; fuel sampling; and safe operating procedures including clearly defined environmental limits and use of appropriate lifesaving appliances. Twin engine helicopters are also used and flown with two pilots.

Fast crew boats are used to transfer personnel from the supply bases to the FPSO and Near Shore Hub/Terminal. Boats have capacity to carry up to 60 passengers. A crew boat major accidents may occur during transit between supply bases and facilities and involve loss of stability/foundering.

Transfer at the Near Shore Hub/Terminal is by protected articulated jetty. Crew transfer at the FPSO will be achieved by a 10-person FROG, lifted by a suitably certified crane on the FPSO to/from a crew boat. Fatality could result in case of a dropped FROG during transfer operations.

Crew boat transportation risks are managed through various safeguards and controls including inspection, testing and maintenance, compliance with recognised marine standards and codes of practice; crew and passenger training and competency; and safe operating procedures including environmental limits and use of appropriate lifesaving appliances.

8.3.2.2.2.6 Materials Handling and Lifting

Numerous materials handling and lifting operations take place offshore. Hazards relevant to all facilities involve use of main cranes for loading and unloading supplies and equipment. Cranes are located on the drillship, FPSO, FLNG and QU platform. With significant lifting activity, there is the potential for dropped objects. Lifts from supply vessel include:

- Almost daily loading and unloading of general supplies and equipment vessel to/from all facilities
- Chemical tote tanks
- Equipment repair parts and spares
- LNG make-up refrigerant containers to the FLNG (3 x 20 m^3 ethylene containers, 6 x 25 m^3 propane containers and 12 x 25 m^3 iso-pentane containers per year)

Dropped objects have the potential to result in damage to topsides facilities equipment, impacts to subsea equipment including risers, damage to supply vessels, and release of hydrocarbons. They may also result in release of make-up refrigerant.

Material handling and lifting risks are managed through various safeguards and controls including inspection and testing of lifting equipment; dedicated lifting and laydown areas; training and competency of crew; cargo manifest verification; and safe operating procedures including environmental limits.

8.3.2.2.2.7 Accommodation Spaces

Accommodation units contain various materials that present a fire risk including cellulose-based materials (e.g., paper, fabrics, etc.), plastics, cooking fats and oils, and electrical equipment. Significant accommodation fires have the potential to result in multiple fatalities, largely due to the large number of people present with facilities permanently manned. However, fires are typically localized, quickly detected with accommodation smoke and fire detection systems, and easily controlled using hand held extinguishers. Hose reels and firewater is also provided in the accommodation spaces.

8.3.2.2.2.8 Diesel Fuel Transfer and Storage

Significant amounts of diesel are stored onboard the drillship and the QU platform at the Near Shore Hub/Terminal. The drillship uses diesel as fuel for the vessel's engines and for power generation. Diesel is stored in bulk on the FPSO, FLNG, and QU platform for use as fuel by the tugs that assist with LNG carrier berthing operations.

Large diesel spills and releases may occur because of leaks or rupture of storage tanks, or during bunkering operations where diesel is transferred in bulk from supply vessels. By far the most likely source of any significant spill or leak is during bunkering. These operations require use of hoses, the operation of multiple valves, and the transfer of diesel into and out of onboard bulk storage tanks.

Bunkering operations however, are strictly controlled to prevent spills and releases. All transfer operations require a "Permit to Work" which helps ensure that risks are understood and appropriate controls are in place. This includes inspection of hoses and transfer equipment; hardware and procedural controls to prevent tank overfilling; bunded areas for spill containment; checks to help ensure appropriate valves are open/closed; and personnel competency and training.

Diesel is a combustible liquid. The IMO International Convention for Safety of Life at Sea (SOLAS) requires diesel fuel used on board of ships have a flash point of more than 60°C. As a result, spills are generally not considered to present a significant fire risk, unless they occur in engine rooms, machinery spaces and utility areas, as discussed below.

8.3.2.2.2.9 Engine Rooms, Machinery Spaces and Utilities Areas

There are a range of fires that may occur in engine room, machinery spaces and utility areas. The main hazardous materials (fuel sources) in these areas are diesel fuel (marine diesel), lube oil, and fuel gas.

Fuel and lube oil are high flash point fluids that will not normally ignite, unless they are heated, soak into lagging, or are sprayed out under pressure (and then contact a hot surface such as an exhaust). Personnel near the fire may suffer burns or be overcome by smoke. Fires can create significant smoke and should fire control and mitigation measures fail or not be effective, they can escalate by spreading to adjacent areas.

Fuel gas is used on the FPSO, FLNG and QU platform and may be routed to utilities areas/machinery spaces. While fuel gas pressures may be relatively low (typically less than 6 bar) and inventories limited once a leak is detected and isolated, any release has the potential to result in a fire and/or explosion.

Fire and explosion risk in engine room, machinery spaces and utility areas are managed through various safeguards and controls including inspection, testing and maintenance of equipment; provision of appropriate fire and gas detection; exhaust lagging; splash guards on exposed pipework; and fire protection such as inert gas systems to flood the space to extinguish any fire. Upon detection of fire or confirmed gas, emergency shutdown also isolates flow of incoming fuel or gas. Utility areas with fuel gas are Zone 2 hazardous areas (an area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time) with all equipment appropriately rated and ignition sources controlled.

8.3.2.2.2.10 Chemical Injection

The FPSO chemical injection system delivers flammable and/or combustible chemicals (e.g., MEG) and methanol) into the production stream, topsides and subsea, at high pressures. Given the relatively large storage volumes, there is the potential for a pool fire (from storage), or an atomised liquid spray with flammable vapour and jet fire (downstream of high pressure injection pumps).

The FPSO chemical injection systems are covered by many of the process related safeguards as described in Section 8.3.2.2.2.1. This includes integrity management programs, including inspection, testing, and maintenance of equipment; provision of process safeguarding systems such as instrumentation, overpressure protection, and emergency shutdown); along with other safety systems such as fire and gas detection, active and passive fire protection, and explosion rated walls and barriers. In addition, as part of the design process, facilities process safety hazards are assessed in detail with facilities designed for anticipated fire and explosion DALs.

Further, process areas in which chemical injection systems are located are Zone 2 hazardous areas (an area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time) with all equipment appropriately rated and ignition sources controlled.

8.3.2.2.2.11 Hydrogen Sulphide

Hydrogen sulphide (H_2S) is highly toxic and can result in fatality at a very low concentration. A single breath that is contaminated by 1,000 parts per million (ppm) can induce a coma. Continued exposure to this concentration, or to an even weaker concentration (on the order of 200 ppm) quickly leads to death.

Hydrogen sulfide (H_2S) may be present in the oil-bearing formation and may be returned to the surface with the drilling mud, or may be contained in production well fluids.

Given exploratory drilling history and anticipated well fluid material balance data, H_2S levels in the well fluids are negligible and should not pose a threat to drilling, or FPSO feed gas pre-processing. The FLNG process does contain amine treatment. Amine treatment onboard the FLNG is used to remove H_2S, sulphur compounds, and carbon dioxide (CO_2) from the feed gas. The stripped overhead gas from the amine regenerator may then contain more concentrated H_2S and CO_2 in the gas stream. H_2S may also be present in other systems such as MEG regeneration onboard the FPSO. However, given the negligible amounts of H_2S in the feed gas, H_2S is not considered to present a significant hazard.

8.3.2.2.2.12 Inspection, Testing and Maintenance

A key purpose of facilities inspection, testing and maintenance is to prevent major hazards from being realised by assuring the ongoing integrity of plant and equipment. While these activities in themselves are not major hazards, the activities undertaken during inspection, testing and maintenance may cause or, contribute to a major hazard being realised. This includes:

- Work involving isolation of, and entry into process piping and vessel
- Mechanical handling of equipment in process areas
- Hot work (providing a potential ignition source)
- Inadequate/poor maintenance of critical equipment

Risks associated with inspection, testing and maintenance are managed through various safeguards and controls including crew training and competence; control of work procedures, including Permit to Work and materials handling; and integrity management systems, including specific requirements for maintenance and reporting of equipment and facilities deemed safety or environmentally critical.

8.3.2.2.3 Hazards Relating to Drillship Drilling Operations

8.3.2.2.3.1 Use of Explosives

Explosives and detonators are required for well perforating during well completion activities onboard the drillship and may pose a risk of accidental explosion. Explosives may also be used in case of unforeseen events such as the wedging or overwrapping of drill pipe during drilling operations to cut the drill pipe.

Premature detonation of explosives has the potential to result in fatality if personnel are in the vicinity. Given the size of charges involved and safe handling procedures, escalation and/or significant structural damage to the drillship is not considered credible but multiple fatalities are possible.

Risks associated with the use of explosives are managed through various safeguards and controls including secure storage of explosives in steel containers that can be jettisoned in the event of a fire and remote from other flammable material storage; import, handling and use by a specialist third party; and radio silence observed when used to eliminate potential for spurious detonation.

8.3.2.2.3.2 Well Control

A well control incident may occur due to an unexpected influx of well fluids during drilling, completion, or workover, resulting in a blowout or well release. A blowout is an accident where formation fluid flows out of the well, or between formation layers, after primary and secondary well barriers have failed. A well release is an incident where unintended oil or gas flows from the well and the flow is stopped by use of the primary or secondary barriers.

The potential for blowouts and well releases varies with the type of operations being performed. Different barriers apply to production, and drilling or well intervention operations. Blowouts or well releases may occur when deep drilling (in the reservoir) or from shallow gas. When deep drilling two blowout barriers exist: the primary barrier is the hydrostatic head of the drilling fluid (mud), and the secondary barrier is the BOP. Deep blowouts and well releases may occur where the well pressure exceeds the hydrostatic head of drilling fluid and there is a failure to control the kick (a flow of reservoir fluids into the wellbore). Reservoir fluids may flow to the surface and be released through the annulus or drill string (e.g. drill string non-return valve failure). A blowout may result if the BOP fails to close or seal the well and/or the drill string non-return valve fails.

Shallow gas blowouts result from drilling into an unexpected pocket of gas at relatively shallow drilling depths, prior to the main reservoir being reached. Generally, the marine riser and BOP will not have been installed on the wellhead and in such cases, gas is released at the seabed. If the marine riser and BOP are installed (but the well depth is too shallow to allow closing of the BOP without risk of fracturing the formation) then gas is routed to the rig and directed overboard using the rig diverter system. Diverter failure may occur, primarily due to high flow and debris (e.g. sand and rock) in the gas.

Blowout may result in a significant release of hydrocarbon oil and gas. This can lead to large oil spills, or if ignited, explosion and fire which may engulf the rig leading to significant fatality. Well releases typically are of shorter duration than blowouts, with less potential for fatality, significant damage to facilities and/or the environment.

Based on assessment in the drillship HSE Case (Atwood Oceanics. 2016), loss of buoyancy from subsea blowout (from shallow gas) is not considered a significant hazard, of more concern should be flammable gas at the surface and any resultant fire or explosion.

Blowouts may also occur from producing wells. During production. both the primary and secondary barriers are mechanical barriers, the surface controlled sub-surface safety valve (SCSSV) and the Xmas tree, both of which can be activated to shut in the well. In addition, the packer, tubing, and casing are passive barriers.

Well control risks are managed through various safeguards and controls including specific third party well control training for the drill crew as part of their competence assurance; systems and equipment in place to detect any influx of well fluids into the well bore, including monitoring of mud return volumes and gas composition; and well control equipment (e.g., BOP) and procedures. Should a kick occur during deep drilling, the BOP can be closed with mud and well fluids circulated via the choke and kill system in a controlled manner. Gas is vented safely via the mud gas separator while mud weight is increased to control the well.

8.3.2.2.3.3 Mud Returns and Processing

Drilling mud returning from the well via the riser passes through the separator (to remove hydrocarbons), the degasser (to remove hydrocarbon gas), and shale shakers (to remove drill cuttings) prior to being returned to the mud pits.

This equipment is in the mud processing area, located on the starboard side of the drillship moon pool area, below the drill floor. In the event of a significant quantity of gas entrained in the drilling mud (gas cut mud) and returned to the mud processing area, an explosion could result.

Risks associated with gas cut mud are managed through various safeguards and controls including mud monitoring with kick and well control procedures to isolate returns to the mud pits and shakers and safely vent entrained gas. Further, the mud processing area is a Zone 1 hazardous area (an area in which an explosive gas atmosphere is likely to occur in normal operation) with all equipment appropriately rated and ignition sources controlled.

8.3.2.2.3.4 Well Testing or Clean-up

Well testing and clean-up involves the controlled flow of well hydrocarbons onto the rig. The well test area for the drillship is located towards the aft of the vessel on the well test platform above main deck. During well testing, there is a certain risk of loss of confinement and release of hydrocarbon oil and gas. In the event of an accidental release, a high momentum jet fire may result.

The well test area is equipped with appropriate gas and fire detection systems during testing, and covered by the deluge system. Upon detection of fire or confirmed gas, emergency shutdown isolates upstream flow from the well at the vessel well head. The well test area is a Zone 2 hazardous area (an area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time) with all equipment appropriately rated and ignition sources controlled (e.g. burners are located remotely from the area at the aft of the vessel on the port and starboard sides). Well test equipment is also identified as safety critical equipment, and is appropriately certified and inspected prior to use.

8.3.2.2.3.5 Heli-fuel

The drillship has a heli-fuel storage tank and dispenser unit located on the top deck of the Living Quarters, next to the Helideck. While heli-fuel is flammable, it is relatively high flash point liquid (>38°C) that would typically require external heating or contact with a hot surface to ignite. The only potential hot surfaces in the vicinity are on the helicopter itself, and these are not located close to the fuel tanks.

In the event of an ignited spill and fire during refueling, fire size should be limited with emergency shutdown of the pumps and closed drain system for fuel spills. As such, it should be rapidly brought under control by the fire-fighting systems. Foam monitors are provided for coverage of the helideck and the heli-fuel skid is protected by an aqueous film-forming foam (AFFF) system. The helicopter is also unoccupied during refueling operations.

8.3.2.2.3.6 Simultaneous Operations

Drilling operations will be ongoing with other field development activities such as offshore construction and installation.

During construction and installation, the drillship is located a significant distance from any activities associated with the FPSO or Near Shore Hub/Terminal. As a result, there are no significant Simultaneous Operations (SIMOPS) risks. During operation, the drilling/workover operations may be ongoing near the two manifold centers, with drilling and completion, and production simultaneous operations (SIMOPs) ongoing. As a result, there is the potential for SIMOPs related hazards and risks, specifically, a dropped object impacting subsea wells and production infrastructure.

Dropped object excursion in water is extremely dependent on the shape and weight of the object. Long slender objects such as drill pipes may experience an oscillating behaviour and have the potential to land a significant distance from the drop point. Massive, box-like objects such as containers will tend to fall vertically. Typical angular deviations range from 2 degrees for very heavy containers, to 15 degrees for drill pipe (DNV. 2010). As a result, given water depths of approximately 2,800m drill pipe may fall over 700m from the drop location, potentially impacting subsea production flowlines.

In the event of well fluid release subsea in deepwater, low concentrations of gas may migrate to the surface with oil spill from production well fluids. Based on assessment in the drillship HSE Case, loss of buoyancy is not considered a significant hazard, and given water depths it is unlikely that concentrations of gas at the surface would reach flammable limits. Shutdown of well fluid flow is provided at the wellhead Xmas tree or SCSSV which isolate flow from the production wells. Subsea facilities however, contain significant flammable inventories given the length, size and pressure.

8.3.2.2.4 Hazards Relating to FPSO Hydrocarbon Processing

8.3.2.2.4.1 Subsea Production Facilities, Risers and Feed Gas Pipeline

The subsea production facilities include wellheads, Xmas trees, manifolds, dual flowlines, a PLEM and risers for distributing well fluids to and from the FPSO. Nine wellheads are in place for production which are connected by 18” nominal bore flowlines to the subsea manifolds (MC1 and MC3) and PLEM approximately 80 km away from MC1. From the PLEM, a 16” Inner Diameter (ID) flexible riser transports the well fluids to the inlet reception facilities onboard the FPSO. Following topside processing, feed gas is sent to the PLEM via two 18” feed gas export risers. Gas is then routed to the Near Shore Hub/Terminal via a 30” nominal bore feed gas pipeline.

Potential hazardous events associated with the subsea facilities involve loss of containment of well fluids or feed gas. Causes of releases include mechanical failure (e.g., corrosion, erosion, construction defects) and impacts (e.g., dropped objects, or supply vessels impacting risers).

In the event of well fluid or gas release subsea in deepwater, low concentrations of gas may migrate to the surface with oil spill from production well fluids. Given the water depths, it is unlikely that concentrations of gas at the surface would reach flammable limits. Shutdown of well fluid flow is provided at the wellhead Xmas tree or SCSSV which isolate flow from the production wells. Isolation of a feed gas release is provided at the FPSO by the riser boarding valve, the PLEM subsea SSIV, and at the Near Shore Hub/Terminal riser platform by the riser boarding valve. Subsea facilities however, contain significant flammable inventories given the length, size and pressure.

Risers present a significant fire hazard. They are high pressure, contain significant inventories and may be located relatively close to other process equipment and facilities manned areas. Two of the six production facility major accidents reviewed in the accidentology involved risers. On the FPSO, the risers are located amidships, some distance from the accommodations. Subsea isolation valves (SSIV) are also provided at the PLEM to isolate flow from subsea production systems and feed gas pipeline.

Risks associated with subsea production facilities, risers and feed gas pipeline are managed through various other safeguards and controls including inspection and pigging; material selection; cathodic protection; corrosion inhibitors; and subsea paint/coatings. Except for risers, subsea equipment is also located a significant distance away from the FPSO and avoids facility dropped object risks.

8.3.2.2.4.2 Processing Well Fluids

Well fluids are distributed from the PLEM to the FPSO reception facilities, via the 16” flexible import riser, for processing. During topsides processing, condensate is separated and stabilized prior to storage within the hull condensate storage tanks. Following separation, gas is dehydrated and undergoes dewpointing before distribution to the Near Shore Hub/Terminal via the feed gas export risers and feed gas pipeline. The FPSO process systems contain significant inventories of hydrocarbon gas and liquid condensates.

Failures or releases from process equipment could lead to hydrocarbon releases and subsequent ignition causing flash fire, explosion, jet fire and pool fires. Depending upon the extent and severity of these events, they have the potential to result in significant fatality.

The slug catchers; and medium pressure (MP), low pressure (LP) low low pressure (LLP) separators, all contain significant liquid inventories. Gas inventories associated with the expander scrubber and low temperature separator are also significant and at high pressure. However, in general the FPSO process is relatively simple with minimal processing. In addition, with minimal topsides processing, there is good separation between process facilities and accommodations (~30m).

Risks associated with the FPSO topsides processing are also managed through various other safeguards as described in Section 8.3.2.2.2.1.

8.3.2.2.4.3 Condensate Storage

Following processing in the LLP separator, stabilized condensate is routed to one of nine condensate storage tanks located within the hull. Condensate is stored in the FPSO hull until offloading operations are undertaken via offtake tanker.

Condensate tanks are provided with fuel gas blanketing (to help ensure the tank vapour space is not within flammable limits) and deck heaters are installed on the main deck to help ensure temperatures are maintained above the wax temperature of the condensate.

Condensate storage presents risks of potentially tank releases or storage tank fires or explosions. Condensate release from the cargo tanks could be caused by overfilling, operator error, structural failure or vessel collision. Fire or explosion can occur upon failure of the gas blanketing system, air ingress into to the tanks, or jet fire impingement on tank tops. Condensate spill to sea, causing pollution would vary dependent on the location, tank fill level, and size of the release.

Risks associated with condensate storage are managed through various safeguards including a double hull design; inspection and maintenance of tanks; cargo monitoring systems (including level, temperature and pressure monitoring with safety instrumented function to close tank filling valves and divert to next tank in loading sequence); deck coaming; 500 m safety zone for the FPSO; inert gas system; storage and transfer procedures; and tank entry procedures.

8.3.2.2.4.4 Condensate Offloading

The condensate offloading system is installed at the Southern end of the FPSO and allows for transfer via a dual or double carcass floating hose to deliver the offloading parcel requirement of 950,000 bbls (approximately 116,500 m^3) in 20 hours. In case of hose connection failure (e.g., offtake tanker loss of position, incorrect hose hook-up, hose degradation or passing vessel collision severing the hose), spill and pollution could result.

Risks associated with condensate offloading are managed through various safeguards and controls including a double carcass design for containment; marine breakaway coupling connection to the offtake tanker with a hose end valve to isolate flow; low initial transfer rate while the system is inspected for leaks; continuous hawser load monitoring and an emergency shutdown system for cargo pumps and cargo valve. There is also a 500 m safety zone around the FPSO for passing marine traffic.

In addition to release from offtake hose, there is the potential for offtake tanker collision with the FPSO. Condensate offload operations is carried out via tandem offloading. The separation distance between the FPSO and the bow of the off-take tanker is approximately 150 m. The mooring system is continuously monitored and equipped with a quick release feature if needed. Hold back tugs will also be available if required during adverse weather or sea states.

8.3.2.2.5 Hazards Relating to Near Shore Hub/Terminal LNG Processing

8.3.2.2.5.1 Feed Gas Pipeline, Risers and Riser Platform

From the subsea PLEM, feed gas travels to the Near Shore Hub/Terminal via a single 30” feed gas pipeline to the riser platform. The riser platform is located at the Near Shore Hub/Terminal, connected to the main hub trestle.

Potential hazardous events associated with the feed gas pipeline and import riser involves loss of containment of feed gas. Causes of releases include mechanical failure (e.g., corrosion, erosion, construction defects) and impacts (e.g., dropped objects, supply vessels impacting risers, or fishing trawl boards).

For the feed gas pipeline, should a release occur in shallower water, there is the potential for flammable gas at the surface. The inventory associated with the feed gas pipeline will be significant given its length, size and pressure. The feed gas import riser also presents a significant fire hazard. It is high pressure and contains significant inventory, including that of the feed gas pipeline which is isolated at the PLEM near the FPSO. However, the riser platform at the Near Shore Hub/Terminal is located remote from other facilities and is a significant distance from the QU platform.

From the riser platform, gas is routed along the hub trestle to the FLNG for processing. The riser platform also has facilities for pigging the gas pipeline, along with a fuel gas take off routed via the hub trestle to the QU platform.

Risks associated with the feed gas pipeline and import riser are managed through various safeguards and controls including inspection and pigging; materials selection; cathodic protection; and subsea paint/coatings. In addition, over-trawl protection is provided on the feed gas pipeline to a nominal water depth of 800m.

8.3.2.2.5.2 LNG Processing

LNG processing onboard the FLNG involves receipt of feed gas from the riser platform. Gas is then metered and treated to remove impurities, in particular, CO_2, sulphur compounds, and residual water. Clean gas is then routed to one of the four liquefaction trains, where it is cooled to LNG. During the liquefaction process, heavy ends (Liquefied Petroleum Gases (LPGs)) are separated in the fractionation train. LNG is finally routed to a flash drum before storage in the hull. The various process equipment and systems onboard the FLNG result in typical hydrocarbon related process safety hazards, primarily gas releases, jet fires, flash fires, LNG pool fires, and explosions. However, there are some specific hazards related to the liquefaction process, properties of LNG and the associated refrigeration medium that are discussed further.

The LNG liquefaction process first requires pre-treatment of the natural gas stream to remove impurities such as water, nitrogen, carbon dioxide (CO_2), and other sulfur compounds. The pre-treated natural gas becomes liquefied at a temperature of approximately -160°C and is then ready for storage and transfer. Because LNG is an extremely cold liquid formed through refrigeration, it is not stored under pressure.

The LNG liquefaction process involves use of the PRICO® SMR technology. This technology has the lowest equipment count compared to the other liquefaction process and is one of the simplest. Liquefaction involves feed gas entering the LNG exchanger at feed conditions and being cooled by the cold SMR stream to the required LNG storage conditions. Cooling also condenses any remaining heavy hydrocarbons (and some butane and propane), which are separated in the fractionation train and routed to the fuel gas system. The cold low-pressure refrigerant stream also acts to condense the high-pressure refrigerant stream, prior to the pressure let down stage that provides the necessary heat exchanger cold side temperature differential. The refrigerant system involves three main stages (two compression stages) with intermediary cooling.

LNG is a clear, odourless, non-corrosive, non-toxic, cryogenic liquid at normal atmospheric pressure. However, as with any gaseous material besides air and oxygen, natural gas that is vaporized from LNG can cause asphyxiation due to lack of oxygen. The density of LNG is about half that of water and LNG spilled on water, floats and vaporizes rapidly. General properties of LNG are summarised in Table 8-6.

Table 8-6. Properties of LNG.

Characteristic	LNG Property Detail
Toxic?	No
Carcinogenic?	No
Flammable Vapor?	Yes, as it evaporates to form a vapour
Asphyxiate?	Yes, in a vapor cloud
Extreme Cold Temperature?	Yes
Flash Point	-188ºC
Boiling Point	-160ºC
Auto-ignition Temperature	540ºC
Vapour Flammability Range in Air	5-15% (by volume)
Stored Pressure	Atmospheric
Behavior if Spilled	Evaporates, forming visible “clouds”. Portions of cloud could be flammable or explosive under certain conditions.

The make-up of the SMR may vary depending to maximise efficiency of the LNG process. A typical make-up given in Table 8-7.

Table 8-7. Typical SMR Make-Up.

Compound	Gas Composition
Ethylene	35%
Methane	30%
Propane	25%
Iso-pentane	5%
Nitrogen	5%

As LNG is released to atmosphere, it begins to warm up, returning to a gas. Initially, the gas is colder and heavier than the surrounding air and creates a vapour cloud above the released liquid. As the gas warms up, it mixes with the surrounding air and begins to disperse. The vapor cloud may ignite if it encounters an ignition source while its concentration is within flammable limits. Depending upon congestion and confinement in the area, this may result in a flash fire or explosion

LNG is cryogenic liquid, which if in direct human contact will freeze the point of contact and can result in significant cold burns and fatality. LNG can also cause brittle fracture of carbon and low alloy steel (e.g., vessel hulls and decks, jacket structures, process skids supports), hence the use of stainless steel for primary containment.

When released on water LNG floats and vaporizes. If large volumes of LNG are released, it may vaporize very quickly causing a rapid phase transition (RPT), resulting in overpressures that could potentially damage lightweight structures. Water temperature and the presence of substances other than methane affect the likelihood of an RPT.

The SMR comprises several components, most notably ethylene and propane. Both ethylene and propane are stored and used under pressure, and may therefore present a risk of boiling liquid expanding vapour cloud explosion (BLEVE). Ethylene and propane are flammable and explosive. Ethylene is highly reactive with laminar flame speed (the propagation velocity of the flame normal to the flame front) approximately twice that of methane. It also has a relatively wide vapour flammability range in air (3% - 28% by volume). Given the high reactivity and laminar flame speeds associated with ethylene, there is the potential for very damaging explosions to occur, and in some rare cases, deflagration to detonation transition (DDT).

For offshore facilities, deflagration is the most common form of gas explosion. It is an explosion where the combustion wave propagates at subsonic velocities relative to the unburned gas immediately ahead of the flame front. With deflagration, the flame speed ranges from a few m/s up to 1,000 m/s, with corresponding explosion overpressures of a few mbar to several bar. For higher overpressures, there must be significant confinement and/or congestion.

Detonation is the most damaging form of gas explosion. Unlike the deflagration, detonation does not require significant confinement or congestion to propagate at high velocity. In an unconfined situation, the behaviour of detonation is quite different from deflagration. With detonation, the combustion wave propagates at supersonic velocities (i.e., the detonation front propagates into unburned gas at a velocity higher than the speed of sound in front of the wave). The gas ahead of a detonation is therefore undisturbed by the detonation wave. In fuel-air mixtures at atmospheric pressure, the detonation velocity is typically 1500 – 2000 m/s, with corresponding overpressures up to 15 - 20 bar.

LNG risks are managed through largely similar safeguards to other offshore oil and gas process. This includes appropriate layout and design of process systems; materials selection and use appropriate for containment of cryogenic material; integrity management programs, including inspection, testing, and maintenance of equipment; provision of process safeguarding systems such as instrumentation, overpressure protection, emergency shutdown, and relief and blowdown); along with other safety systems such as fire and gas detection, active and passive fire protection, and explosion rated walls and barriers. Containment systems are also provided to contain smaller cryogenic spill. In addition, as part of the design process, facilities process safety hazards are assessed in detail with facilities designed for anticipated fire and explosion DALs.

Further, equipment will be selected appropriate to the hazardous area zone where it is located.

8.3.2.2.5.3 LNG Storage

LNG is stored in six Moss type spherical tanks onboard the FLNG with an overall capacity of 125,000m^3. The tank structure is spherical in shape, and it is so positioned in the ship's hull that only half or a greater portion of the sphere is under the main deck level. The outer surface of the tank plating is provided with external insulation, and the portion of the tank above the main deck level, covered by a weather protective layer. A vertical tubular support is led from the top of the tank to the bottom, which houses the piping and the access rungs.

Due to the tank design, any leakage would cause the spill to accumulate on the drip tray below the tank. The drip pan and the equatorial region of the tank are equipped with temperature sensors to detect the presence of LNG. This acts as a partial secondary barrier for the tank.

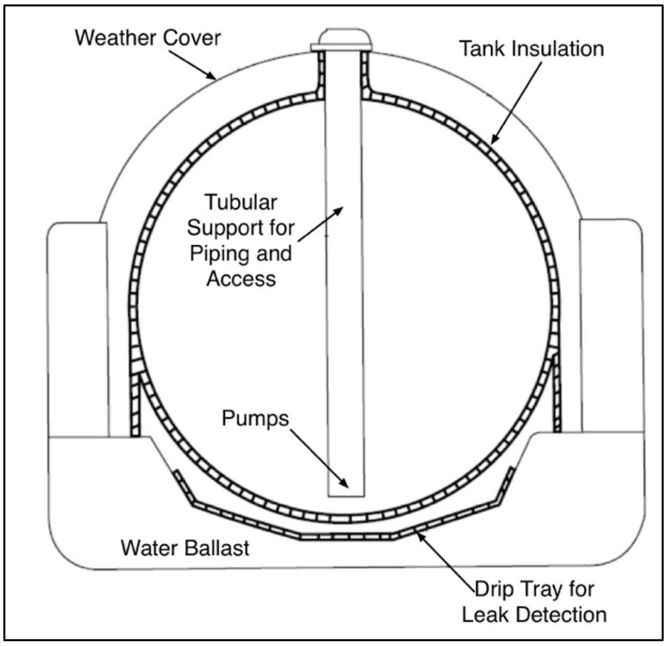


Figure 8-19. Moss LNG Tank Layout.

When LNG of different densities are loaded into a tank, it does not mix immediately. Instead, it layers itself in unstable strata within the tank. As the lower LNG layer heats up, it changes density until it finally becomes lighter than the upper layer and at that point, a liquid rollover occurs. This results in a sudden vapourisation of LNG that may be too large to be released through the normal tank pressure release valves. The excess pressure can result in cracks or other structural failures in the tank. Rollover is primarily a hazard for onshore terminal tanks receiving multiple loads from different vessels with different cargo densities.

The GTA Phase 1 Project LNGC may require two loads to fill its tanks (the total capacity of the LNGC tanks can vary from 150,000 – 180,000m^3 compared to the FLNG tanks of 125,000m^3). As a result, it may take two parcels from the FLNG, several days apart. While rollover risks increase where the LNG has been added to a tank with product that has been stored for a period, it is not considered a significant hazard for GTA Phase 1 Project LNG loading operations. The time between parcels is short and LNG is from the same source with similar density.

In addition to rollover, another hazard associated with shipping of LNG is sloshing. Depending upon LNG tank fill levels, the natural pitching and rolling movement of the ship at sea, along with the liquid free-surface effect, can cause the liquid to move within the tank creating high impact pressure on the tank surface. This effect is called sloshing and can cause structural damage.

However, sloshing is a problem which effects membrane constructed tanks. Independent containment systems such as the spherical Moss design are not subject to the same sloshing impacts. Partial loading at any tank filling level is inherent in the design of Moss design tanks.

8.3.2.2.5.4 LNG Offloading

LNG will be exported from the FLNG across the hub trestle via cryogenic pipework and marine loading arms to the offloading LNGC. The LNGC will be temporarily moored at the trestle after being assisted to berthing by two in-field support tug boats at the Near Shore Hub/Terminal. The FLNG will be equipped with four marine loading arms (two liquid, one vapour and 1 dual/spare) for transfer operations with a maximum offloading rate of 10,000m^3/hr. Vapour return will be handled by the FLNG.

LNG offloading risks include a potential release of LNG during transfer from the FLNG to LNGC. Release of LNG could lead to dispersion to the atmosphere and depending upon congestion and confinement in the area, flash fire or explosion if ignited. LNG contact with equipment however, could lead to brittle fracture of carbon and low alloy steels as well as significant cold burns or fatalities in the event of human contact. If a large amount of LNG is released to sea, it may vaporize very quickly causing a RPT, resulting in overpressures that could potentially damage lightweight structures.

LNG offloading risks are managed through various safeguards and controls including LNG catchment and impounding in the jetty trestle area to contain and restrict the spread of any LNG loading arm release; foam blanketing provided on impounding basin to reduce LNG vaporization rates; and overflow lines directed to sea for cases should the LNG release exceeds the design capacity. In addition, offloading operations are highly controlled and monitored. Closed Circuit Television (CCTV) coverage is provided in the loading area and loading arms are equipped with emergency release systems to isolate flow and limit LNG spilt.

8.3.2.2.6 Hazards Relating to Product Used, Stored or Produced

Oil and gas development and production operations involve significant quantities of hydrocarbons and other hazardous materials that are produced, used and stored. For the purposes of the Risk Study, major hazard inventories are considered. These comprise process safety inventories (i.e., significant quantities of flammable or explosive materials, and/or acutely toxic inventories); inventories with the potential for hazardous events resulting in multiple fatality (e.g. >3); significant spills; and/or far field effects.

These major hazard inventories form a key basis for the assessment of major hazard risk and are documented in Table 8-8.

Table 8-8. Major Hazard Inventories.

Inventory Description	Material	Physical State	Hazards	Pressure bar	Temp ºC	Volume m³	Mass kg
Subsea Production Facilities	Wellfluids	Gas/Two Phase	Flammable, explosive, pollutant	97	3	13,955	1,548,974
Gas Pipeline	Methane	Gas	Flammable, explosive	79	15	15,733	1,101,329
FPSO							
Subsea Injection Chemicals – Corrosion Inhibitor	Solution including petroleum distillate and mineral spirits	Liquid	Health hazard, combustible, pollutant	Atmospheric	Ambient	64.0	49,920
Subsea Injection Chemicals – Methanol	Methanol	Liquid	Flammable	Atmospheric	Ambient	Not Determined. Only used intermittently, for an estimated two complete shutdown and startup events	
Production Chemical – Emulsion Breaker	Hydrotreated light distillates	Liquid	Flammable	Atmospheric	Ambient	7.4	7,326
Condensate Storage Tank 1P	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	12,960	10,406,880
Condensate Storage Tank 1C	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	27,143	21,795,829
Condensate Storage Tank 1S	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	12,960	10,406,880
Condensate Storage Tank 2P	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	19,807	15,905,021
Condensate Storage Tank 2C	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	32,884	26,405,852

Inventory Description	Material	Physical State	Hazards	Pressure bar	Temp ºC	Volume m^3	Mass kg
Condensate Storage Tank 2S	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	19,807	15,905,021
Condensate Storage Tank 3P	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	19,807	15,905,021
Condensate Storage Tank 3C	Condensate	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	32,884	26,405,852
Condensate Storage Tank 3S	Condensate (Offspec)	Liquid	Flammable, tank vapour space explosive, pollutant	Atmospheric	Ambient	19,807	15,905,021
Diesel Storage	Diesel	Liquid	Combustible, pollutant	Atmospheric	Ambient	1,600	1,344,000
Diesel Storage	Diesel	Liquid	Combustible, pollutant	Atmospheric	Ambient	1,600	1,344,000
Diesel Storage	Diesel	Liquid	Combustible, pollutant	Atmospheric	Ambient	533	447,720
Diesel Storage	Diesel	Liquid	Combustible, pollutant	Atmospheric	Ambient	533	447,720
Production Riser	Wellfluids	Gas/Two Phase	Flammable, explosive, pollutant	97	3	437	48,523
Reception Facilities (Gas)	Methane	Gas	Flammable, explosive	93	1.4	143	13,319
Reception Facilities (Liquid)	Condensate	Liquid	Flammable, pollutant	93	1.4	48	36,807
Condensate Separation – MP (Gas)	Methane	Gas	Flammable, explosive	40	45	93	2,887
Condensate Separation – MP (Liquid)	Condensate	Liquid	Flammable, pollutant	40	45	31	23,906
Condensate Separation – LP (Gas)	Methane	Gas	Flammable, explosive	45	12	18	203
Condensate Separation – LP (Liquid)	Condensate	Liquid	Flammable, pollutant	45	12	18	14,417
Condensate Stabilisation – LLP (Gas)	Methane	Gas	Flammable, explosive	65	1.6	9	21
Condensate Stabilisation – LLP (Liquid)	Condensate	Liquid	Flammable, pollutant	65	1.6	26	20,267
Flash Gas Compression	Methane	Gas	Flammable, explosive	39	46	8	154
Fuel Gas System	Methane	Gas	Flammable, explosive	38	45	2	95

Inventory Description	Material	Physical State	Hazards	Pressure bar	Temp ºC	Volume m^3	Mass kg
Gas Treatment and Metering (Gas)	Methane	Gas	Flammable, explosive	91	15	35	3,063
Gas Treatment (Liquid)	Condensate	Liquid	Flammable, pollutant	91	-3.5	2	1,384
Gas Export Riser	Methane	Gas	Flammable, explosive	79	15	437	30,600
Condensate Offloading Hose	Condensate	Liquid	Flammable, pollutant	Atmospheric	Ambient	30	24,413
Near Shore Hub/Terminal							
Trestle Feed Gas Flowline	Methane	Gas	Flammable, explosive	74	16	46	2,919
Metering and Amine Treatment	Methane	Gas	Flammable, explosive	Max 60	44	Not determined [1]	28,670
Dehydration and Regen Compression	Methane	Gas	Flammable, explosive	Max 60	40	Not determined [1]	19,962
Fractionation	Methane, LPG's	Gas/Two Phase/Liquid	Flammable, explosive	30	-40	310	19,250
Liquefaction Refrigerant Closed Loop (x4 Trains)	SMR	Gas/Two Phase/Liquid	Flammable, explosive, cryogenic	10 - 40	45 - 55	148	17,349
Liquefaction Process	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	18	-109	25	11,750
LNG Flash Drum	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	6	-158	64	30,143
Boil off Gas Compression	Methane	Gas	Flammable, explosive	60	36	Not determined [1]	131
Fuel Gas	Methane	Gas	Flammable, explosive	38	45	4	191
Ethylene Make Up	Ethylene	Two Phase/Liquid	Flammable, explosive, cryogenic, BLEVE	3	-83 (bubble point)	20 [2]	11,400
Propane Make Up	Propane	Two Phase/Liquid	Flammable, explosive, cryogenic, BLEVE	9	25	50 [3]	25,500
Iso-pentane Make Up	Pentane	Two Phase/Liquid	Flammable, explosive, cryogenic, BLEVE	1.5	48	75 [4]	46,200
LNG Storage Tank 1	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	Atmospheric	-158	20,833	9,791,667

Inventory Description	Material	Physical State	Hazards	Pressure bar	Temp ºC	Volume m^3	Mass kg
LNG Storage Tank 2	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	Atmospheric	-158	20,833	9,791,667
LNG Storage Tank 3	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	Atmospheric	-158	20,833	9,791,667
LNG Storage Tank 4	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	Atmospheric	-158	20,833	9,791,667
LNG Storage Tank 5	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	Atmospheric	-158	20,833	9,791,667
LNG Storage Tank 6	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	Atmospheric	-158	20,833	9,791,667
LNG Export Piping and Loading Arm	Methane	Two Phase/Liquid	Flammable, explosive, cryogenic	Atmospheric	-158	40	18,800
Diesel Storage (FLNG)	Diesel	Liquid	Combustible, pollutant	Atmospheric	Ambient	4,266	3,583,440
Diesel Storage (QU Platform)	Diesel	Liquid	Combustible, pollutant	Atmospheric	Ambient	400	336,000
Fuel Gas (to QU Platform)	Methane	Gas	Flammable, explosive	38	45	2	95
Drillship							
Diesel (Supply, Settling and Service Tanks)	Diesel	Liquid	Combustible, pollutant	Atmospheric	Ambient	8,458	7,104,720
Base Oil (for Oil Based Drilling Mud)	Mineral Oil	Liquid	Combustible, pollutant	Atmospheric	Ambient	815	684,600
Heli-fuel	Jet Fuel	Liquid	Combustible, pollutant	Atmospheric	Ambient	2.9	2,436
Lube Oil	Oil	Liquid	Combustible, pollutant	Atmospheric	Ambient	190	159,600
Waste Oil	Oil	Liquid	Combustible, pollutant	Atmospheric	Ambient	90	75,600

Notes:
[1] BP MAR Assessment inventory;
[2] 3 x 20 m^3 ethylene make-up tanks per year, one stored on the FLNG at any time
[3] 6 x 25 m^3 propane make-up tanks per year, two stored on the FLNG at any time
[4] 12 x 25 m^3 iso-pentane make-up tanks per year, three stored on the FLNG at any time

8.3.2.3 Major Hazard Categorisation and Initial Listing

All relevant major hazards and associated accident events were documented in a Hazard Register (Goddard. 2018a). Organisation and documentation of hazards in the register is based around the categories of offshore oil and gas related hazards given in ISO 17776: Major Accident Hazard Management During the Design of New Installations (ISO. 2016).

These categories along with associated accident hazard guidewords provide an extensive hazard checklist for GTA Phase 1 Project major hazards. This checklist was used as a final review to capture and organise relevant major hazards (including those discussed in the previous sections), and to help ensure the identification process was robust and comprehensive.

Table 8-9 presents major accident hazards the GTA Phase 1 Project facilities.

Table 8-9. Major Accident Hazards.

Ref #	Hazard Category	Major Accident Hazards
H-01	Hydrocarbons	• Wellfluids (blowout, oil spills, loss of containment of flammable materials) • Pipeline inventories (oil spills, loss of containment of flammable materials) • Riser inventories (oil spills, loss of containment of flammable materials) • Process inventories including methane, condensate, light hydrocarbon liquids, and LNG (loss of containment of flammable materials) • LNG and condensate storage tank inventories (oil spills, LNG spills, loss of containment of flammable materials) • Condensate offloading (oil spills, loss of containment of flammable materials) • LNG export (loss of containment of flammable materials) • LNG refrigerant inventories (loss of containment of flammable materials, BLEVE, possible detonation)
H-02	Refined hydrocarbons	• Diesel fuels (oil spills, loss of containment of combustible materials) • Heli-fuel (loss of containment of flammable materials)
H-03	Other flammables	• Chemical storage (flammable/combustible materials) • Injection chemicals (loss of containment of flammable materials) • Cellulosic materials in accommodation spaces (combustible materials)
H-04	Explosives	• Explosives used for well completion
H-05	Pressure	• Produced water and hydrate formation (leading to oil spill, loss of containment of flammable materials)
H-06	Height difference	• Lifting over live process, risers, pipelines (dropped object leading to oil spill, loss of containment of flammable materials)
H-07	Induced stress	• High loads on risers (leading to oil spill, loss of containment of flammable materials) • High loads on mooring systems (leading to mooring system failures, loss of stability)
H-08	Dynamic situations	• Loss of vessel stability • Major structural failure • Helicopter crash • Fast crew boat foundering • Dropped transfer FROG • Passing vessel collision • Support vessel collision • Condensate offtake tanker collision • LNG carrier collision
H-09	Natural environment	• Extreme weather (contributing to other major accident hazards)
H-10	Hot surfaces	Occupational hazard, not major
H-11	Hot fluids	Occupational hazard, not major
H-12	Cold surfaces	Occupational hazard, not major
H-13	Cold fluids	Occupational hazard, not major

Ref #	Hazard Category	Major Accident Hazards
H-14	Open flame	• Flare problems/issues
H-15	Electricity	Occupational hazard, not major
H-16	Electromagnetic radiation	Occupational hazard, not major
H-17	Ionizing radiation open source	Occupational hazard, not major
H-18	Ionizing radiation closed source	Occupational hazard, not major
H-19	Asphyxiates	Occupational hazard, not major
H-20	Toxic gas	Occupational hazard, not major
H-21	Toxic liquid	Occupational hazard, not major
H-22	Toxic solids	Occupational hazard, not major
H-23	Corrosives	Occupational hazard, not major
H-24	Biological	Occupational hazard, not major
H-25	Human factors	Occupational hazard, not major
H-26	Psychological	Occupational hazard, not major
H-27	Security	• Terrorists or pirates
H-28	Natural resources	• Erosion/degradation of breakwater
H-29	Medical	Occupational hazard, not major
H-30	Noise	Occupational hazard, not major
Note: Ref # is taken directly from ISO 17776 hazard categories (ISO, 2016)		

8.3.3 Preliminary Risk Analysis

Following hazard identification and the documentation of hazards in the hazard register, an initial listing of potential major accident events was developed. This then formed the basis for preliminary risk analysis. The preliminary risk analysis worksheets are given in Appendix O-2. These worksheets contain the assessment of all major hazards and associated accident events, as identified in Table 8-9.

The preliminary risk analysis provided an initial assessment of risk. It was used to evaluate event causes and consequences, along with the controls in place to prevent, control and mitigate hazardous effects. In addition, the analysis was used to identify major accident events to be subject to more detailed assessment of consequences and risk.

The risk of a major hazardous event is the combination of the likelihood of the realisation of the event and the severity of such an event. The preliminary risk analysis process involved risk ranking each hazardous event by considering the likelihood of occurrence and the severity of the potential harm.

Risk were ranked using the Republic of Senegal (2005) Risk Study Guide risk matrix, as shown in Figure 8-20. The risk matrix provides a powerful and easy-to-use tool for the identification, assessment, and prioritisation of risk. An initial risk ranking was assigned by considering the hazard and potential consequences without any safeguards. Safeguards were then identified and a residual risk assessed. This process helped identify whether existing safeguards were sufficient, or whether further safeguards were required.

The preliminary risk analysis was used to define major accident events for subsequent detailed risk analysis. Specifically, those events with a consequence ranking of Catastrophic (several deaths; extensive damages; long production halt) or Critical (life-long handicapping injury; 1-3 deaths;

significant damages; production halt; significant environmental effects) were carried forward for further analysis.

An estimate of the accident kinetics was also made. This was used to characterize qualitatively the speed at which the undesired event takes place, and to assess the responsiveness of the intended safeguards. Kinetics are represented by the letters “R” (“rapid”), “M” (“moderate”), and “S” (“slow”).

Table 8-10 then presents a summary of the results, specifically, events with consequences ranked Catastrophic or Critical, the likelihood (L), severity (S) and risk ranking (RR), the kinetic (K), and consequence effects of interest for more detailed analysis. Consequence of interest were defined in terms of:

- Oil spill
- Cryogenic spill (including gas dispersion from flashing release/liquid pool, where relevant explosion, and pool fire effects)
- Explosion (including assessment of flammable gas cloud volumes)
- Fire (including jet fire, pool fire and BLEVE effects)
- Fatality

Within Table 8-10, some events are rationalised under a single major accident event heading. For all major accident events, a unique reference number is also provided with ‘D’ denoting Drillship events, ‘F’ denoting FPSO events, and “N’ denoting Near Shore Hub/Terminal events. Major accident events for detailed risk analysis are then summarised in Figure 8-21.

LEVEL OF RISK		Severity (S)				
		5 Catastrophic	4 Critical	3 Significant	2 Minor	1 Negligible
Likelihood (L)	5 Constant	U	U	U	U	S
	4 Frequent	U	U	U	S	S
	3 Occasional	U	U	S	S	A
	2 Rare	U	S	S	A	A
	1 Unlikely	S	S	A	A	A

Score	Likelihood (L)	Severity (S)
1	**Unlikely**: Never seen in this industrial sector; nearly impossible in the establishment	**Negligible**: Minor impact on employees; No production halt; Low environmental effects
2	**Rare**: Already encountered in this industrial sector; possible in the establishment	**Minor**: Medical attention for employees; Minor damages; Small loss of production; Minor environmental effects
3	**Occasional**: Already encountered in the establishment; occasional, but may happen a few times in the establishment	**Significant**: Seriously injured employees (prolonged halt of work); Limited damages; Partial halt of production; Localized environmental effects
4	**Frequent**: Happens 2 to 3 times a year in the establishment	**Critical**: Life-long handicapping injury, 1-3 deaths; Significant damages; Production halt; Significant environmental effects
5	**Constant**: Happens several times yearly in the establishment (more than 3 times a year)	**Catastrophic**: Several deaths; Extensive damages; Long production halt

U (RED)	**Unacceptable high risk** which is going to require a detailed study of major accident. The establishment must take immediate reductive measures in putting into place means of prevention and protection. Priority 1.
S (YELLOW)	**Significant risk**. The establishment must propose a reductive plan to be put into place over the short, medium and long term. Priority 2.
A (GREEN)	**Acceptable risk**. No additional action is required. Priority 3.

Figure 8-20. Major Hazard Risk Matrix.

Table 8-10. Summary of Preliminary Risk Analysis Results.

ID	Event	L	S	RR	K	Feared Effect/ Consequence of Interest	Major Accident Event	
Drillship								
H-01.02.01	Well blowout during drilling, or completion (subsea or surface flow)	1	5	S	R	Oil Spill; Explosion; Fire; Fatality	D-01	Blowout or Well Release
H-01.02.03	Well blowout during production (subsea flow)							
H-01.06.03	Well fluid release from subsea wells wellheads (9) – inboard the tree wing valve							
H-01.06.01	Hydrocarbon release from drillship mud/gas separator or degasser	1	4	S	R	Explosion; Fire; Fatality	D-02	Gas Release in Mud Processing Area
H-01.06.02	Fire or explosion in the drilling-mud return areas (shale shakers)							
H-01.02.02	Hydrocarbon leaks or spills during well testing	1	4	S	R	Fire; Fatality	D-03	Hydrocarbon Release during Well Testing or Clean-up
H-08.00.01	Loss of stability of the drillship	1	5	S	S	Fatality (may result in D-01 Blowout or Well Release)	D-04	Loss of Vessel Stability/Capsize
H-08.03.01	Helicopter crash	1	5	S	R	Fatality	D-05	Transportation (Helicopter) Accident
H-08.04.02	Passing vessel collision with drillship	1	5	S	M	Fatality (may result in D-01 Blowout or Well Release)	D-06	Passing Vessel Collision
FPSO								
H-01.06.10	Well fluid release from production riser to FPSO	1	5	S	R/M	Fire; Fatality	F-01	Hydrocarbon Release from Production Riser
H-07.01.01	High load on FPSO risers							
H-07.01.02	Mooring system failure							
H-07.01.01	High load on FPSO risers	1	5	S	R/M	Fire; Fatality	F-02	Gas Release from Export Gas Risers
H-07.01.02	Mooring system failure							
H-01.06.22	Gas release from export gas risers from FPSO (x2)							

ID	Event	L	S	RR	K	Feared Effect/ Consequence of Interest	Major Accident Event	
H-01.06.11	Gas (including well fluid) release from FPSO inlet header or slug catcher tops (95 barg, 0ºC)	1	4	S	R	Explosion; Fire; Fatality	F-03	Gas Release from Reception Facilities (Slug Catchers)
H-01.05.01	Flammable Liquid release from FPSO slug catcher bottoms or heat exchanger (2 x 50%) (90 barg)	1	4	S	S	Explosion (Flashing Liquid); Fire; Fatality	F-04	Liquid Release from Reception Facilities (Slug Catchers)
H-01.06.19	Gas release from gas treatment (expander scrubber inlet cooler, expander scrubber tops, turbo expander (81 barg, -2.8ºC)	1	4	S	R	Explosion; Fire; Fatality	F-05	Gas Release from Gas Processing
H-01.06.20	Gas release from low temperature separator (75 barg, -13ºC)							
H-01.06.21	Gas release from export gas metering packages (78 barg, -4.3ºC)							
H-01.05.08	Condensate release from FPSO expander scrubber bottoms	1	4	S	S	Explosion (Flashing Liquid); Fire; Fatality	F-06	Liquid Release from Gas Processing
H-01.05.02	Flammable liquid release from FPSO condensate separation medium pressure separator bottoms (39 barg, 45ºC)	1	4	S	S	Explosion (Flashing Liquid); Fire; Fatality	F-07	Liquid Release from MP Separator
H-01.05.03	Flammable liquid release from FPSO condensate separation low pressure separator bottoms and/or heater (10 barg, 43ºC)	1	4	S	S	Explosion (Flashing Liquid); Fire; Fatality	F-08	Liquid Release from LP Separator
H-01.05.04	Condensate release from FPSO condensate stabilisation low low pressure separator bottoms and/or heater (0.8 barg, 74ºC)	1	4	S	S	Fire; Fatality	F-09	Liquid Release from LLP Separator
H-01.06.12	Flammable gas release from FPSO condensate separation medium pressure separator tops (39 barg, 45ºC)	1	4	S	R	Explosion; Fire; Fatality	F-10	Gas Release from Flash Gas Compression
H-01.06.13	Flammable Gas release from FPSO condensate separation low pressure separator tops (10 barg, 43ºC)							
H-01.06.17	Gas release from FPSO flash gas compression (LP flash gas scrubber, compressor, MP flash gas scrubber, compressor)							

ID	Event	L	S	RR	K	Feared Effect/ Consequence of Interest	Major Accident Event	
H-01.06.18	Gas release from FPSO fuel gas system	1	4	S	R	Explosion; Fire; Fatality	F-11	Gas Release from Fuel Gas System
H-03.00.03	Flammable chemical injection release on the FPSO	1	4	S	R	Fire; Fatality	F-12	Injection Chemical Release Topsides
H-01.07.02	Condensate release from FPSO storage tank	1	5	S	M/S	Oil Spill	F-13	Condensate Release from Storage Tank
H-01.07.05	FPSO cargo tanks are over/under pressurized							
H-07.01.02	Mooring system failure							
H-01.07.05	FPSO cargo tanks are over/under pressurized	1	5	S	R/M	Fire; Fatality	F-14	Condensate Storage Tank Fire
H-01.07.03	FPSO condensate storage tank fire							
H-01.07.04	FPSO cargo vapour in the ballast tanks							
H-07.01.02	Mooring system failure	1	5	S	M/S	Fatality (may result in F-13 Condensate Release from Storage Tank)	F-15	Loss of Vessel Stability/Capsize
H-08.00.03	Loss of stability of the FPSO							
H-08.04.01	Fast crew boat founders	1	4	S	R/M	Fatality	F-16	Transportation (Crew Boat/FROG) Accident
H-08.08.01	Dropped Transfer FROG							
H-08.04.05	Condensate tanker impacts FPSO during offload	1	5	S	M	Fatality (may result in F-13 Condensate Release from Storage Tank)	F-17	Condensate Offtake Tanker Collision
H-08.04.02	Passing vessel collision with FPSO	1	5	S	M	Fatality (may result in F-13 Condensate Release from Storage Tank)	F-18	Passing Vessel Collision
Near Shore Hub/Terminal								
H-01.06.25	Gas release from Near Shore Hub/Terminal riser (riser platform)	1	5	S	R	Fire; Fatality	N-01	Gas Release from Import Gas Riser
H-01.06.26	Gas release from piping/flexible hose between riser platform and FLNG	1	4	S	R	Fire; Fatality	N-02	Gas Release from Trestle Feed Gas Flowline/Hose to FLNG

ID	Event	L	S	RR	K	Feared Effect/ Consequence of Interest	Major Accident Event	
H-01.06.34	Fuel gas release from Near Shore Hub/ Terminal (NSH) trestle fuel gas flowline to QU platform	1	4	S	R	Fire; Fatality	N-03	Gas Release from Trestle Fuel Gas Flowline to QU platform
H-01.06.27	Gas release from FLNG gas metering or High Pressure (HP) separator	1	4	S	R	Explosion; Fire; Fatality	N-04	Gas Release from FLNG Inlet Metering and Amine Treatment
H-01.06.28	Gas release from FLNG gas filter, contactor feed exchanger or amine contactor							
H-01.06.29	Gas release from FLNG mol sieve inlet scrubber, filter, dehydrator or Mercury removal vessel	1	4	S	R	Explosion; Fire; Fatality	N-05	Gas Release from FLNG Dehydration and Regeneration
H-01.06.31	Gas release from Boil-off Gas (BOG)/flash gas compression or exchangers	1	4	S	R	Explosion; Fire; Fatality	N-06	Gas Release from FLNG Boil Off Gas/Flash Gas Compression (FGC)
H-01.06.35	Fuel Gas Release from FLNG Fuel Gas System (HP)	1	4	S	R	Explosion; Fire; Fatality	N-07	Gas Release from FLNG HP Fuel Gas System
H-01.06.30	Flammable gas release from FLNG fractionation	1	4	S	R	Explosion; Fire; Fatality	N-08	Gas Release from FLNG Fractionation
H-01.03.01	Light Hydrocarbon Liquid (LPGs) Releases from FLNG fractionation	1	4	S	R	Far Field Flammable Gas; Explosion; Fire, Fatality	N-09	Light Hydrocarbon Liquid Releases from FLNG fractionation
H-01.04.01	LNG release from FLNG liquefaction train	1	4	S	R	Cryogenic Spill; Far Field Flammable Gas; Explosion; Fire, Fatality	N-10	LNG Release from FLNG Liquefaction Process
H-01.04.02	LNG release from FLNG expander, LNG flash drum or transfer pump	1	4	S	R	Cryogenic Spill; Far Field Flammable Gas; Explosion; Fire, Fatality	N-11	LNG Release from FLNG Flash Gas Drum
H-01.03.03	Boiling liquid expanding vapour explosion (BLEVE) from the vessel containing liquefied gas (LPG)	1	4	S	M	Fire; Fatality	N-12	BLEVE of Vessel on FLNG Containing Refrigerant
H-01.03.02.1	LNG refrigerant (LPG) release from drum, compressors or exchangers - gas	1	5	S	R	Explosion; Fire; Fatality	N-13	Gas Release from FLNG SMR Closed Loop

ID	Event	L	S	RR	K	Feared Effect/ Consequence of Interest	Major Accident Event	
H-01.03.02.2	LNG refrigerant (LPG) release from drum, compressors or exchangers - liquid/two phase	1	5	S	R	Cryogenic Spill; Far Field Flammable Gas; Explosion; Fire, Fatality	N-14	Liquid/Two Phase Release from FLNG SMR Closed Loop
H-01.03.04	Refrigerant release (LPG) from FLNG refrigerant make-up (make-up ethylene, propane, & iso-pentane)	1	5	S	R	Cryogenic Spill; Far Field Flammable Gas; Explosion; Fire, Fatality	N-15	Refrigerant Release from FLNG Refrigerant Storage
H-01.06.33	Fuel gas in QU platform utility space/area	2	4	S	M	Explosion; Fire; Fatality	N-16	Gas Release (Fuel Gas) in QU platform Utility Space/Area
H-01.06.16	Gas ingress into FLNG and QU safe areas (e.g. living quarters, FLNG control room, electrical rooms etc.)	1	5	S	M/S	Cryogenic Spill; Far Field Flammable Gas; Fire, Fatality	N-17	LNG Release from FLNG/LNGC Storage Tanks
H-01.04.03	LNG release from storage tank (FLNG or LNGC)							
H-07.02.01	Mooring system failure							
H-01.04.04	LNG release during transfer from FLNG to LNGC (loading arm)	1	4	S	R	Cryogenic Spill; Far Field Flammable Gas; Fire, Fatality	N-18	LNG Release during LNGC Loading
H-08.00.05	Structural failure of QU platform	1	5	S	S	Fatality	N-19	Failure of QU platform Structure
H-08.04.01	Fast crew boat founders	1	4	S	M	Fatality	N-20	Transportation (Crew Boat) Accident
H-08.04.06	LNGC collision at breakwater	1	5	S	M	Fatality (may result in N-17 LNG Release from FLNG/ LNGC Storage Tanks)	N-21	LNG Carrier Collision with Berth
General								
H-27.01.01	Attack from terrorists or pirates	1	5	S	N/A	N/A	G-01	Security Incident [1]

[1] For the purposes of the detailed risk analysis, only bowtie analysis is conducted for piracy and terrorism events. It is impossible to 'quantify' the effects of related events, and they are managed though robust security arrangements, plans and procedures

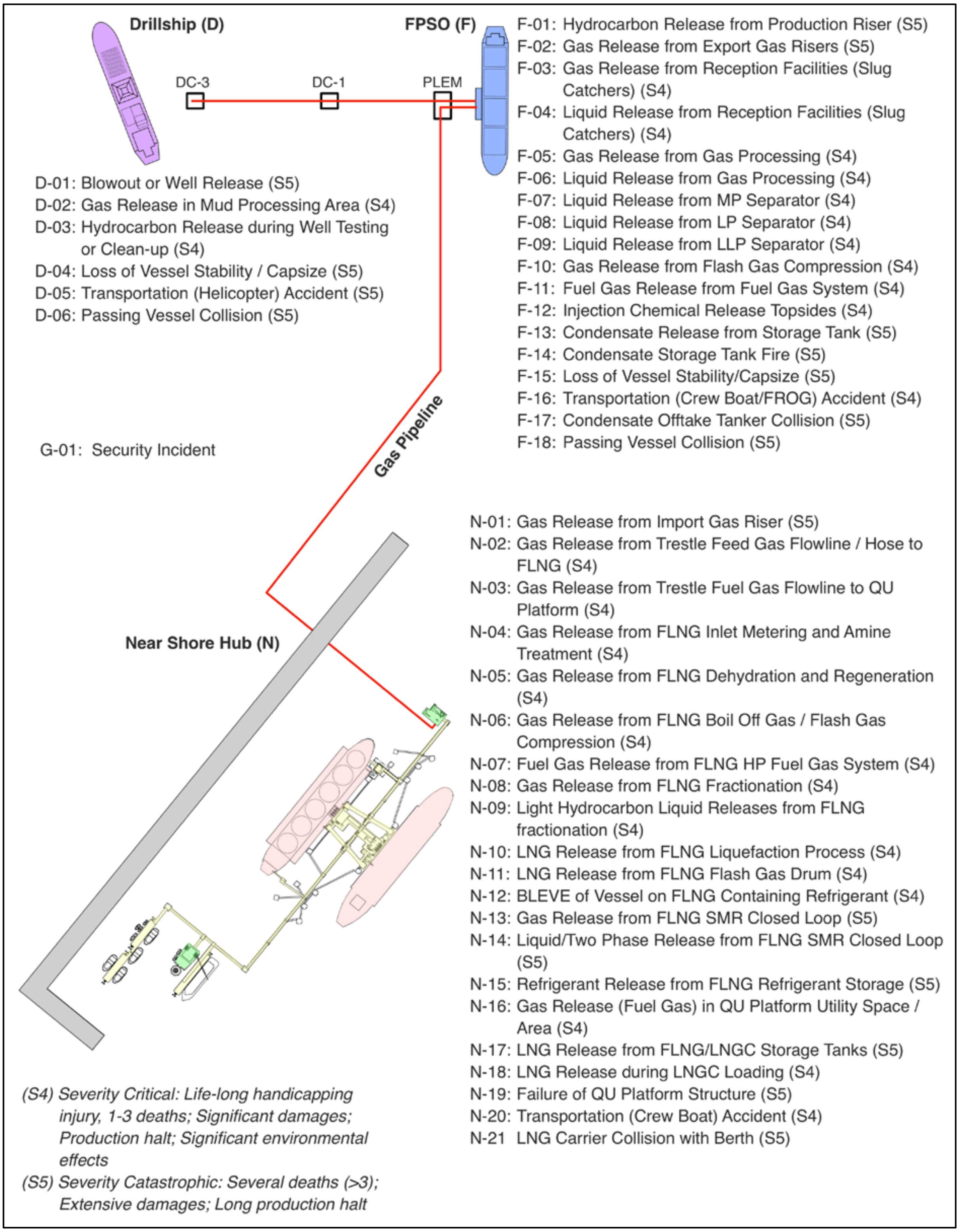


Figure 8-21. Major Accident Events for Detailed Risk Analysis.

8.3.4 Detailed Risk Analysis

Following the preliminary risk analysis and screening of major hazards and associated accident events, detailed risk analysis was undertaken. Detailed risk analysis involved:

1) Modelling to quantify event consequences and effect distances
2) Bowtie analysis to assess existing prevention, control and mitigation barriers
3) Calculation of risk including
    - Frequency analysis
    - Risk to facilities workers
    - Risk of far field impacts

Risk to facilities workers is assessed by calculating fatality rates (the number of fatalities) and the likelihood of fatality. Risk to sea users and neighbouring communities is assessed by considering consequence effect distances, and by calculating fatality risk contours (the likelihood of fatality with distance from the facilities) for the Near Shore Hub/Terminal.

The consequence and risk analysis conducted as part of the Risk Study is supported by detailed standalone studies, specifically:

- Oil Spill Modelling Report – Well Head Failure, given in Appendix N-1
- Oil Spill Modelling Report – FPSO Storage Tank & Diesel Tank Failure, given in Appendix N-1
- Ahmeyim/Guembeul Project Consequence Modelling Report, given in Appendix N-2.
- Ahmeyim/Guembeul Project Concept Risk Assessment (Atkins. 2018)
- Ahmeyim/Guembeul Project Facilities Transportation Hazards Analyses (Goddard. 2018b)
- Ahmeyim/Guembeul Project Facilities Ship Collision Hazards Analyses (Goddard. 2018c)
- Drillship Quantitative Risk Assessment (QRA) Report (Atwood Oceanics. 2014a)
- Drillship Fire and Explosion Risk Analysis (FERA) Report (Atwood Oceanics. 2014b)

Consequence, Bowtie and risk analysis was undertaken for all major accident events identified in the preliminary risk analysis with a severity ranking of Catastrophic (5) or Critical (4) as given in Table 8-10. Given the number of events, only consequence analysis results and Bowties for events ranked Catastrophic are presented in the main body of the Risk Study. Other consequence analysis results are given in Appendix N-2 (and supporting studies) as referenced above. Bowties for major accident events with preliminary risk analysis severity ranking Critical (4) are given in Appendix O-3.

Table 8-11 then summarises the major accident events with preliminary risk analysis severity Catastrophic (5) and relevant consequence effects modelled.

Table 8-11. Major Accident Event with Preliminary Risk Analysis Severity 5.

ID	Major Accident Event Description	Consequence Effect Modelled
Drillship		
D-01	Blowout or Well Release	Oil Spill; Explosion; Fire
D-04	Loss of Vessel Stability/Capsize	See D-01: Blowout or Well Release
D-05	Transportation (Helicopter) Accident	N/A – No consequence to model
D-06	Passing Vessel Collision	See D-01: Blowout or Well Release
FPSO		
F-01	Hydrocarbon Release from Production Riser	Fire
F-02	Gas Release from Export Gas Risers	Fire
F-13	Condensate Release from Storage Tank	Oil Spill
F-14	Condensate Storage Tank Fire	Fire
F-15	Loss of Vessel Stability/Capsize	See F-13: Condensate Release from Storage Tank
F-17	Condensate Offtake Tanker Collision	See F-13: Condensate Release from Storage Tank
F-18	Passing Vessel Collision	See F-13: Condensate Release from Storage Tank
Near Shore Hub		
N-01	Gas Release from Import Gas Riser	Fire
N-13	Gas Release from FLNG SMR Closed Loop	Explosion; Fire
N-14	Liquid/Two Phase Release from FLNG SMR Closed Loop	Cryogenic Spill; Far Field Flammable Gas; Explosion; Fire
N-15	Refrigerant Release from FLNG Refrigerant Storage	Cryogenic Spill; Far Field Flammable Gas; Explosion; Fire
N-17	LNG Release from FLNG/LNGC Storage Tanks	Cryogenic Spill; Far Field Flammable Gas; Fire
N-19	Failure of QU Platform Structure	N/A – No consequence to model
N-21	LNG Carrier Collision with Berth	See N-17: LNG Release from FLNG/LNGC Storage Tanks
General		
G-01	Security Incident	N/A – No consequence to model

8.3.4.1 Quantification of Consequence Effects

8.3.4.1.1 Impairment and Damage Criteria

To assist with consequence effect and risk quantification, specific impairment criteria are defined as they relate to the vulnerability of people, plant or structure to fire, explosion, and cold spill consequences. The key criteria given in Table 8-12 form the basis for the quantification of consequences and risk (République du Sénégal. 2005).

Table 8-12. Impairment and Damage Criteria.

Event	Criteria	Impact
Explosion	0.02 bar	Threshold of irreversible effects corresponding to the area with indirect effects on human beings, threshold of destruction of windows greater than 10%
	0.05 bar [0.035 bar][1]	Threshold of irreversible effects corresponding to the area with significant hazards to human beings, threshold of light damages to structures, destruction of 75% of windows
	0.14 bar [0.07 – 0.20 bar] [1]	Threshold of initial lethal effects, threshold of domino effect, partial collapse of walls and roofs of houses
	0.35 bar [0.20 – 0.40 bar] [1]	Threshold of very significant lethal effects, threshold of very serious damage to structures, destruction of buildings, breaking of pipelines
Fire	3 kW/m^2 [1.6 kW/m^2] [1]	Threshold of irreversible effects, blisters in 30s for unprotected persons
	5 kW/m^2 [4.7 kW/m^2] [1]	Threshold of first lethal effects, threshold of destruction of windows by thermal effect
	10 kW/m^2 [9.5 kW/m^2] [1]	Threshold of very significant lethal effects, third-degree burns, domino effect, risk of fire for combustible materials
	20 kW/m^2 [15.6 kW/m^2] [1]	Destruction or breaking of structural elements, concrete holds for some hours
Flammable Gas	100% Lower Flammability Limit (LFL)	Extent of main flammable gas cloud (limit for possible ignition from remote sources)
BLEVE	600 $kW^{4/3}$ s	Threshold of irreversible effects, blisters in 30s for unprotected persons
	1,000 $kW^{4/3}$ s	Threshold of first lethal effects
	2,600 $kW^{4/3}$ s	Threshold of very significant lethal effects, third-degree burns

[1] These criteria [within square brackets] were used for the drillship consequence analysis reports (OGP. 2010). These criteria are consistent with, but generally more conservative than the Senegal Risk Study Guide criteria

8.3.4.1.2 Modelling Software Basis

Drillship blowout and well release fire effects were modeled using the ComputIT (2017) Kameleon Fire Experiment (KFX) software package, while explosions were modeled using the Gexcon (2017) Flame Acceleration Simulator (FLACS) software package. KFX and FLACS are commercially available computational fluid dynamics (CFD) programs that are used primarily for modeling gas dispersion, fire and explosions effects.

KFX software estimates the intensity of the thermal radiation. FLACS first uses dispersion tools to determine the spread and characteristics of flammable gas, before determining explosion overpressure following ignition.

Blowout oil spill modelling was carried out using the SINTEF (2017b) Oil Spill Contingency and Response (OSCAR) model. OSCAR is a 3D modelling tool used to predict the movement and fate of oil on the sea surface and throughout the water column.

All remaining consequence effects were modelled using the DNV Germanischer Lloyd (GL) (2017) Process hazard analysis software – Phast. Phast is a comprehensive process hazard analysis software tool that examines the progress of a potential incident/accident from the initial release to far-field dispersion analysis, including modelling of pool spreading and evaporation, and fire and explosion effects. Phast uses extensively validated algorithms to determine consequence effects. These algorithms are based on empirical observations rather than on mathematically describable relationships, which form the basis for 3D/CFD tools.

CFD consequence analysis will be conducted as part of the design process as described in Section 8.3.5.3.

8.3.4.1.3 D-01: Blowout or Well Release

In the event of a blowout or a well release, well fluid would be ejected at very high pressure either subsea or in the drill floor area of the drillship, depending on the blowout location.

The immediate consequence of a subsea release or an un-ignited release at the drill floor would be an oil spill since the well fluid contains liquid condensate. This condensate would be released at sea since it would be impossible to contain the oil spill on the vessel.

If the released wellfluids were to ignite, immediate consequences could be an explosion and/or a fire in the drill floor/mud processing area. Personnel near the explosion or fire could be killed immediately. Personnel who survive the initial event would seek egress to the primary safe muster area (forward), or the alternate safe muster area (aft).

Depending upon the duration of the blowout or well release, explosion or fire may result in escalation/domino effects. While attempts would be made to control the accident, if this were not possible, personnel would evacuate the vessel and be rescued at sea.

8.3.4.1.3.1 Oil Spill Effects

Oil spill effects from an un-ignited blowout were modelled based on a spill of 227,000 m^3 of condensate over 60 a day duration. Two scenarios were then considered:

- Scenario 1: Well blowout during boreal summer (April-September)
- Scenario 2. Well blowout during boreal winter (October-March)

Shoreline Impact

A spill at this location (approximately 125 km from the shore) has a 96% probability of making shoreline impact (light oiling or higher) if the spill happens in boreal summer and a 33% chance of shoreline impact if it occurs in boreal winter. Mauritania and Senegal are the only two countries at risk of shoreline impact, but Senegal is most likely to be more severely impacted.

In the worst-case scenario, a spill in boreal summer may impact the shore in approximately 4 days after the release. However, there is a 50% chance that condensate would not make landfall within approximately 2 weeks and in the best-cast scenario condensate wouldn't reach the shore for over 8 weeks. Similarly, the severity of the shoreline impact in boreal summer ranges from negligible (4% chance) in the best-case scenario, to more than 11,000 tonnes in the worst-case. There is a 50% chance that more than 3,000 tonnes could wash ashore. Whilst no "heavy" shoreline oiling is expected in boreal summer, there is an 84% chance that moderate shoreline oiling would occur and could extend up to nearly 300 km. There could also be an additional 185 km of light shoreline oiling.

In the worst-case scenario, a spill in boreal winter could impact the shore in approximately 5 days after the release. However, the similarity between boreal summer and winter ends there since there is a 50% chance that condensate would not make landfall within approximately 7 weeks and in the best-case scenario, condensate wouldn't reach the shore at all. Similarly, the severity of the shoreline impact in boreal winter ranges from negligible in the best-case scenario (67% chance), to more than 2,200 tonnes in the worst-case. Whilst no "heavy" shoreline oiling is expected in the boreal winter, there is an 19% chance that moderate shoreline oiling would occur and could extend up to nearly 54 km. There may also be an additional 98 km of light shoreline oiling.

Surface Impact

Both Mauritania and Senegal waters will be impacted by this spill scenario, along with the waters of several neighboring countries. Whilst more countries would be impacted in the boreal summer scenario (9 countries versus 6 countries in boreal winter), a boreal winter spill is far more likely to impact waters of Cape Verde (51% in boreal summer versus 100% in boreal winter) and The Gambia (42% in boreal summer versus 92% in boreal winter). However, the thickness of the spill is limited to mostly sheen and rainbow sheen that would more readily disperse. A small amount of metallic sheen (>5 μm) may be found in the local area around the well (~25 km). Because of the high turbidity created by the gas at the well site, condensate droplets are very small. Consequentially, they rise more slowly and do not concentrate in the same way as if there was an absence of gas.

Figure 8-22 then shows the overall area impacted by a blowout oil spill by oil spill thickness (given in terms of μm – $1x10^{-6}$ of a meter). Figure 8-23 then shows the overall total maximum oil concentration from a blowout oil spill (given in terms of ppb – parts per billion).

The impact of oil spill on flora and fauna is assessed in Section 7.5, Impacts of Accidental Events.

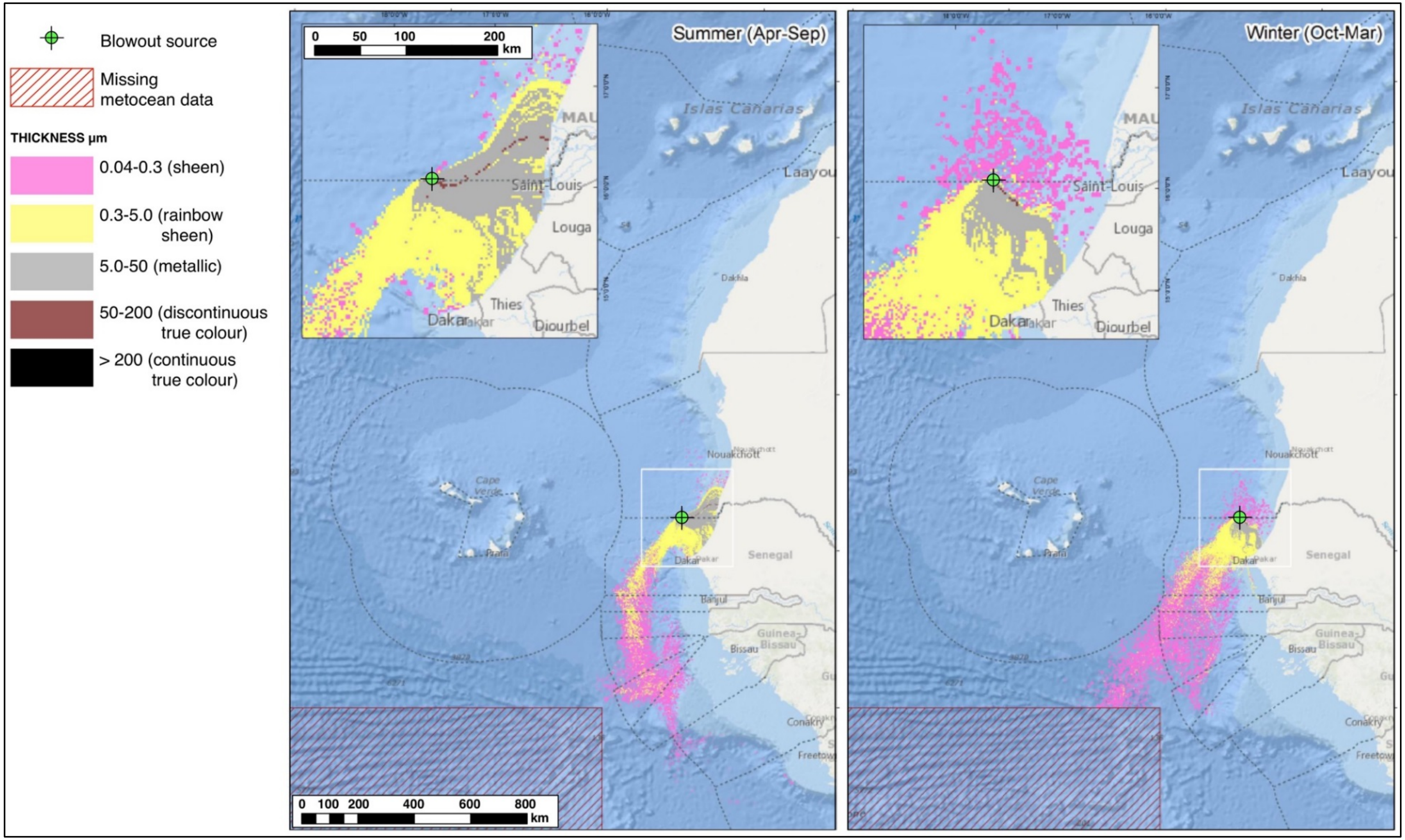


Figure 8-22. D-01 Oil Spill Impacted Area.

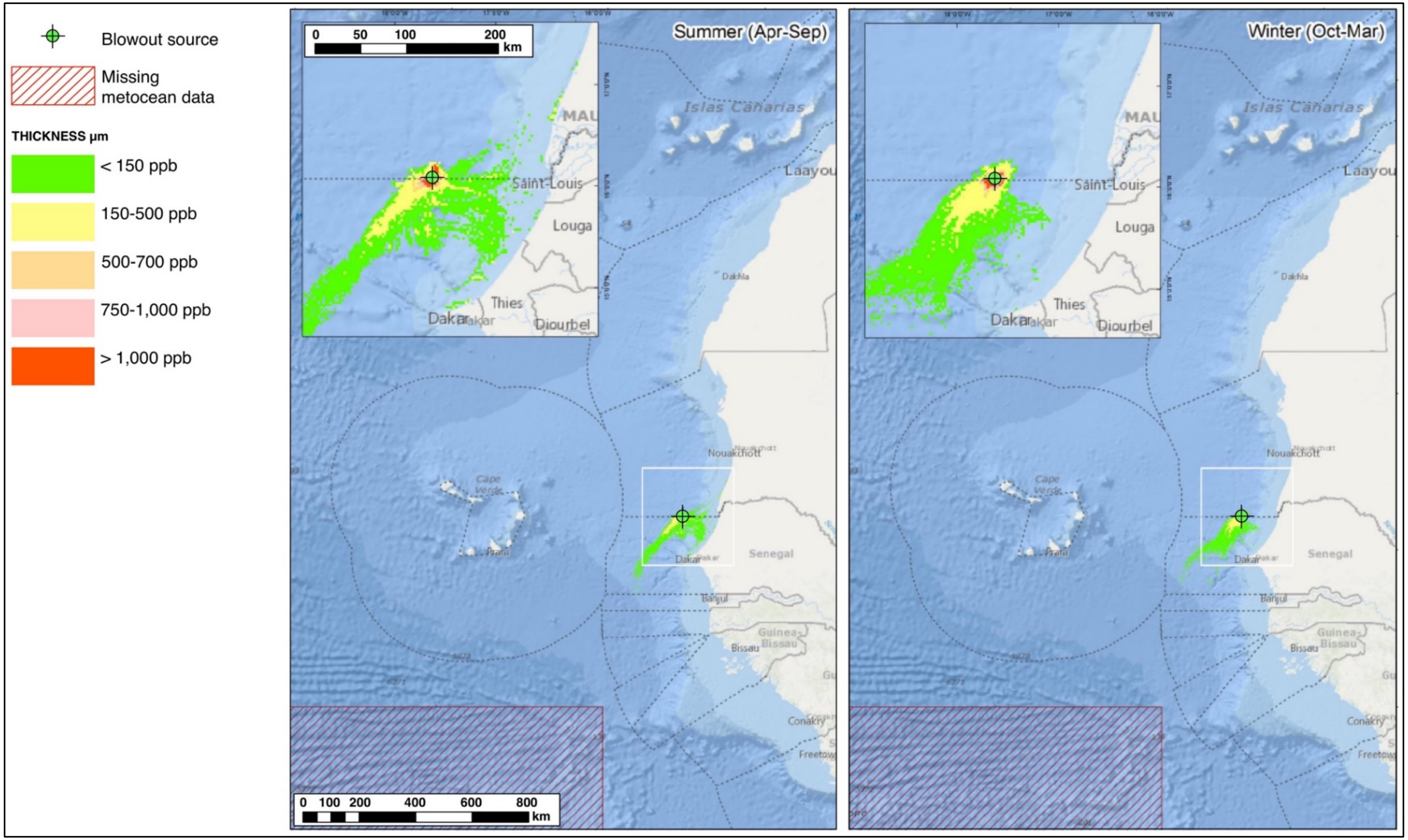


Figure 8-23. D-01 Oil Spill Maximum Total Oil Concentration.

8.3.4.1.3.2 Explosion Effects

Gas dispersion and explosion effects were modeled as high momentum methane blowout releases, assuming discharge rates of 35 kg/s (credible case) and 150 kg/s (worst case – full flow). Based on dispersion results, 11 explosion scenarios were developed with varying gas cloud location, size of volume, and ignition. The largest gas cloud volume of 7,290 m^3 filled the entire drill floor area represents the most conservative case for explosion overpressure modeling. Explosion overpressures from a worst case 150 kg/s blowout are shown in Figure 8-24 for two different location of the ignition source (represented by a white star).

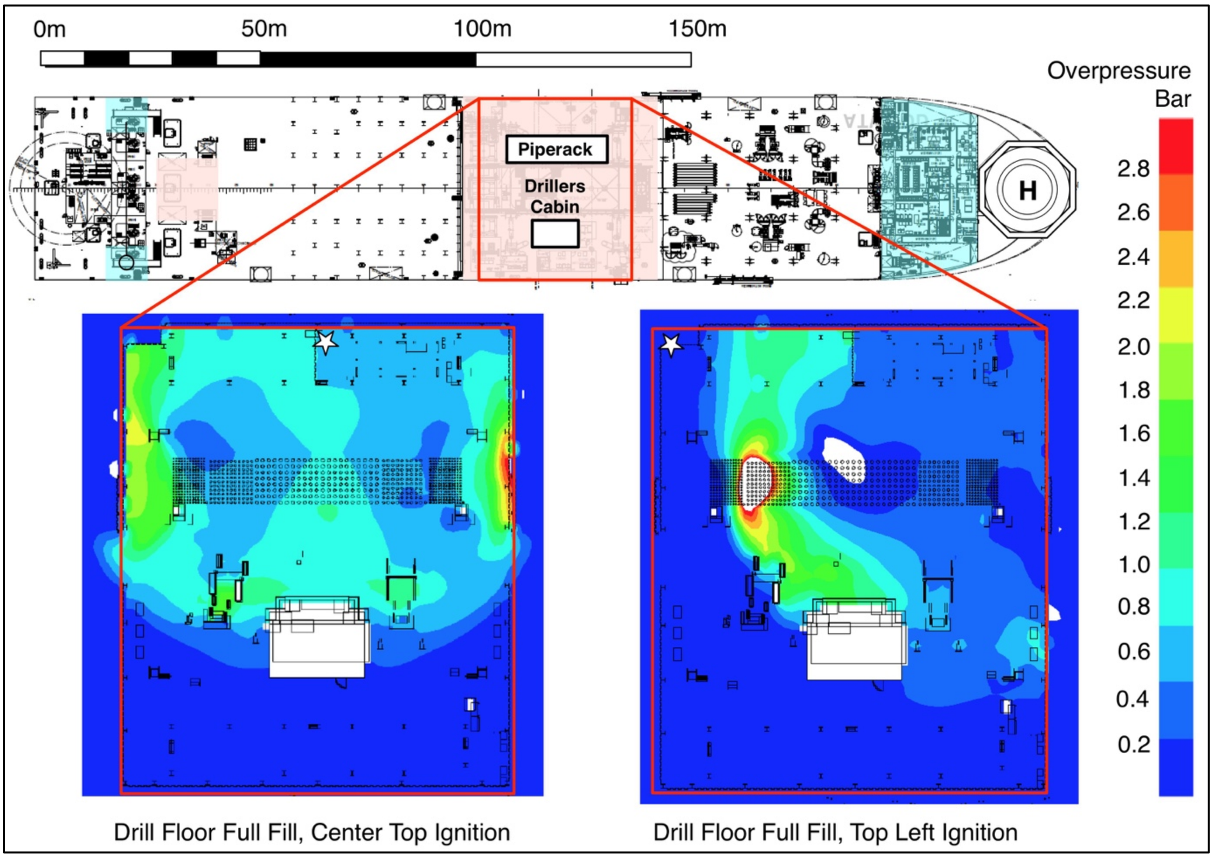


Figure 8-24. D-01/D-02 Worst Case FLACS Explosion Overpressure Modeling.

A maximum overpressure of more than 3 bar can be seen in the area where drill pipe is stacked (piperack). This is caused by the regular arrangement of the drill pipe, which prevents the immediate dispersion of the combustion products after ignition, while also generating strong turbulence in this area. High overpressures (up to 1.4 bar) are also anticipated:

- On the control panels located on the window of the driller's cabin
- On the wall of the tensioner platform carrying the riser, which is directly exposed to the explosion effects in the derrick area

Such overpressures would be extremely damaging, however, are localised and personnel should have been able to evacuate the area before the accumulation of such a large gas cloud. Overpressures in other areas such as the accommodation and alternate muster area are relatively low (less than 0.01 bar).

Other simulations give worst case overpressures at the upper wall of the accommodation facing the derrick, and the funnel structure near the alternate muster area of 0.12 bar and 0.07 bar respectively. Such overpressures are unlikely to result in significant damage to facilities.

8.3.4.1.3.3 Fire Effects

Fires were modeled as high momentum methane blowout releases, assuming discharge rates of 35 kg/s (credible case) and 150 kg/s (worst case – full flow). A vertical release was assumed from the centre of the rotary table, with a 6.1 m/s wind. Thermal radiation from a worst case 150 kg/s blowout is shown in Figure 8-25.

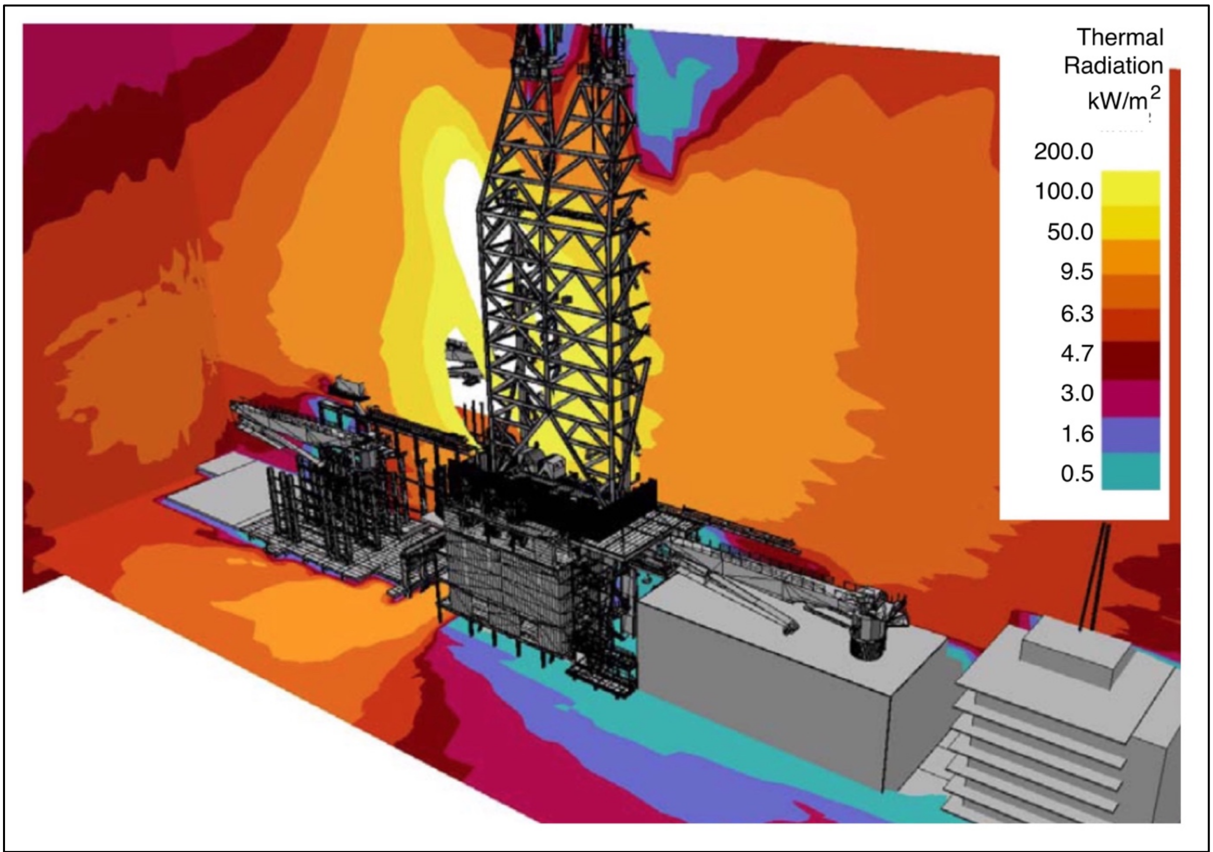


Figure 8-25. D-01/D-02 Worst Case KFX Fire Thermal Modelling.

Along main escape routes, the areas in which thermal radiation exceeds the impairment criteria (4.7 kW/m^2) is limited. The primary and alternate safe muster areas are protected by the accommodation space, and by the rear structure of the funnel respectively, and are exposed to thermal radiation less than 4.7 kW/m^2 allowing for safe muster. Thermal radiation levels along the main evacuation route from the muster areas to the lifeboats are also less than 4.7 kW/m^2.

Fire does not directly impinge on the accommodation in either the 35 kg/s and 150 kg/s blowout cases. However, thermal radiation levels at the upper corner of the accommodation are of the order of 10 kW/m^2 for the higher flow rate blowout. These radiation levels will have no significant impact on the accommodation as it is A-60 fire rated, which includes insulation to protect against the radiant effects of fire.

8.3.4.1.3.4 Summary of Potential Consequence Impacts

The effects of Drillship blowout or well release related fire and/or explosion events are largely limited to the immediate vicinity of the blowout. Given the location of the drillship in deep water with its 500 m safety zone, escalation/domino effects to other facilities are not considered credible. While fatality may result for personnel in the immediate vicinity of the ignited blowout, escape, routes, muster areas, and evacuation facilities should remain available and unimpaired. If the blowout or well release could not be controlled, there is the potential for significant structural damage and possible loss of stability.

Far field impacts may occur because of an oil spill following blowout. This event has the potential to impact the waters and shorelines of Mauritania and Senegal. It also has the potential to impact the waters (but not the shorelines) of Cape Verde, Guinea, Guinea-Bissau, Morocco, Sierra Leone, The Gambia and Western Sahara.

8.3.4.1.4 F-01 and F-02 Releases from Risers

In the event of an accidental release from the production riser or the gas export riser, wellfluids or gas would be ejected at very high pressure near the risers boarding area of the FPSO.

The immediate consequence of an un-ignited release from the production riser would be an oil spill since the well fluid contains liquid condensate. Risers are located outboard of the vessel and oil spill would be directly to sea. Released inventory however would be limited, with a subsea isolation valve (SSIV) provided at the PLEM. There would be no significant immediate consequences for an un-ignited release from a gas export riser, with SSIV’s also provided at the PLEM.

If the released wellfluid or gas were to ignite, immediate consequences would be a jet fire or a fireball near the risers boarding area depending on the size of the release. Personnel present near the fire may be killed immediately. Personnel who survive the initial fire would seek egress to the primary safe muster area (aft), or the alternate safe muster area (forward).

This initial fire may result in escalation/domino effects, including spreading of fire along the FPSO. The potential for escalation/domino effects is limited by the provision of SSIVs at the PLEM and Riser Emergency Shutdown Valves which minimise released riser inventory and reduce event duration. The topside process will also commence blowdown on a confirmed fire. While attempts would be made to control the accident, if this were not possible, personnel would evacuate the vessel and be rescued at sea.

Modelling of fire effects following a release from the FPSO production and gas export risers has been undertaken using input data as summarised in Table 8-13.

Table 8-13. F-01 and F-02 Key Modelling Parameters.

Parameter	Production Riser Input (F-01)	Gas Export Riser Input (F-02)
Assumed Material	Methane	Methane
Pressure (bara)	97	79
Temperature (^{o}C)	3	15
Phase	Gas	Gas
Inventory (kg)	48,523 (riser to SSIV on PLEM)	30,600 (riser to SSIV on PLEM)
Release/Event Duration (mins)	20 minutes for 50 mm release <5 minutes for 400mm full bore rupture (with closing of SSIV’s at the PLEM)	20 minutes for 50 mm release <5 minutes for 450 mm full bore rupture (with closing of SSIV’s at the PLEM)

Ignition following loss of containment from a credible (50 mm) failure is modelled as a horizontal gas jet fire with the thermal radiation effect plot and hazard envelope given in Figure 8-26 (production risers) and Figure 8-27 (gas export riser). Ignition following loss of containment from a worst case (full bore rupture) failure is modelled as a fireball with the thermal radiation effect plot and hazard envelope given in Figure 8-28 (production risers) and Figure 8-29 (gas export riser).

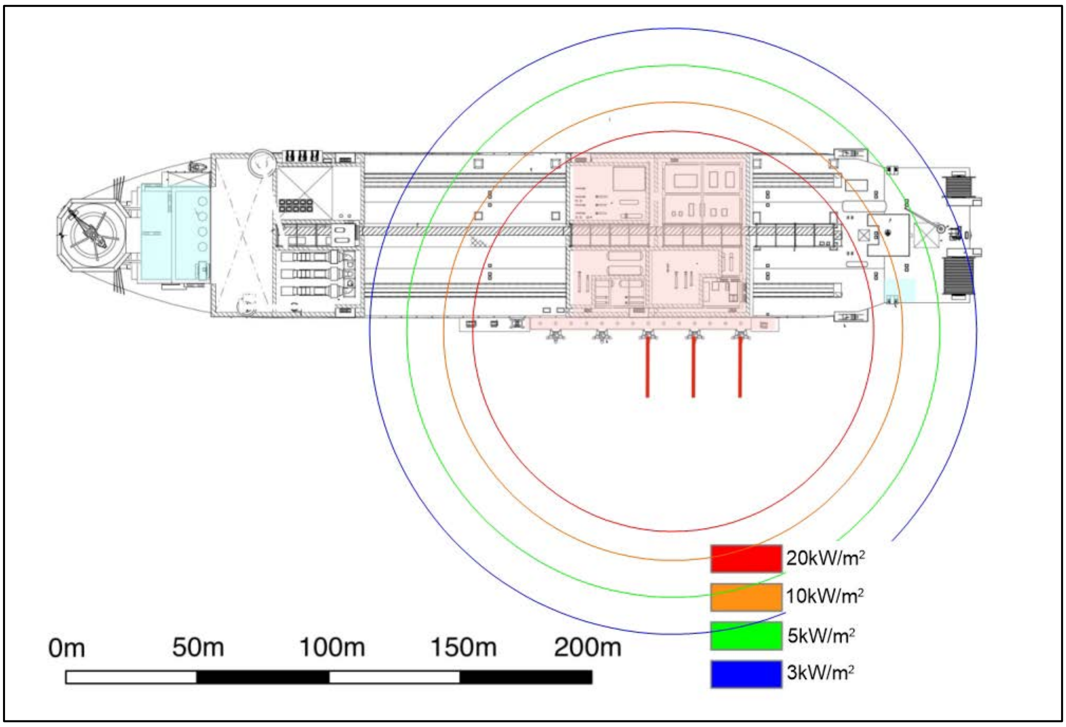


Figure 8-26. F-01 50 mm Failure Jet Fire Effect Distances.

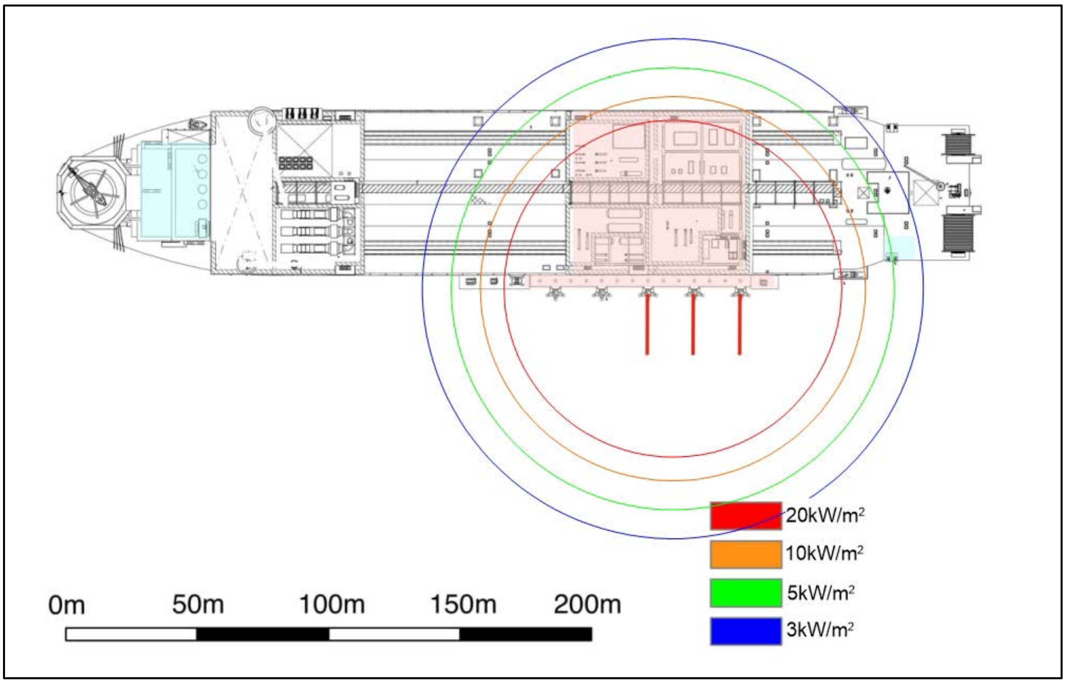


Figure 8-27. F-02 50 mm Failure Jet Fire Effect Distances.

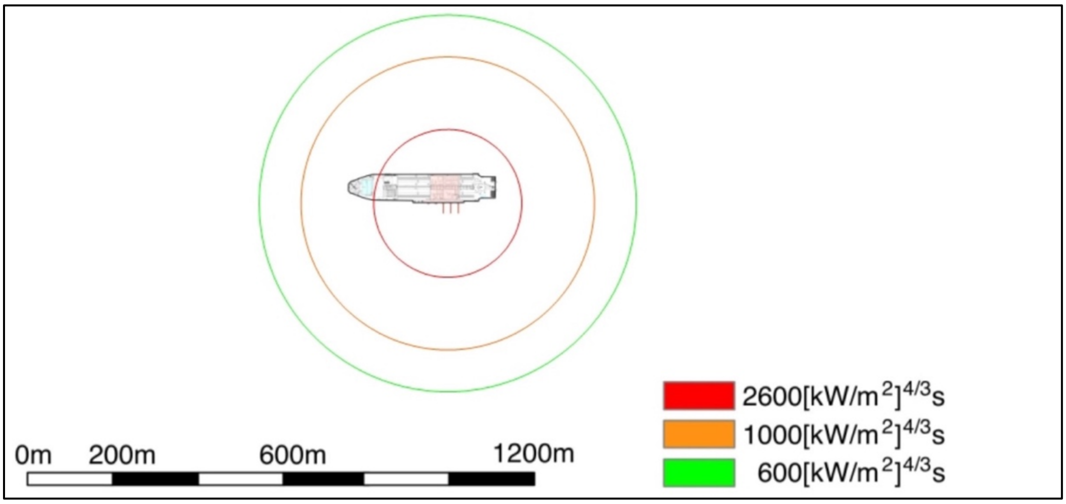


Figure 8-28. F-01 400 mm Full Bore Rupture Fireball Effect Distances.

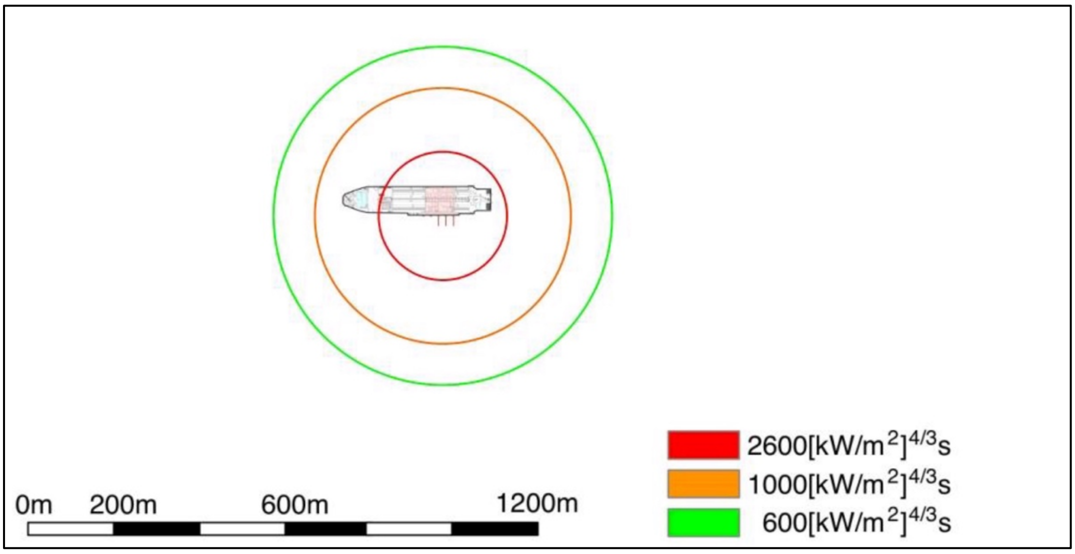


Figure 8-29. F-02 450 mm Full Bore Rupture Fireball Effect Distances.

Potential consequence impacts are summarised in Table 8-14.

Table 8-14. F-01 and F-02 Summary of Potential Consequence Impacts.

50 mm Jet Fire					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Possible	Possible	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire for personnel in unprotected deck areas. Thermal radiation may also impair escape routes along the starboard side near the riser porch. Escape along the port side would only be impaired should the jet fire be directed across the FPSO. This is unlikely with protection provided by the FPSO hull structure. Should both escape routes be impaired, people could egress forward and use the alternate safe muster area and evacuation facilities. Appropriate fire and blast protection should be provided for these facilities. Subsea isolation valves (SSIV) are provided on the production risers (at the PLEM) which should limit jet fire durations to approximately 20 minutes. Fire impingement on the FPSO hull could potentially result in hull failure and storage tank rupture, although some protection is provided by the double hull design. The temporary refuge (TR) is remote from the risers and should not be significantly impacted by the fire event, allowing for an orderly evacuation by lifeboat if required. Thermal radiation levels (3 kW/m^2) extend less than 200m from the FPSO and are well within the 500 m safety zone limit.					
400/450 mm Full Bore Rupture Fireball					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	No	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire for personnel in unprotected deck areas. This may cover a significant area of the FPSO. Thermal radiation may also initially impair escape routes along a significant proportion of port and starboard sides. However, the production and gas export risers are equipped with SSIVs. A primary purpose of these valves is to limit fire effects and duration following catastrophic rupture of a riser. As such, event durations following release should be short with limited potential for long terms impairment of escape routes or escalation/domino effects. As a result, personnel who survive the initial fire should be able to muster safely in the TR with the fire quickly subsiding as inventory quickly depletes. Thermal radiation levels (600 $[kW/m^2]^{4/3}s$) extend less than 450m from the FPSO and are within the 500 m safety zone limit.					
Notes regarding fatality/consequence/impairment/impact: *Yes – Very likely to occur; Possible – Could occur; Unlikely – Very unlikely to occur; No – Will not occur*					

8.3.4.1.5 F-13: Condensate Release from Storage Tank

In the event of an accidental loss of containment of condensate from the FPSO storage tanks, liquid condensate would be released at sea. This may also result in a fire (see consequences in Section 8.3.4.1.6). Such a fire should be limited to the area around the FPSO where the slick thickness is greatest (<0.5 mm) (Vinnem, Jan-Erik. 2014) and a widespread sustained sea fire from a large condensate tank release is considered very unlikely.

Oil spill effects from an un-ignited condensate release from a storage tank were modelled based on a spill of 160,000 m^3 of condensate over 160 hours, and 3,200 m^3 of diesel over 3.2 hours. This was considered the representative of a worst case passing vessel collision event. Two scenarios were then considered:

- Scenario 1: Release during boreal summer (April-September)
- Scenario 2. Release during boreal winter (October-March)

Shoreline Impact

A spill at this location (approximately 40 km from the shore) would have 100% chance of making a significant shoreline impact (light oiling or higher) if the spill happens in boreal summer and an 82% chance of shoreline impact if it occurs in boreal winter. Mauritania and Senegal are the only two countries at risk of shoreline impact, but Senegal is most likely to be more severely impacted.

In the worst-case scenario, a spill in boreal summer could impact the shore 1 day, 14 hours after the release. However, there is a 10% chance that condensate and diesel would not make landfall within 4 days and in the best-cast scenario oil wouldn't reach the shore for 8 days. Similarly, the severity of the shoreline impact in boreal summer ranges from around 1,000 tonnes in the best-case scenario, to more than 20,000 tonnes in the worst-case. There is a 50% chance that more than 9,500 tonnes could wash ashore. A shoreline impact in boreal summer months is expected to have at least moderate shoreline oil. Further, these is a 22% chance of "heavy" shoreline oiling. Spatially, only a few km is expected to have heavy shoreline oiling but up to 323 km could be impacted by moderate oiling.

In the worst-case scenario, a spill in boreal winter could impact the shore in a little more than 2 days after the release. However, the similarity between boreal summer and boreal winter ends there since there is a 50% chance that oil would not make landfall within approximately 5 days and in the best-cast scenario oil wouldn't reach the shore at all. Similarly, the severity of the shoreline impact in boreal winter ranges from negligible (18% chance) in the best-case scenario, to more than 21,000 tonnes in the worst-case. There is a 69% chance of moderate shoreline oiling and 14% chance of light oiling, no heavy shoreline oiling is expected. Spatially, around 25 km is expected to have moderate shoreline oiling but up to 363 km could be impacted by moderate oiling in the worst-case.

Surface Impact

Senegal waters are more than likely to be impacted by this spill scenario, but Mauritania may not due to a southerly flowing current occurring in some scenarios. The waters of Cape Verde, Guinea-Bissau and The Gambia are also at risk in both boreal summer and boreal winter scenarios. The waters of Mauritania and Senegal could experience a spill with a surface thickness more than 5 µm making them candidates for containment and recovery techniques. The waters of other neighbouring countries could experience oil sheen on the surface waters but not at a thickness that would warrant containment and recovery.

Figure 8-30 then shows the overall area impacted by a blowout oil spill by oil spill thickness (given in terms of μm – $1x10^{-6}$ of a meter). Figure 8-31 then shows the overall total maximum oil concentration from a blowout oil spill (given in terms of ppb – parts per billion).

The impact of oil spill on flora and fauna is assessed in Section 7.5, Impacts of Accidental Events.

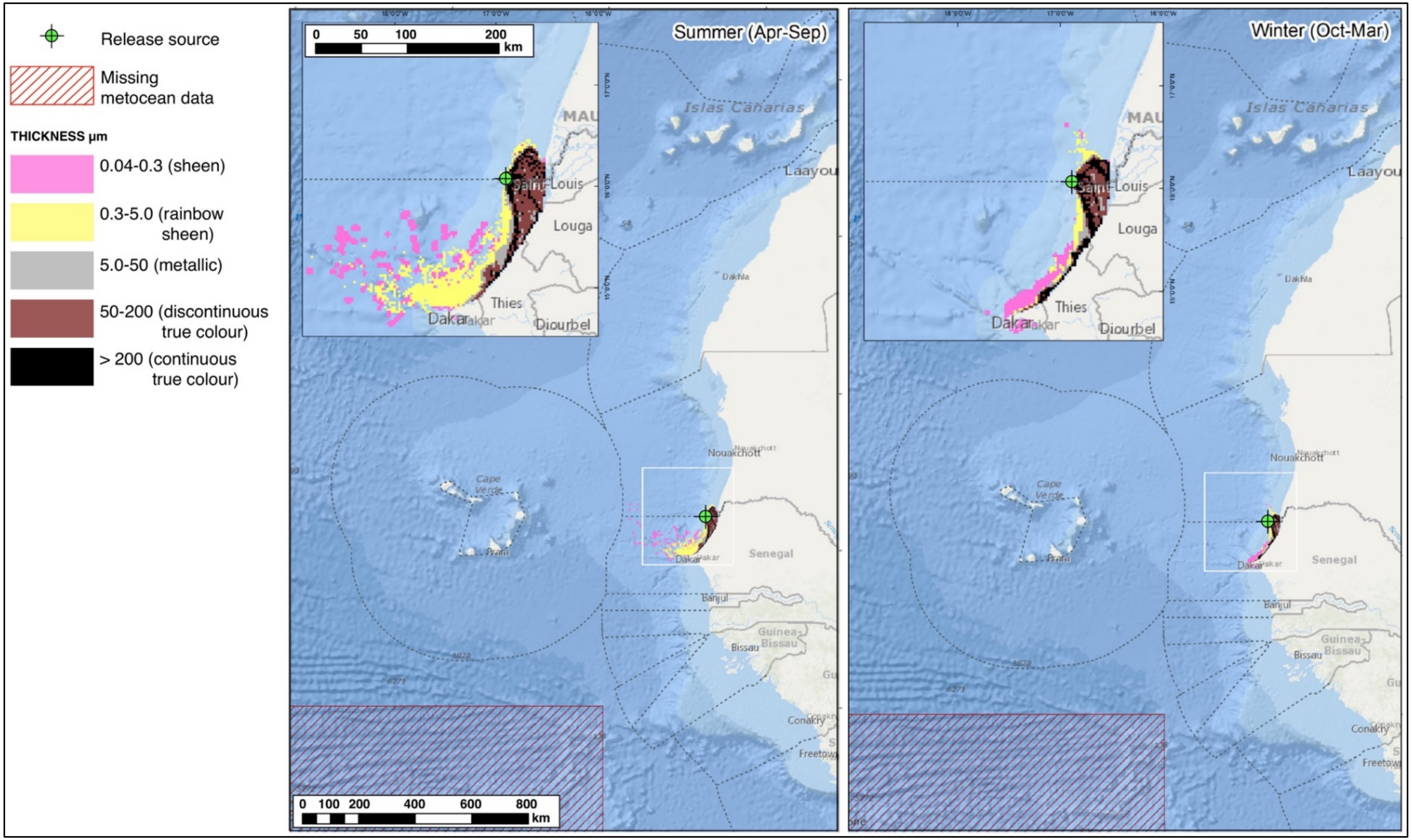


Figure 8-30. F-13 Oil Spill Impacted Area.

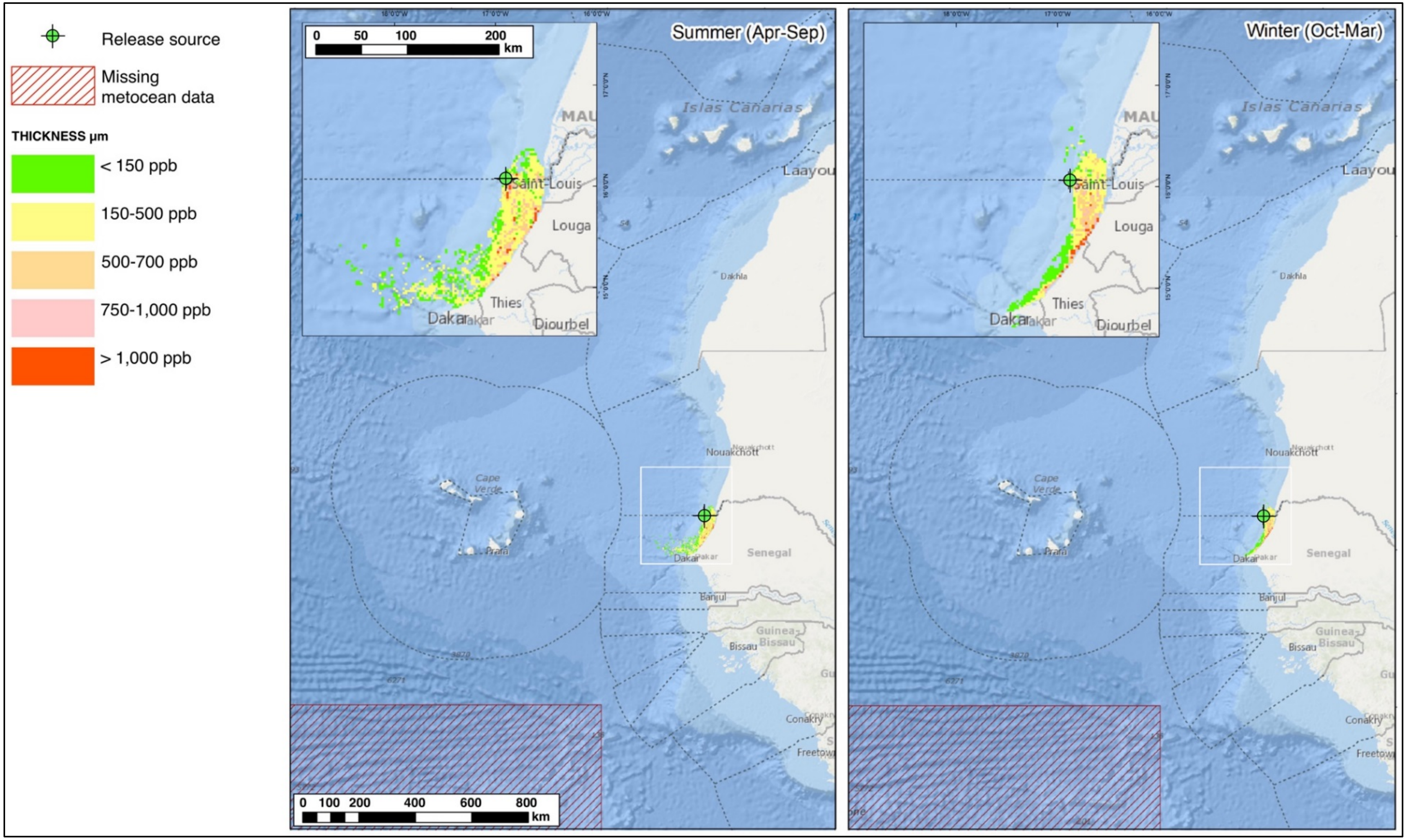


Figure 8-31. F-13 Oil Spill Maximum Total Oil Concentration.

8.3.4.1.6 F-14: Condensate Storage Tank Fire

If a flammable atmosphere were to form inside the condensate storage tank and if this flammable atmosphere were to ignite, this would result in a condensate tank fire.

Personnel should not by impacted by the initial event as confined within the storage tank, and would seek egress to the primary safe muster area (aft), or the alternate safe muster area (forward).

This initial fire may result in escalation/domino effects, including spreading of fire along the FPSO. While attempts would be made to control the accident, if this were not possible, personnel would evacuate the vessel and be rescued at sea.

Consequence modelling of a condensate storage tank fire effects has been undertaken assuming one cargo tank on fire with a total inventory of 26,405,852 kg of condensate at 20ºC. Any fire would continue for a significant time (>60 minutes). Thermal radiation effect plot and hazard envelope are given in Figure 8-32.

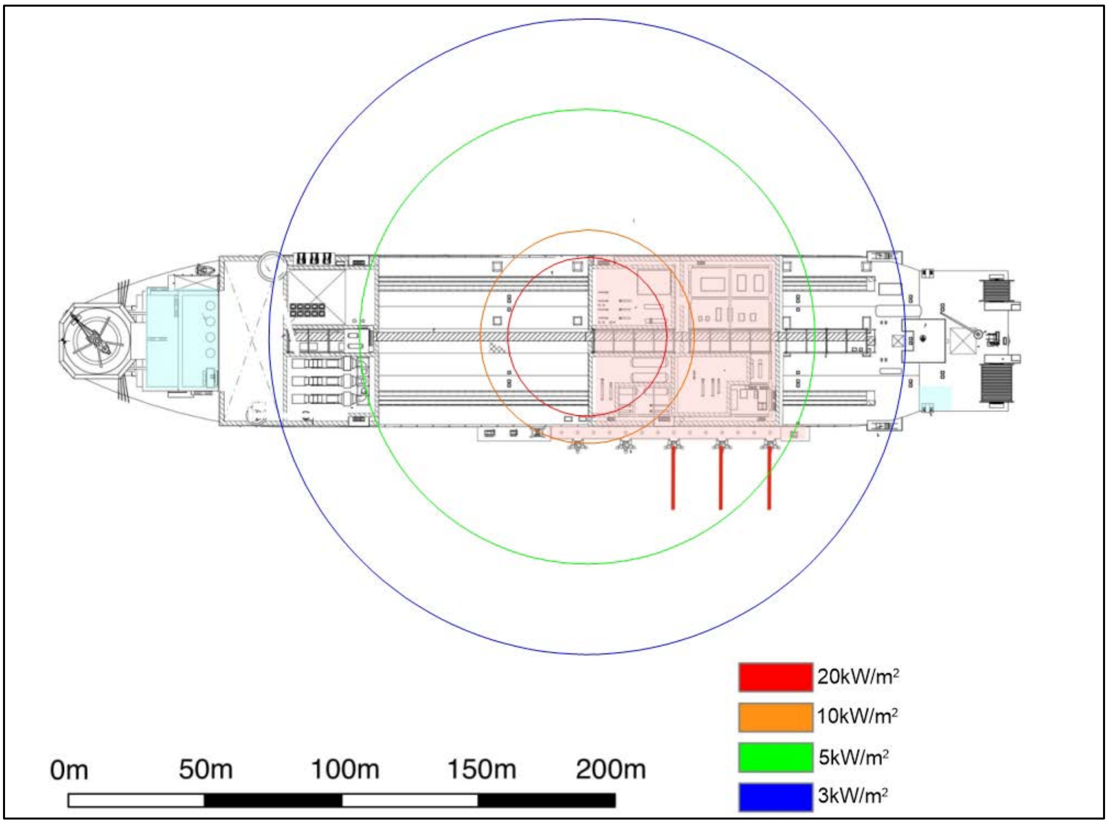


Figure 8-32. F-14 Tank Fire Effect Distances.

Potential consequence impacts are summarised in Table 8-15.

Table 8-15. F-14 Summary of Potential Consequence Impacts.

Tank Fire					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Unlikely	Possible	Yes	Possible	Possible	No
The initial fire would be largely contained within the storage tank and would be unlikely to lead to immediate fatality. As the fire develops, significant quantities of smoke and high levels of thermal radiation could impair escape along port and starboard sides. However, this may take time, depending upon the characteristics of the fire and how effective foam systems were in controlling the event. This may allow time for personnel to escape to the TR (primary safe muster area). In any case, personnel in forward areas could egress to the alternate safe muster area should escape to the TR be impaired. A cargo tank fire is a long duration event and is likely to present a significant threat to the integrity of the FPSO. TR impairment is possible, depending upon the location of the tank fire and how it escalates. However, the TR is protected from fire and smoke and may remain intact for sufficient time for an orderly evacuation to take place. The TR and primary evacuation facilities are also located upwind of prevailing winds to reduce potential for smoke logging and impairment. Thermal radiation levels (3 kW/m^2) extend approximately 200m from the FPSO and are well within the 500 m safety zone limit.					
Notes regarding fatality/consequence/impairment/impact: *Yes – Very likely to occur; Possible – Could occur; Unlikely – Very unlikely to occur; No – Will not occur*					

8.3.4.1.7 N-01: Gas Release from Import Gas Riser

In the event of an accidental release from the gas riser, gas would be ejected at very high pressure at the Near Shore Hub/Terminal riser platform. There would be no significant immediate consequences for an un-ignited release from a gas riser.

If the gas were to ignite, immediate consequences would be a jet fire or a fireball at the riser platform. Personnel present near the fire may be killed immediately. Personnel who survive the initial fire would seek egress via the hub trestle escape route to the primary safe muster area on the QU platform.

Given the large inventory within the gas pipeline from the FPSO, fire may result in escalation/domino effects. The riser platform is remote from other Near Shore Hub/Terminal facilities so these effects may be limited to riser platform and adjacent trestle structure. While attempts would be made to control the accident, if this were not possible and the integrity of the QU platform TR were threatened, personnel would evacuate from the Near Shore Hub/Terminal via Crew Boat, or lifeboat (and be rescued at sea).

Modelling of fire effects following a release from the Near Shore Hub/Terminal gas import riser has been undertaken using input data as summarised in Table 8-16.

Table 8-16. N-01 Key Modelling Parameters.

Parameter	Input
Assumed Material	Methane
Pressure (bara)	74
Temperature (^oC)	16
Phase	Gas
Inventory (kg)	1,101,329
Release/Event Duration (mins)	>60

Ignition following loss of containment from a credible (50 mm) failure is modelled as a horizontal gas jet fire with the thermal radiation effect plot and hazard envelope given in Figure 8-33. Ignition following loss of containment from a worst case (450 mm full bore rupture) failure is modelled as a fireball with the thermal radiation effect plot and hazard envelope given Figure 8-34.

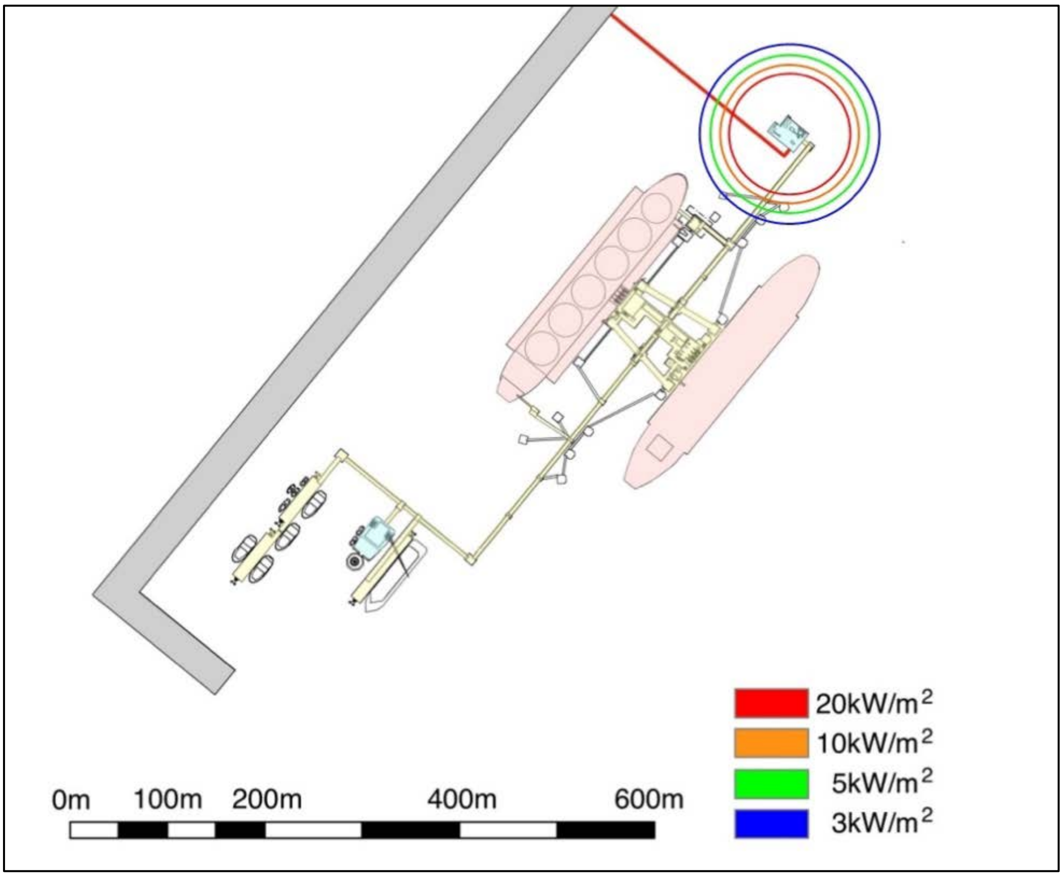


Figure 8-33. N-01 50 mm Release Jet Fire Effect Distances.

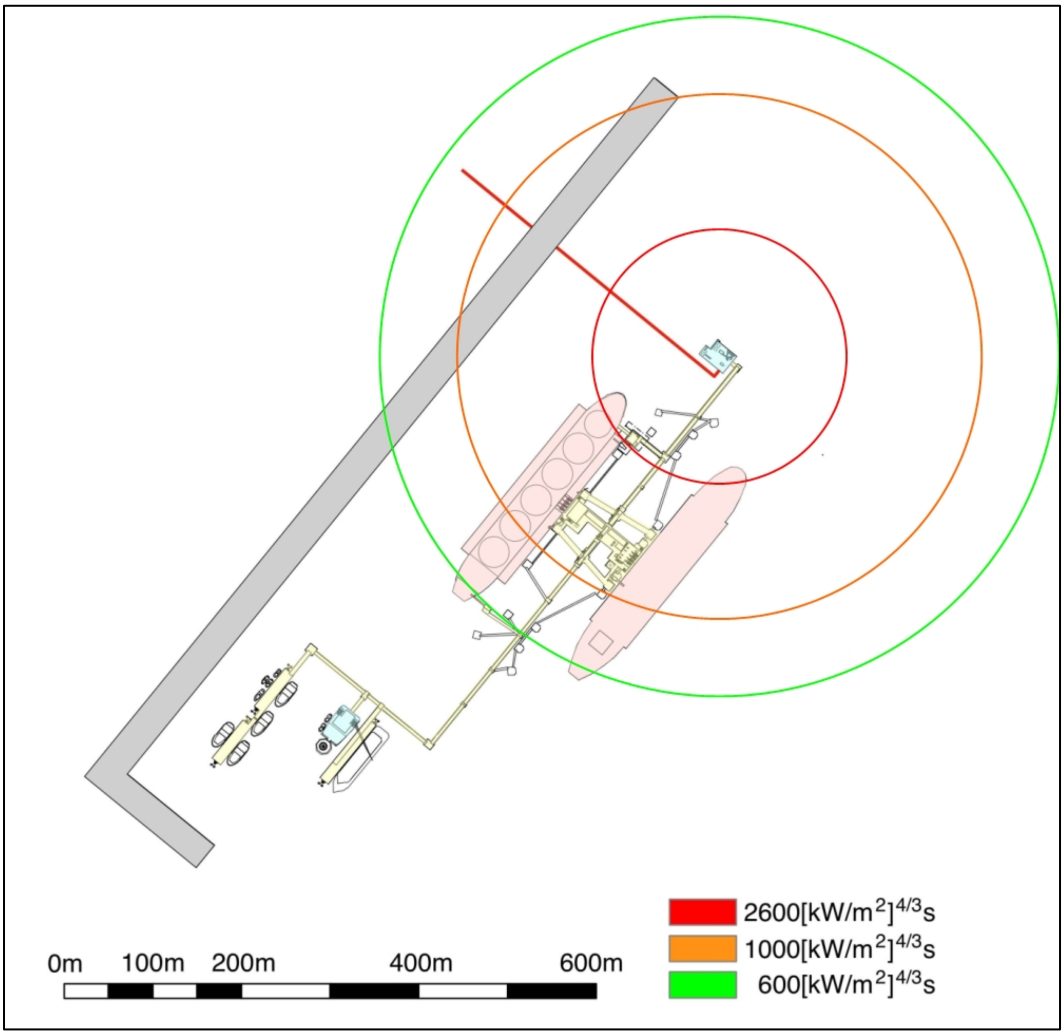


Figure 8-34. N-01 450 mm Full Bore Rupture Fireball Effect Distances.

Potential consequence impacts are summarised in Table 8-17.

Table 8-17. N-01 Summary of Potential Consequence Impacts.

<table>
<tr><th colspan="6">50 mm Jet Fire</th></tr>
<tr><th>Immediate Fatality</th><th>Escape Impairment</th><th>Escalation</th><th>TR Impairment</th><th>Evacuation Impairment</th><th>Safety Zone Impacts</th></tr>
<tr><td>Possible</td><td>Possible</td><td>Localised</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="6">Fire and high levels of thermal radiation may result in immediate fatalities near the fire along with localised impairment of escape at the north end of the trestle should personnel survive the immediate effects of the fire. However, this area is not normally manned.
Any fire would be of significant duration (>60 minutes) resulting in the likely total loss of the riser platform and damage to the north trestle structure. However, the riser platform is remote from other Near Shore Hub/Terminal facilities which should not be impacted by the fire.
Thermal radiation levels (3 kW/m^2) extend approximately 200m from the riser platform and are well within the 500-600 m safety zone limit.</td></tr>
<tr><th colspan="6">450 mm Full Bore Rupture Fireball</th></tr>
<tr><th>Immediate Fatality</th><th>Escape Impairment</th><th>Escalation</th><th>TR Impairment</th><th>Evacuation Impairment</th><th>Safety Zone Impacts</th></tr>
<tr><td>Yes</td><td>Possible</td><td>Localised</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="6">Fire and high levels of thermal radiation may result in immediate fatalities near the fire for personnel in unprotected deck areas. This may include forward areas of the FLNG and LNGC (if berthed).
Following the fireball, a jet fire would result. Escape may be impaired at the North end of the trestle should personnel survive the immediate effects of the fire. However, this area is not normally manned and escape routes at the east of the FLNG and LNGC (if berthed) should remain available.
Given the length of the pipeline and the large inventory within it, even a large fire could continue for a significant duration resulting in the likely total loss of the riser platform and damage to the north trestle structure. However, the riser platform is remote from other Near Shore Hub/Terminal facilities which should not be impacted by the fire.
Thermal radiation levels (600 $[kW/m^2]^{4/3}s$) extend less than 400m from the FPSO and are within the 500-600 m safety zone limit.</td></tr>
<tr><td colspan="6">Notes regarding fatality/consequence/impairment/impact:
Yes – Very likely to occur; Possible – Could occur; Unlikely – Very unlikely to occur; No – Will not occur</td></tr>
</table>

8.3.4.1.8 N-13: Gas Release from Floating LNG SMR Closed Loop

In the event of an accidental release in the vapour space of the FLNG SMR closed loop, flammable gas would be ejected at very high pressure in the refrigerant area of the FLNG.

There would be no significant immediate consequences for an un-ignited gas release.

A spontaneous ignition following the release would result in a jet fire or a fireball depending on the size of the release. A delayed ignition would result in the explosion of the flammable gas cloud confined in the refrigerant area. Personnel near the fire or explosion may be killed immediately. Personnel who survive the initial fire or explosion would seek egress via escape routes towards the primary safe muster area on the QU platform or the alternate safe muster area on the riser platform.

The initial fire or explosion may result in escalation/domino effects with further explosion and/or spreading of fire on the FLNG. While attempts would be made to control the accident, if this were not possible and the integrity of the QU platform TR were threatened, personnel would evacuate from the Near Shore Hub/Terminal via Crew Boat, or lifeboat (and be rescued at sea).

Modelling of explosion and fire effects following a gas release from the FLNG SMR closed loop has been undertaken using input data as summarised in Table 8-18. Results are presented in the following sections and a summary of consequences effects is presented at the end of the section.

Table 8-18. N-13 Key Modelling Parameters.

Parameter	Input
Assumed Material	Propane
Pressure (bara)	10
Temperature (^oC)	45
Phase	Gas
Inventory (kg)	1,725
Congested Volume (m^3)	20,300
Release/Event Duration (mins)	5 minutes for 50 mm release Instantaneous for catastrophic rupture (modelled as an instantaneous release of the full inventory)

8.3.4.1.8.1 Explosion Effects

Delayed ignition of flammable gas dispersed into a congested region following loss of containment is modelled as a vapour cloud explosion (VCE). Flammable gas from a credible (50 mm) release and a worst case (catastrophic) rupture is assumed to completely fill the congested volume. The overpressure effect plot and hazard envelope are given in Figure 8-35.

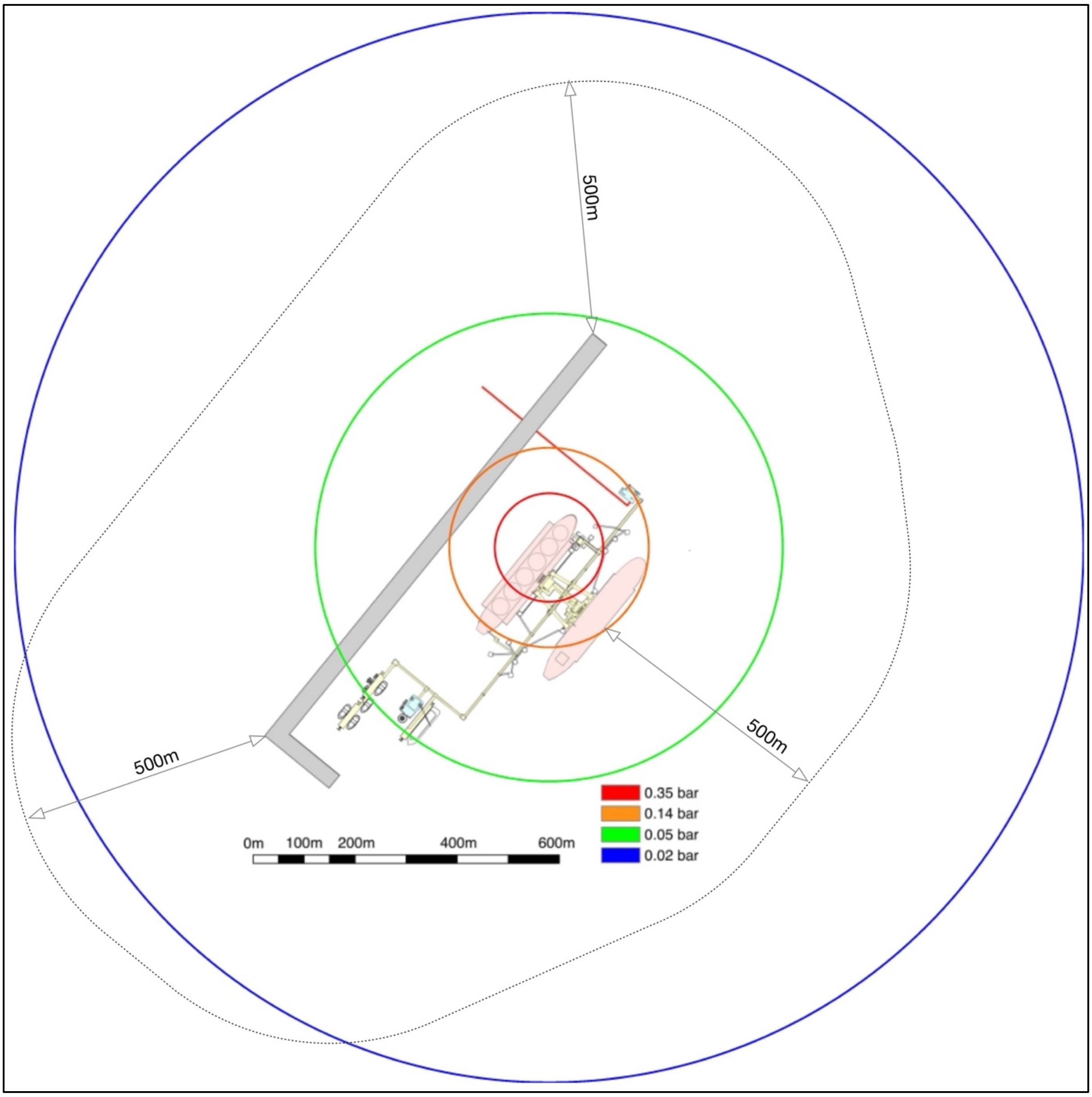


Figure 8-35. N-13 Explosion Effect Distances.

8.3.4.1.8.2 Fire Effects

Immediate ignition following loss of containment from a credible (50 mm) failure is modelled as a horizontal gas jet fire with the thermal radiation effect plot and hazard envelope given in Figure 8-36. Ignition following loss of containment from a worst case (catastrophic) rupture is modelled as a fireball with the thermal radiation effect plot and hazard envelope given in Figure 8-37.

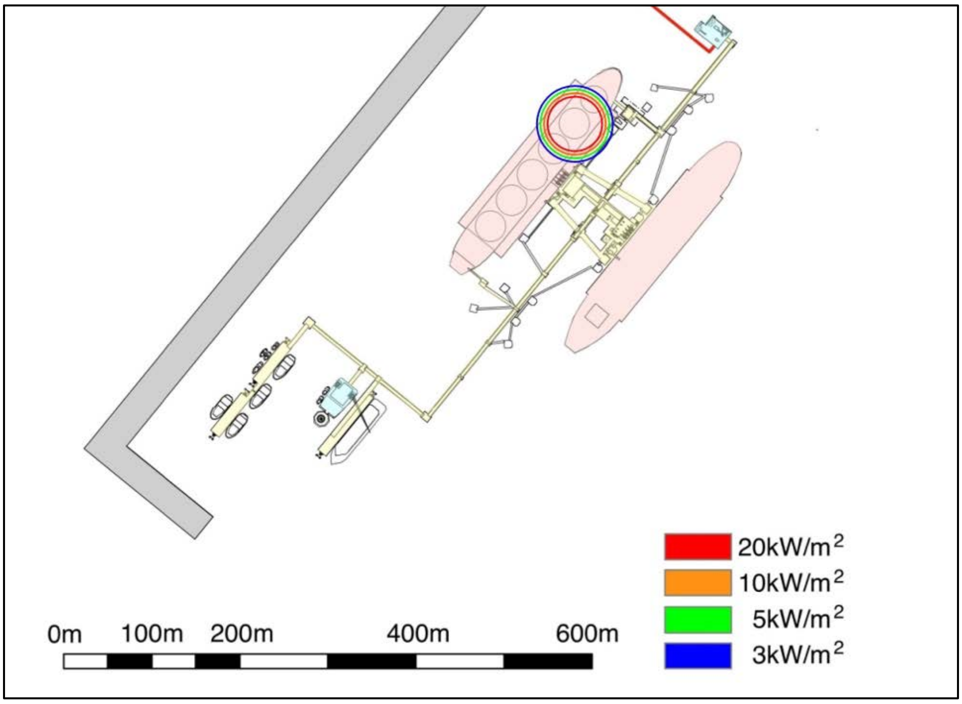


Figure 8-36. **N-13 50 mm Release Jet Fire Effect Distances.**

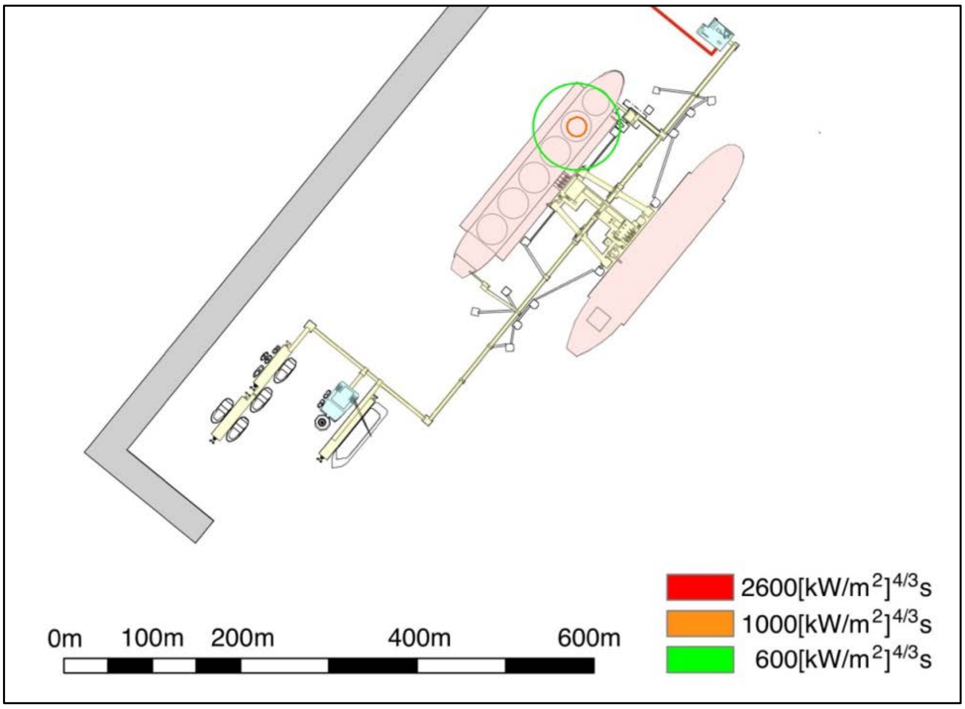


Figure 8-37. **N-13 Catastrophic Rupture Fireball Effect Distances.**

8.3.4.1.8.3 Summary of Potential Consequence Impacts

Potential consequence impacts are summarised in Table 8-19.

Table 8-19. N-13 Summary of Potential Consequence Impacts.

Explosion					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Yes	Yes	No	No	Yes
Significant explosion effects would be relatively localised but could result in immediate fatalities for personnel in the open, or within vulnerable buildings that are not blast rated. There is also the potential for impairment of escape routes forward of the FLNG and escalation/domino effects to other process equipment and structures. These effects should be limited to areas experiencing higher overpressures, typically greater than 0.35 bar. Escape routes at the aft of the FLNG should not be impacted with personnel able to egress safely to the QU platform TR. Damage to the main escape route on the trestle may result in personnel on the riser platform having to muster at the alternate safe muster area. However, the riser platform is not normally manned. Other facilities such as the QU platform and LNGC are outside the 0.35 bar blast contour. The LNGC may experience some damage from the blast but this is unlikely to be significant. Overpressures at the QU platform are relatively low (approximately 0.05 bar) and well within normal design criteria for offshore TR and structures. Maximum overpressures at the limit of the 500-600 m safety zone are of the order of 0.03 to 0.04 bar. At this level, minor damage may occur, for example, breakage of windows.					
50 mm Jet Fire					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	No	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire along with localised impairment of escape on the FLNG. The short event duration, of the order of 5 minutes, means that overall, escape should not be impaired should personnel survive the initial fire. With fire limited to the FLNG, localised damage may occur but should not result in escalation/domino effects or any other significant impacts. Thermal radiation levels (3 kW/m^2) only just extend beyond the port or starboard side of FLNG, and are well within the 500-600 m safety zone limit.					
Catastrophic Rupture Fireball					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	No	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire for personnel in unprotected deck areas. Following the initial fireball, the inventory would quickly deplete. Fire may result in localised damage but should not result in impairment of escape, escalation/domino effects or any other significant impacts. As with the 50 mm jet fire, thermal radiation levels (600 $[kW/m^2]^{4/3}s$) only just extend beyond the port or starboard side of FLNG, and are well within the 500-600 m safety zone limit.					
Notes regarding fatality/consequence/impairment/impact: *Yes – Very likely to occur; Possible – Could occur; Unlikely – Very unlikely to occur; No – Will not occur*					

8.3.4.1.9 N-14: Liquid/Two Phase Release from Floating LNG SMR Closed

In the event of an accidental release in the liquid space of the FLNG SMR closed loop, flammable liquefied gas would be ejected at very high pressure in the refrigerant area of the FLNG.

In the absence of ignition, immediate consequences could result from the cryogenic effects of the release. Material not designed for cryogenic temperature could undergo embrittlement and failure. Personnel exposed to direct contact with the cryogenic liquid may be severely injured or killed. A cryogenic liquid pool may also form. With flammable gas flashing from the spray release and liquid pool, cold heavy gas may disperse a significant distance.

A spontaneous ignition following the release would result in a spray/gas jet fire or a fireball near the refrigerant area depending on the size of the release. A delayed ignition would result in the explosion of the flammable gas cloud. Should gas disperse a significant distance in open areas, a flash fire could also result. Personnel near the fire or explosion may be killed immediately. Personnel who survive the initial fire or explosion would seek egress to the primary safe muster area on the QU platform, or the alternate safe muster area on the riser platform.

The initial fire or explosion may result in escalation/domino effects and result in further explosion and/or spreading of fire on the FLNG. While attempts would be made to control the accident, if this were not possible and the integrity of the QU platform TR were threatened, personnel would evacuate from the Near Shore Hub/Terminal via Crew Boat, or lifeboat (and be rescued at sea).

Modelling of cold spill, dispersion, explosion and fire effects following a liquid/two phase release from the FLNG SMR closed loop has been undertaken using input data as summarised in Table 8-20.

Table 8-20. N-14 Key Modelling Parameters.

Parameter	Input
Assumed Material	Propane
Pressure (bara)	40
Temperature (ºC)	55
Phase	Liquid/Two Phase
Inventory (kg)	15,624
Congested Volume (m^3)	20,300
Release/Event Duration (mins)	<5 minutes for 50 mm release Instantaneous for catastrophic rupture (modelled as an instantaneous release of the full inventory)

8.3.4.1.9.1 Cold Spill Effects

Cold spill effects are determined by modelling the extent of a cryogenic pool following loss of containment from a credible (50 mm) failure and worst case (catastrophic) rupture. Modelling of a spill has been completed using propane as representative of the SMR. While a release propane will not present a cryogenic threat, when mixed with ethylene the liquid temperature following discharge may drop significantly, presenting a cryogenic risk to structures, equipment and personnel.

For a 50 mm release, the pool spreads to a radius of 20 m, while for a catastrophic rupture, the pool spreads to a radius of 24 m. Given the relatively small size, consequence effects are not plotted.

8.3.4.1.9.2 Flammable Gas Dispersion Effects

The distances to 100% LFL are determined for a credible (50 mm) release and worst case (catastrophic) rupture. This distance is taken as the maximum extent of any flash fire and potential fatality effects. Two wind speed/stability class combinations were assessed, a worst case (2D – very stable conditions) and average conditions (5D). Flammable gas dispersion effect plot and hazard envelope are given in Figure 8-38 and Figure 8-39. With respect to these figures, it should be noted that dispersion of flammable gas is directional and downwind of the release. The figures show the maximum extent of dispersion, not the actual gas plume which is much smaller and downwind of the release location.

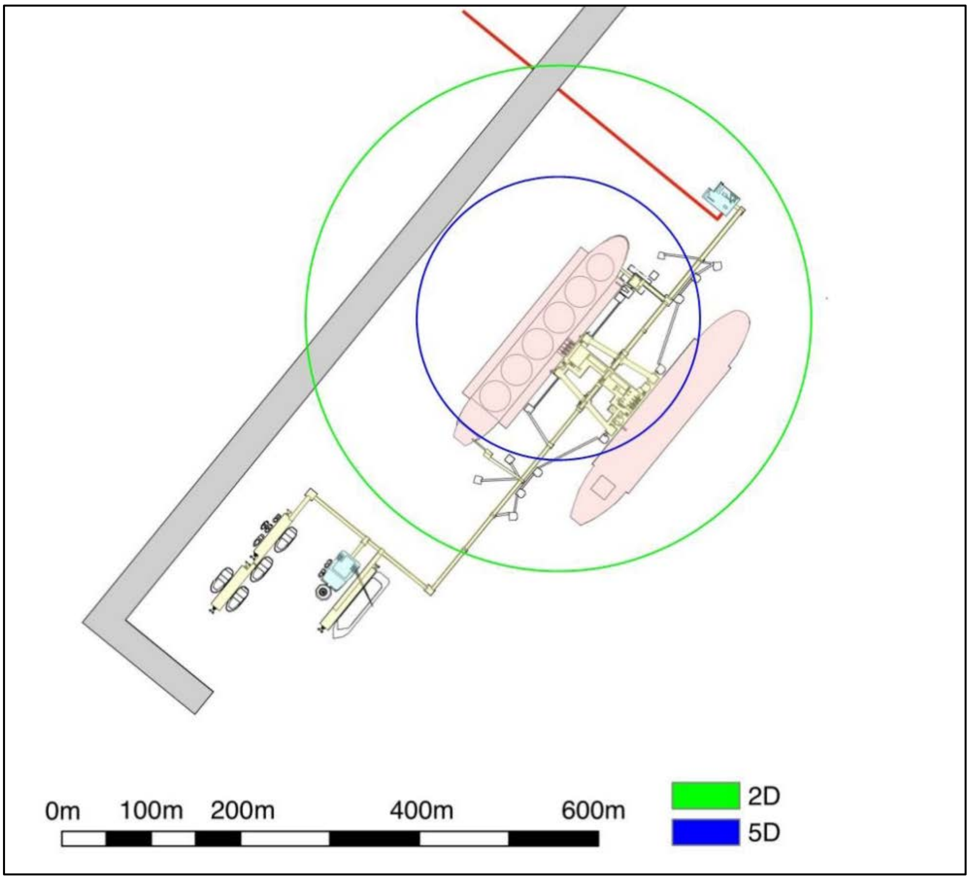


Figure 8-38. N-14 50 mm Release Flammable Gas Effect Distances.

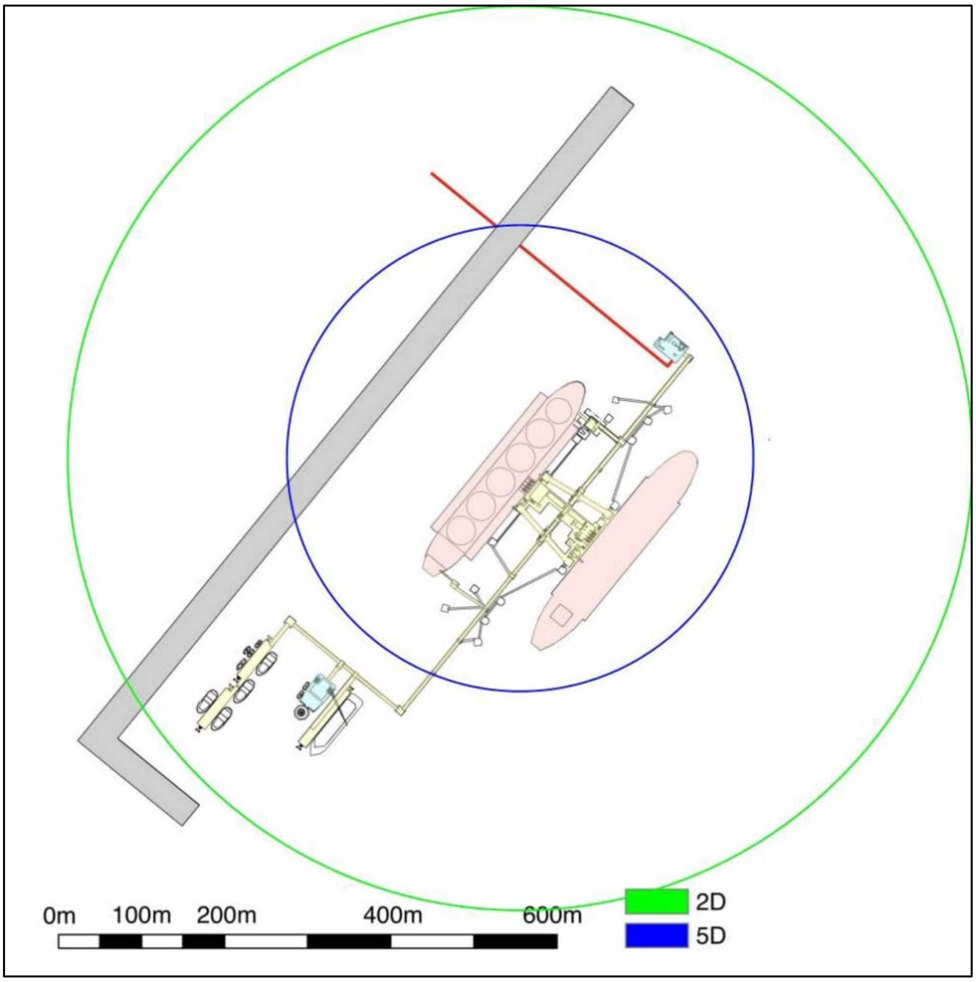


Figure 8-39. N-14 Catastrophic Rupture Flammable Gas Effect Distances.

8.3.4.1.9.3 Explosion Effects

Delayed ignition of flammable gas dispersed into a congested region following loss of containment is modelled as a VCE. Flammable gas from a credible (50 mm) release and a worst case (catastrophic) rupture is assumed to completely fill the congested volume. Overpressure effect plot and hazard envelope are given in Figure 8-40.

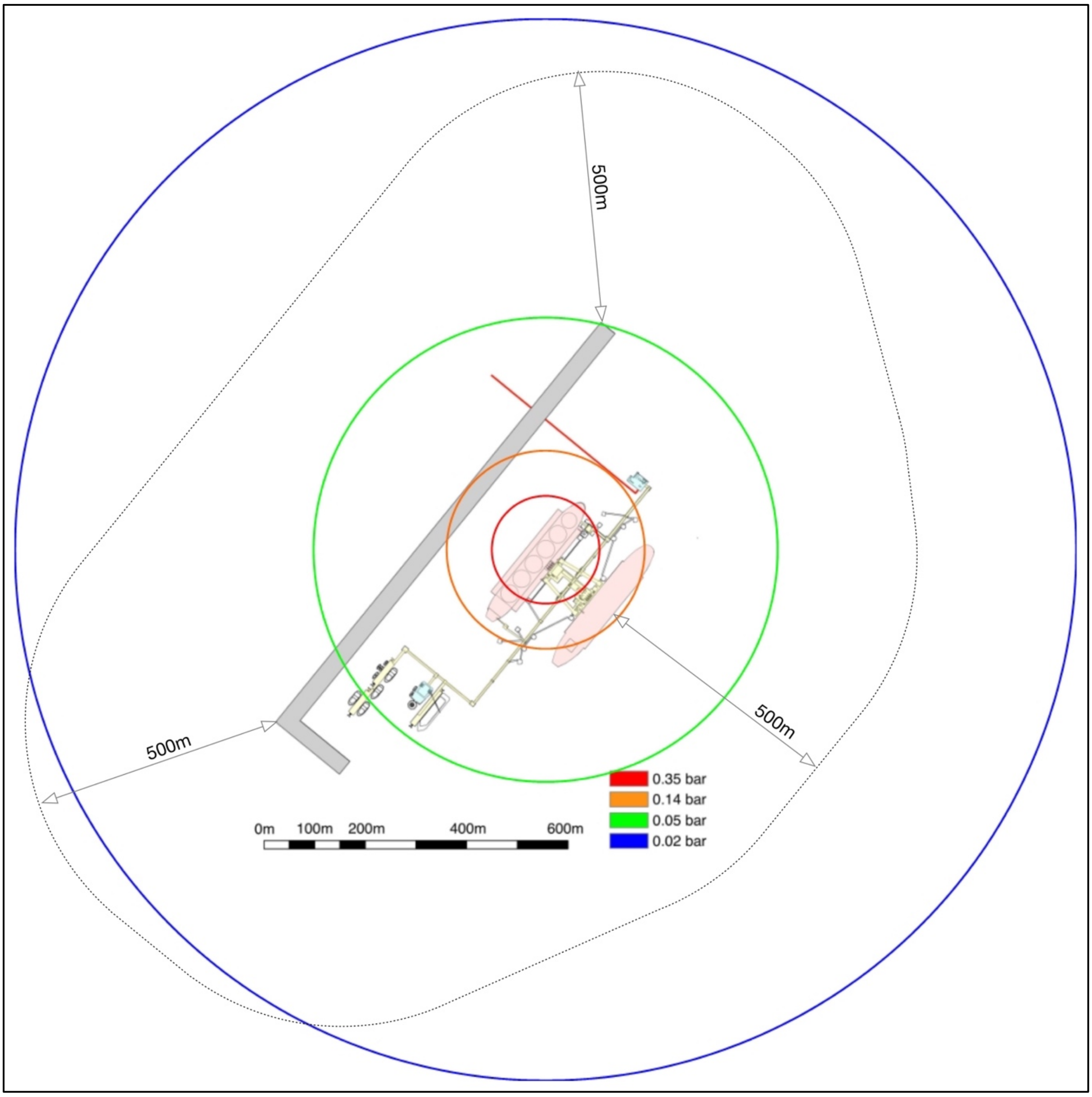


Figure 8-40. N-14 Explosion Effect Distances.

8.3.4.1.9.4 Fire Effects

Immediate ignition following loss of containment from a credible (50 mm) failure is modelled as a horizonal liquid spray/gas jet fire with the thermal radiation effect plot and hazard envelope given in Figure 8-41. Ignition following loss of containment from a worst case (catastrophic) rupture is modelled as a fireball with the thermal radiation effect plot and hazard envelope given in Figure 8-42.

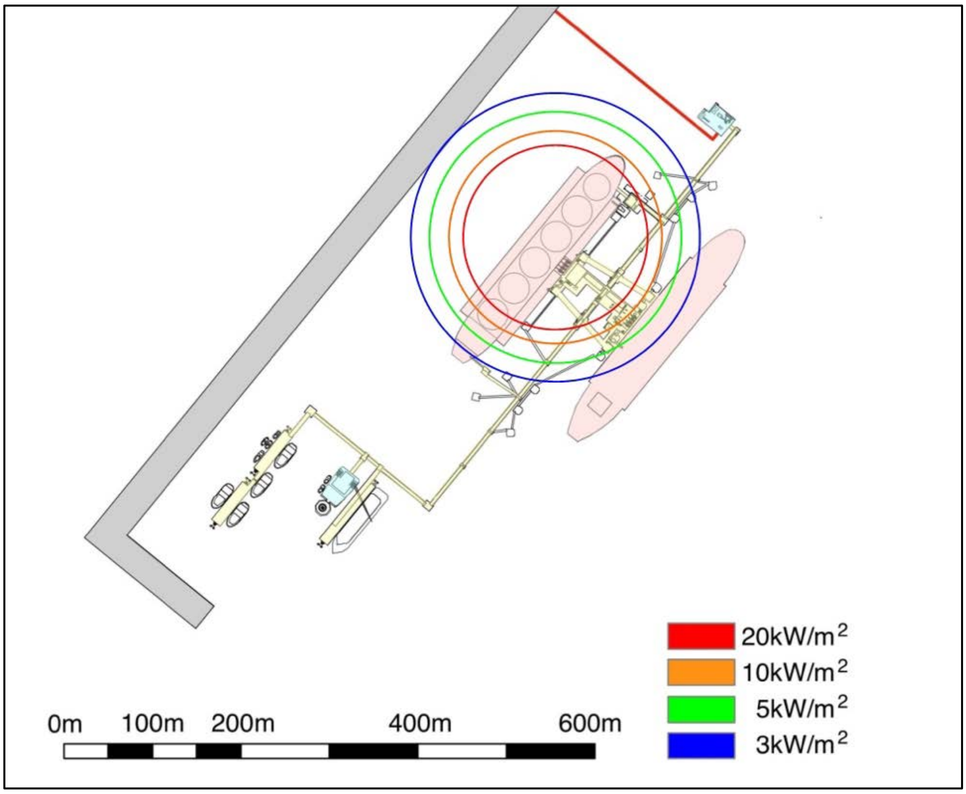


Figure 8-41. N-14 50 mm Release Spray/Jet Fire Effect Distances.

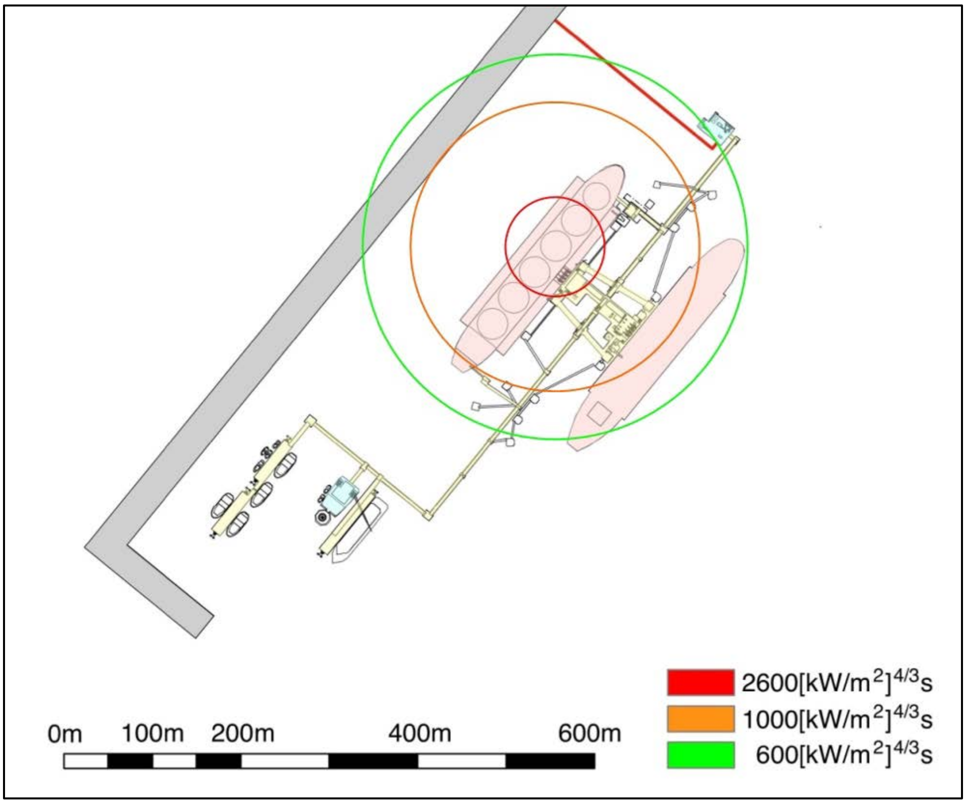


Figure 8-42. N-14 Catastrophic Rupture Fireball Effect Distance.

8.3.4.1.9.5 Summary of Potential Consequence Impacts

Potential consequence impacts are summarised in Table 8-21.

Table 8-21. N-14 Summary of Potential Consequence Impacts.

<table>
<tr><th colspan="6">50 mm and Rupture Cold Spill</th></tr>
<tr><th>Immediate Fatality</th><th>Escape Impairment</th><th>Escalation</th><th>TR Impairment</th><th>Evacuation Impairment</th><th>Safety Zone Impacts</th></tr>
<tr><td>Yes</td><td>No</td><td>Localised</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="6">Cryogenic pool sizes are relatively small. Immediate fatality may result for personnel caught in the immediate vicinity of the pool. Impairment of any escape routes would be localised with alternatives routes available for personnel to egress safely to the QU platform TR. Localised damage may occur due to embrittlement of structures and equipment not protected from cryogenic spills but pool sizes are insufficient to present a direct threat to the integrity of the QU platform TR or evacuation facilities.</td></tr>
<tr><th colspan="6">50 mm Flammable Gas Dispersion</th></tr>
<tr><th>Immediate Fatality</th><th>Escape Impairment</th><th>Escalation</th><th>TR Impairment</th><th>Evacuation Impairment</th><th>Safety Zone Impacts</th></tr>
<tr><td>Yes</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="6">Immediate fatality may result for personnel caught within the flammable gas envelope, with a flash fire should ignition occur (explosions are considered separately below). While flammable gas may extend some distance from the FLNG, reaching the trestle and LNGC, if berthed, the relatively short event duration of less than 5 minutes, with flammable gas not reaching the QU platform or safety zone limit, means that immediate fatality is considered the only significant impact.</td></tr>
<tr><th colspan="6">Catastrophic Rupture Flammable Gas Dispersion</th></tr>
<tr><th>Immediate Fatality</th><th>Escape Impairment</th><th>Escalation</th><th>TR Impairment</th><th>Evacuation Impairment</th><th>Safety Zone Impacts</th></tr>
<tr><td>Yes</td><td>No</td><td>No</td><td>Unlikely</td><td>No</td><td>No</td></tr>
<tr><td colspan="6">Immediate fatality may result for personnel caught within the flammable gas envelope, with a flash fire should ignition occur (explosions are considered separately below). Gas may disperse a significant distance with flammable gas dispersing beyond the QU platform, and to near the 500-600 m safety zone limit. However, the height of the flammable gas plume is less than 2 m and QU platform HVAC intakes are equipped with gas detection with shutdown of dampers if gas if detected. Given gas detection and shutdown function, they should prevent flammable gas ingress into the TR. The short event duration means that immediate fatality is considered the only significant impact.</td></tr>
<tr><th colspan="6">Explosion</th></tr>
<tr><th>Immediate Fatality</th><th>Escape Impairment</th><th>Escalation</th><th>TR Impairment</th><th>Evacuation Impairment</th><th>Safety Zone Impacts</th></tr>
<tr><td>Yes</td><td>Yes</td><td>Yes</td><td>No</td><td>No</td><td>Yes</td></tr>
<tr><td colspan="6">Significant explosion effects are relatively localised but could result in immediate fatalities for personnel in the open, or within vulnerable buildings not blast rated. There is also the potential for impairment of escape routes forward of the FLNG and escalation/domino effects to other process equipment and structures. These effects should be limited to areas experiencing higher overpressures, typically greater than 0.35 bar. Escape routes at the aft of the FLNG should not be impacted with personnel able to egress safely to the QU platform TR. Damage to the main escape route on the trestle may result in personnel on the riser platform having to muster at the alternate safe muster area. However, the riser platform is not normally manned.

Other facilities such as the QU platform and LNGC are outside the 0.35 bar blast contour. The LNGC may experience some damage from the blast but this is unlikely to be significant. Overpressures at the QU platform are relatively low (approximately 0.05 bar) and well within normal design criteria for offshore TR and structures.

Maximum overpressures at the limit of the 500-600 m safety zone are of the order of 0.03 to 0.04 bar. At this level, minor damage may occur, for example, breakage of windows.</td></tr>
</table>

50 mm Jet Fire					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	No	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire along with impairment of escape routes on port and starboard sides of the FLNG. The short event duration, under 5 minutes, means that overall, escape should not be impaired should personnel survive the initial fire. With fire largely limited to the FLNG, localised damage may occur but should not result in escalation/domino effects or any other significant impacts. Thermal radiation levels (3 kW/m^2) extend beyond the port or starboard side of FLNG, but are well within the 500-600 m safety zone limits.					
Catastrophic Rupture Fireball					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	No	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire for personnel in unprotected deck areas. Following the initial fireball, the inventory would quickly deplete. Fire may result in damage but should not result in impairment of escape, escalation/domino effects or any other significant impacts. As with the 50 mm jet fire, thermal radiation levels (600 [kW/m^2]$^{4/3}$s) extend beyond the port or starboard side of FLNG and may impact the LNGC, but are well within the 500-600 m safety zone limit.					
Notes regarding fatality/consequence/impairment/impact: *Yes – Very likely to occur; Possible – Could occur; Unlikely – Very unlikely to occur; No – Will not occur*					

8.3.4.1.10 N-15: Refrigerant Release from FLNG Refrigerant Storage

In the event of an accidental release from the FLNG refrigerant storage, flammable liquefied gas would be ejected at pressure in the refrigerant storage area of the FLNG.

In the absence of ignition, immediate consequences could result from the cryogenic effects of the release. Material not designed for cryogenic temperature could undergo embrittlement and failure. Personnel exposed to direct contact with the cryogenic liquid may be severely injured or killed. A cryogenic liquid pool may also form. With flammable gas flashing from the spray release and liquid pool, cold heavy gas may disperse a significant distance.

A spontaneous ignition following the release would result in a spray/gas jet fire or a fireball near the refrigerant area depending on the size of the release. A delayed ignition would result in the explosion of the flammable gas cloud. Should gas disperse a significant distance in open areas, a flash fire could also result. Personnel near the fire or explosion may be killed immediately. Personnel who survive the initial fire or explosion would seek egress to the primary safe muster area on the QU platform, or the alternate safe muster area on the riser platform.

The initial fire or explosion may result in escalation/domino effects and result in further explosion and/or spreading of fire on the FLNG. While attempts would be made to control the accident, if this were not possible and the integrity of the QU platform TR were threatened, personnel would evacuate from the Near Shore Hub/Terminal via Crew Boat, or lifeboat (and be rescued at sea).

Modelling of cold spill, dispersion, explosion and fire effects following a liquid/two phase release from the FLNG SMR closed loop has been undertaken using input data as summarised in Table 8-22.

Table 8-22. N-15 Key Modelling Parameters.

Parameter	Input	Input
Assumed Material	Propane	Ethylene
Pressure (bara)	9	3
Temperature (ºC)	25	-83
Phase	Boiling Liquid	Boiling Liquid
Inventory (kg)	25,500	11,400
Congested Volume (m^3)	12,180	12,180
Release/Event Duration (mins)	20 minutes for 50 mm propane/ethylene release Instantaneous for catastrophic rupture (modelled as an instantaneous release of the full inventory)	

8.3.4.1.10.1 Cold Spill Effects

Cold spill effects are determined by modelling the extent of a cryogenic pool following loss of containment from a credible (50 mm) failure and worst case (catastrophic) rupture. FLNG refrigerant storage includes ethylene, propane and isopentane. While a release from propane or isopentane storage will not present a cryogenic threat, a release from ethylene storage would result in liquid temperatures following discharge that may drop significantly, presenting a cryogenic threat to structures, equipment and personnel.

For a 50 mm release, the pool spreads to a radius of 21m, while for a catastrophic rupture, the pool spreads to a radius 28m. Given the relatively small size, consequence effects are not plotted.

8.3.4.1.10.2 Flammable Gas Dispersion Effects

The distances to 100% LFL are determined for a credible (50 mm) release and worst case (catastrophic) rupture. This distance is taken as the maximum extent of any flash fire. Two wind speed/stability class combinations were assessed, a worst case (2D – very stable conditions) and average conditions (5D). Flammable gas dispersion effect plot and hazard envelope are given in Figure 8-43 and Figure 8-44. With respect to these figures, it should be noted that dispersion of flammable gas is directional and downwind of the release. The figures show the maximum extent of dispersion (for all wind directions), not the actual gas plume which is much smaller and downwind of the release location.

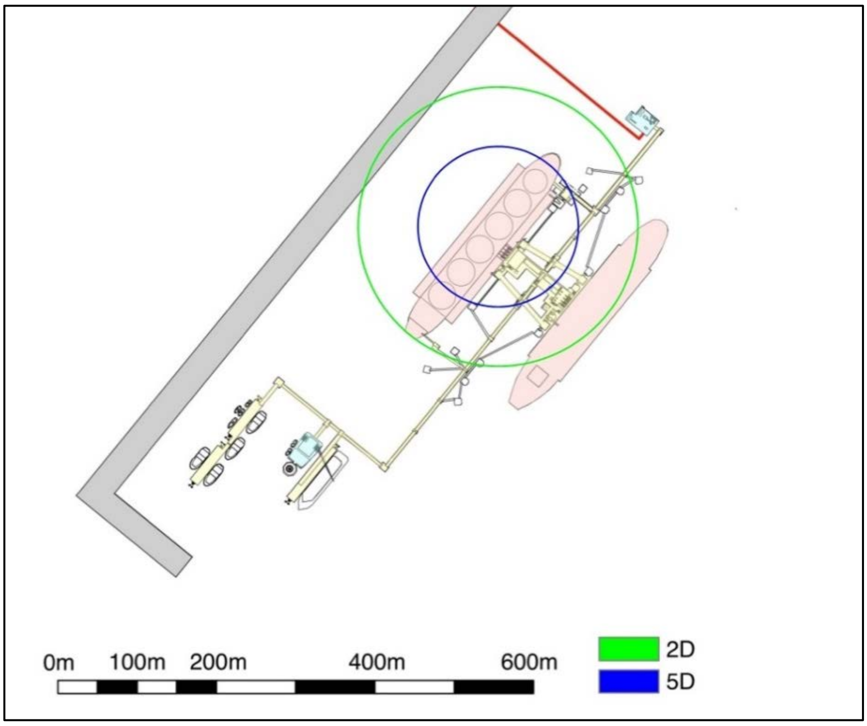


Figure 8-43. **N-15 50 mm Release Flammable Gas Effect Distances.**

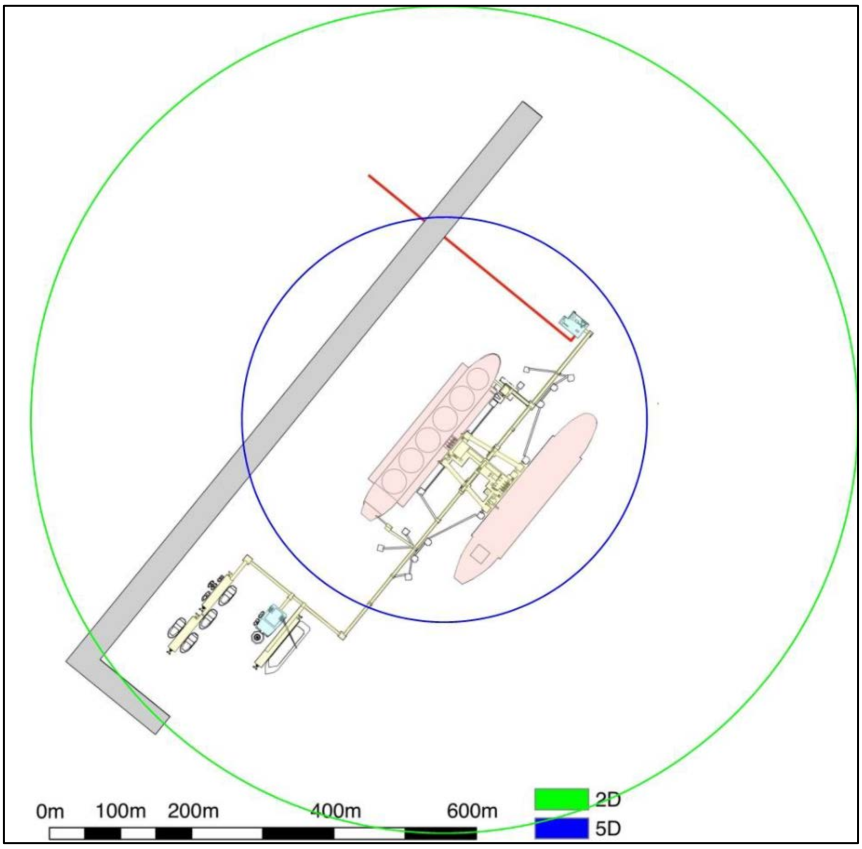


Figure 8-44. **N-15 Catastrophic Rupture Flammable Gas Effect Distances.**

8.3.4.1.10.3 Explosion Effects

Delayed ignition of flammable gas dispersed into a congested region following loss of containment is modelled as a VCE. Flammable gas from a credible (50 mm) release and a worst case (catastrophic) rupture is assumed to completely fill the congested volume. Overpressure effect plot and hazard envelope are given in Figure 8-45.

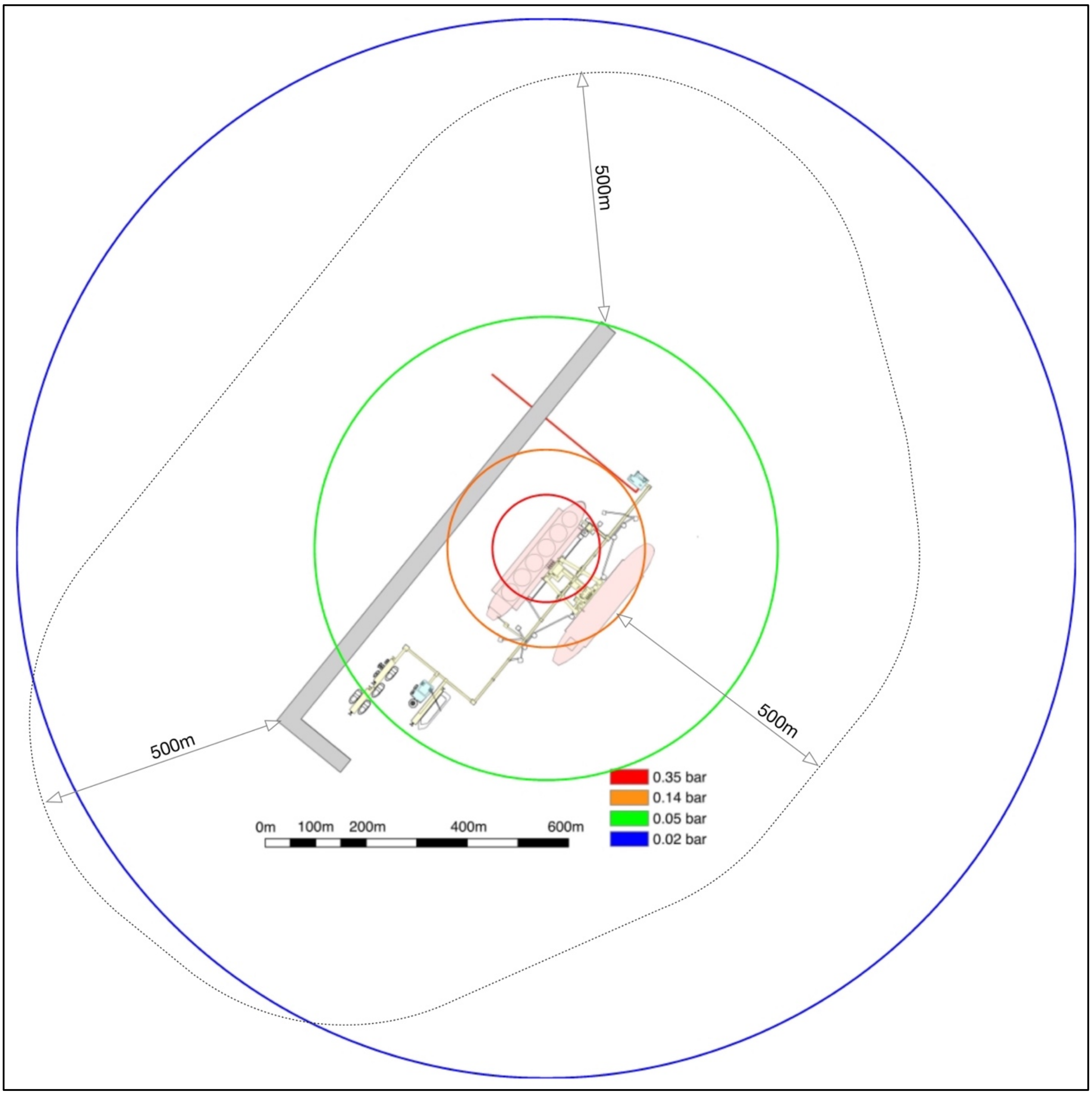


Figure 8-45. N-15 Explosion Effect Distances.

8.3.4.1.10.4 Fire Effects

Immediate ignition following loss of containment from a credible (50 mm) failure is modelled as a horizontal liquid spray/gas jet fire with the thermal radiation effect plot and hazard envelope given in Figure 8-46. Ignition following loss of containment from a worst case (catastrophic) rupture is modelled as a fireball with the thermal radiation effect plot and hazard envelope given in Figure 8-47.

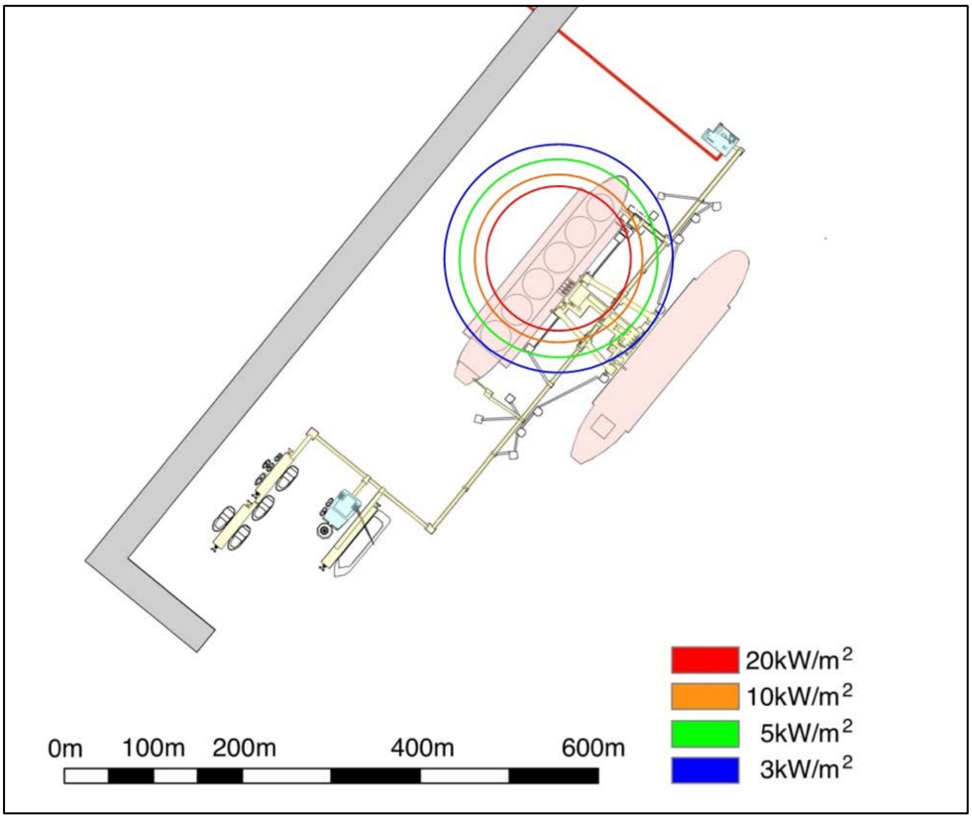


Figure 8-46. N-15 50 mm Release Spray/Jet Fire Effect Distances.

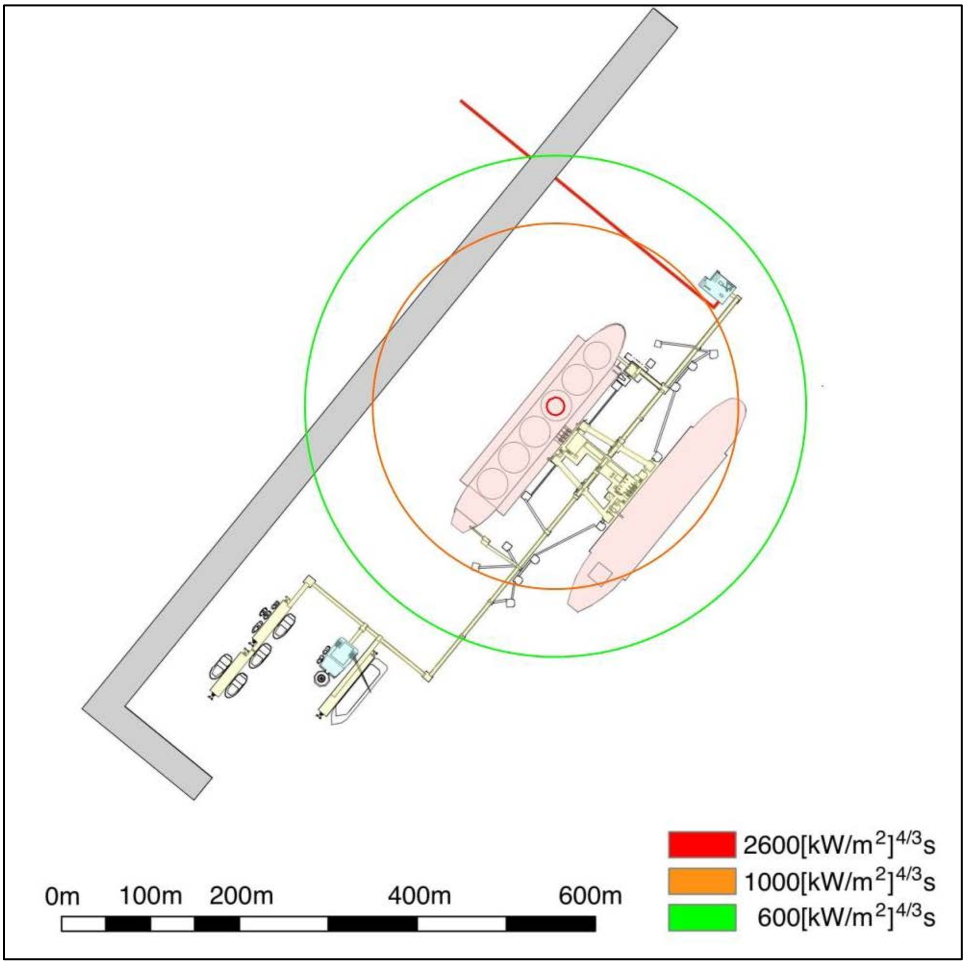


Figure 8-47. N-15 Catastrophic Rupture Fireball Effect Distances.

8.3.4.1.10.5 Summary of Potential Consequence Impacts

Potential consequence impacts are summarised in Table 8-23.

Table 8-23. N-15 Summary of Potential Consequence Impacts.

50 mm and Rupture Cold Spill					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	Localised	No	No	No
Cryogenic pool sizes are relatively small. Immediate fatality may result for personnel caught in the immediate vicinity of the pool. Impairment of any escape routes would be localised with alternatives routes available for personnel to egress safely to the QU platform TR. Localised damage may occur due to embrittlement of structures and equipment not protected from cryogenic spills but pool sizes are insufficient to present a direct threat to the integrity of the QU platform TR or evacuation facilities.					
50 mm Flammable Gas Dispersion					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Yes	No	No	No	No
Immediate fatality may result for personnel caught within the flammable gas envelope, with a flash fire should ignition occur (explosions are considered separately below). Flammable gas may extend some distance from the FLNG, reaching the trestle and LNGC, if berthed. Event durations of 20 minutes mean that escape from the north end of the hub trestle and riser platform may be impaired. However, this area is not normally manned. Flammable gas does not reach the QU platform or 500-600 m safety zone limit. As a result, immediate fatality and impairment of escape from the QU platform/north end of the trestle are considered the only significant impacts.					
Catastrophic Rupture Flammable Gas Dispersion					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	No	Unlikely	No	No
Immediate fatality may result for personnel caught within the flammable gas envelope, with a flash fire should ignition occur (explosions are considered separately below). Gas may disperse a significant distance with flammable gas dispersing beyond the QU platform, and to near the 500-600 m safety zone limit. However, the height of the flammable gas plume is less than 2 m and QU platform HVAC intakes are equipped with gas detection with shutdown of dampers if gas if detected. Given gas detection and shutdown function, they should prevent flammable gas ingress into the TR. The short event duration means that immediate fatality is considered the only significant impact.					
Explosion					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Yes	Yes	No	No	Yes
Significant explosion effects are relatively localised but could result in immediate fatalities for personnel in the open, or within vulnerable buildings not blast rated. There is also the potential for impairment of escape routes forward of the FLNG and escalation/domino effects to other process equipment and structures. These effects should be limited to areas experiencing higher overpressures, typically greater than 0.35 bar. Escape routes at the aft of the FLNG should not be impacted with personnel able to egress safely to the QU platform TR. Damage to the main escape route on the trestle may result in personnel on the riser platform having to muster at the alternate safe muster area. However, the riser platform is not normally manned. Other facilities such as the QU platform and LNGC are outside the 0.35 bar blast contour. The LNGC may experience some damage from the blast but this is unlikely to be significant. Overpressures at the QU platform are relatively low (approximately 0.05 bar) and well within normal design criteria for offshore TR and structures. Maximum overpressures at the limit of the 500-600 m safety zone are of the order of 0.03 to 0.04 bar. At this level, minor damage may occur, for example, breakage of windows.					

50 mm Jet Fire					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Yes	Yes	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire along with impairment of escape routes on port and starboard sides of the FLNG and the trestle. Event durations of 20 minutes mean that escape from the north end of the hub trestle and riser platform may be impaired. However, this area is not normally manned. At 20 minutes escalation/domino effects are possible, this may result in failure of structures or other process equipment. Thermal radiation levels (3 kW/m^2) extend beyond the port or starboard side of FLNG, but are well within the 500-600 m safety zone limit.					
Catastrophic Rupture Fireball					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	No	No	No	No	No
Fire and high levels of thermal radiation may result in immediate fatalities near the fire for personnel in unprotected deck areas. Following the initial fireball, the inventory would quickly deplete. Fire may result in damage but should not result in impairment of escape, escalation/domino effects or any other significant impacts. As with the 50 mm jet fire, thermal radiation levels (600 $[kW/m^2]^{4/3}s$) extend beyond the port or starboard side of FLNG and may impact the LNGC, but are well within the 500-600 m safety zone limit.					
Notes regarding fatality/consequence/impairment/impact: *Yes – Very likely to occur; Possible – Could occur; Unlikely – Very unlikely to occur; No – Will not occur*					

8.3.4.1.11 N-17: LNG Release from Floating LNG/LNG Carrier Storage Tanks

In the event of a failure/breach of an LNG storage tank on the LNGC or FLNG, LNG would spill onto the sea in the vicinity of the Near Shore Hub/Terminal trestle/LNG loading berth. For very large release such as the worst-case breach of a tank from a collision of the LNGC, LNG would form an unrestricted spreading pool on the surface of the sea.

In the absence of ignition, immediate consequences could result from the cryogenic effects of the release. Material not designed for cryogenic temperature could undergo embrittlement and failure. Personnel exposed to direct contact with the cryogenic liquid may be severely injured or killed. With flammable gas flashing from the liquid pool, cold heavy gas may disperse a significant distance.

A spontaneous ignition following the release would result in a pool fire. Should gas disperse a significant distance in open areas before ignition, a flash fire could result. Personnel near the fire may be killed immediately. Personnel who survive the initial fire would seek egress to the primary safe muster area on the QU platform, or the alternate safe muster area on the riser platform.

The initial fire may result in escalation/domino effects and result explosions and/or spreading of fire on the FLNG or LNGC. While attempts would be made to control the accident, if this were not possible and the integrity of the QU platform TR were threatened, personnel would evacuate from the Near Shore Hub/Terminal via Crew Boat, or lifeboat (and be rescued at sea).

Modelling of cold spill, dispersion, and fire effects following a liquid release from a LNGC or FLNG storage tank has been undertaken using input data as summarised in Table 8-24.

Table 8-24. N-17 Key Modelling Parameters.

Parameter	Input
Assumed Material	Methane
Pressure (bara)	1.8
Temperature (ºC)	-158
Phase	Liquid
Inventory (kg)	9,791,667
Release/Event Duration (mins)	>60 minutes

8.3.4.1.11.1 Cold Spill Effects

Cold spill effects are determined by modelling the extent of a cryogenic pool following loss of containment from worst case (catastrophic – 750 mm) tank breach assuming liquid head of 17m. In such cases. the pool spreads to a radius of 63m. Cold spill effect plot and hazard envelope are included with the dispersion effects in given in Figure 8-48.

8.3.4.1.11.2 Flammable Gas Dispersion Effects

The distances to 100% LFL are determined for a worst case (catastrophic) – 750 mm tank breach. This distance is taken as the maximum extent of any flash fire. Two wind speed/stability class combinations were assessed, a worst case (2D – very stable conditions) and average conditions (5D). Flammable gas dispersion effect plot and hazard envelope are given in Figure 8-48.

With respect to this figure, it should be noted that dispersion of flammable gas is directional and downwind of the release. The figure shows the maximum extent of dispersion, not the actual gas plume which is much smaller and downwind of the release location. Given the significant consequence effect distance, the dispersion plume with prevailing wind direction is inset into the overall potential hazard effect envelope in Figure 8-49 (pool centered between the FLNG and LNGC). The circle-shape contour represents the maximum extent of dispersion in all wind directions, assuming identical wind conditions (speed, stability) in every direction.

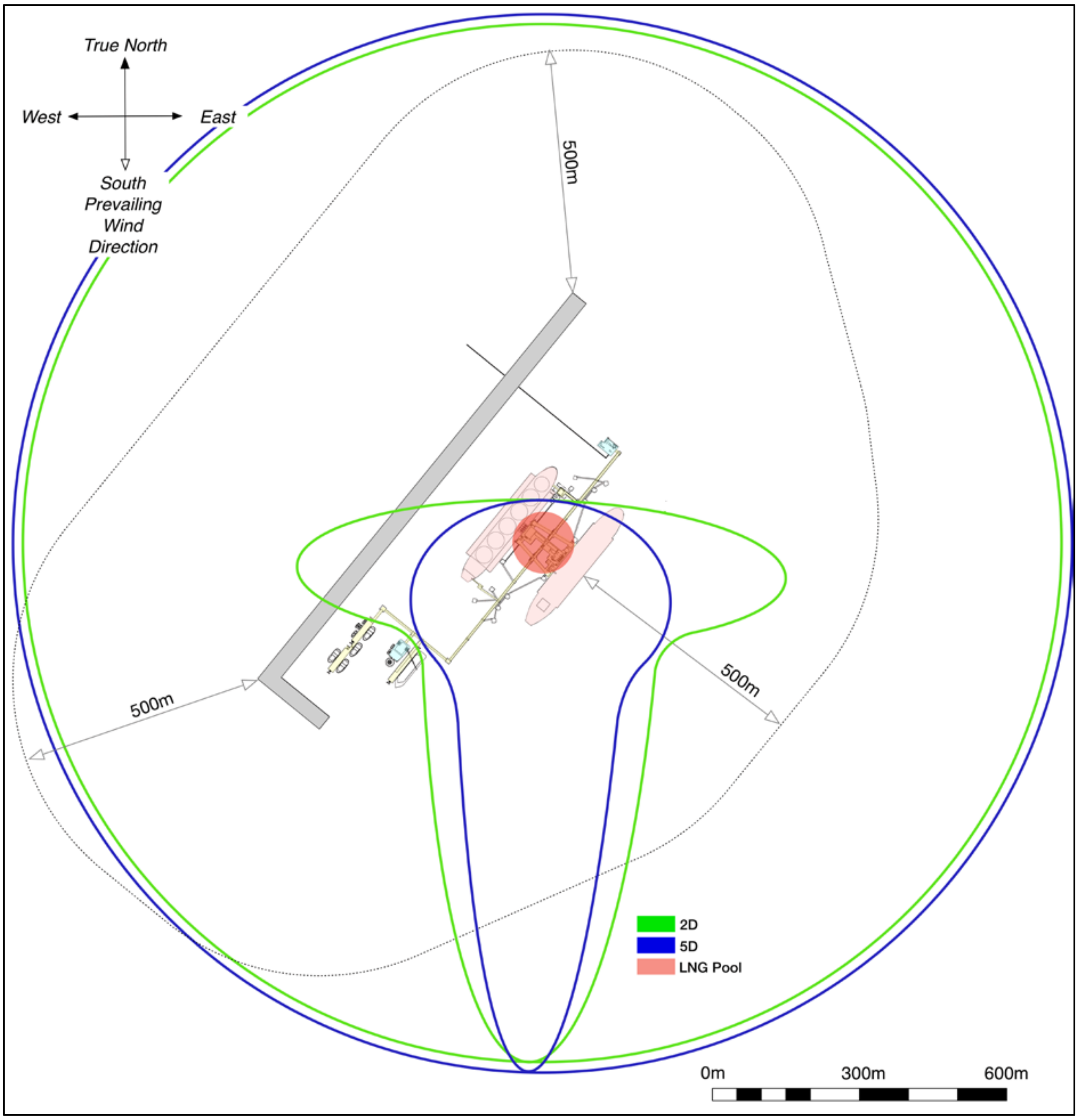


Figure 8-48. N-17 750 mm Tank Breach Flammable Gas Effect Distances.

8.3.4.1.11.3 Fire Effects

Immediate ignition following loss of containment from a worst case (750 mm) failure is modelled as an unrestricted sea surface pool fire with the thermal radiation effect plot and hazard envelope given in Figure 8-49.

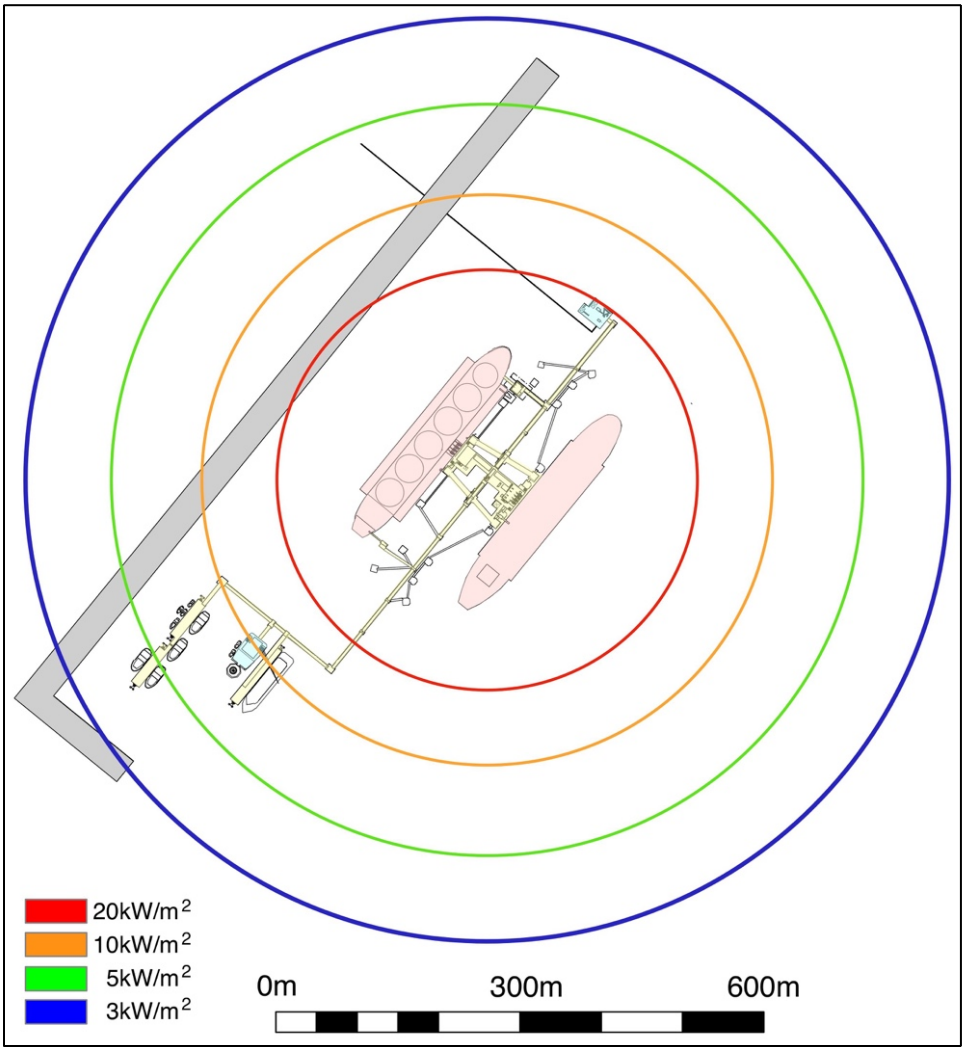


Figure 8-49. N-17 750 mm Tank Breach Pool Fire Effect Distances.

8.3.4.1.11.4 Summary of Potential Consequence Impacts

Potential consequence impacts are summarised in Table 8-25.

Table 8-25. N-17 Summary of Potential Consequence Impacts.

Cold Spill					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Yes	Yes	No	No	No
Cryogenic pool diameter may be relatively large, of the order of 125 m. While the spill is on water, immediate fatality may result for personnel caught in the immediate vicinity of the pool. Impairment of escape routes on the starboard side of the FLNG and trestle may also occur. Event durations of greater than 60 minutes mean that escape from the north end of the hub trestle and riser platform may be impaired. However, this area is not normally manned. Escalation/domino effects may occur due to embrittlement of structures and equipment. This may include trestle structure, and FLNG and LNGC hulls. Pool sizes are insufficient to present a direct threat to the integrity of the QU platform TR or evacuation facilities.					
Flammable Gas Dispersion					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Yes	No	Unlikely	Unlikely	Yes
Immediate fatality may result for personnel caught within the flammable gas envelope, with a flash fire should ignition occur. Flammable gas may extend some distance from the FLNG/LNGC, extending beyond the 500-600 m safety zone limit. Prevailing winds will also tend to disperse the gas towards the TR with the maximum flammable gas plume height some 30 m. TR integrity is maintained through general air tightness by design, including gas detection and shutdown of Heating, Ventilation and Air Conditioning (HVAC). However, event durations of greater than 60 minutes mean impairment of the QU platform TR and evacuation facilities is possible, albeit very unlikely.					
Pool Fire					
Immediate Fatality	**Escape Impairment**	**Escalation**	**TR Impairment**	**Evacuation Impairment**	**Safety Zone Impacts**
Yes	Yes	Yes	No	Yes	No
Fire and high levels of thermal radiation may result in immediate fatalities over a significant area, reaching the riser platform and south west of the trestle. Radiation levels may also result in impairment of escape routes to the QU platform TR over most of the Near Shore Hub/Terminal facilities. Even with event durations of greater than 60 minutes, TR integrity should not be directly threatened by the high levels of thermal radiation (given external bulkhead design and insulation), however, evacuation routes and lifeboats may be impaired. Thermal radiation levels (3 kW/m^2) extend almost 400m but are within the 500-600 m safety zone limit.					
Notes regarding fatality/consequence/impairment/impact: *Yes – Very likely to occur; Possible – Could occur; Unlikely – Very unlikely to occur; No – Will not occur*					

8.3.4.2 Bowtie Analysis

8.3.4.2.1 Introduction

Bowtie analysis is used to assess and qualitatively verify whether sufficient controls are in place to manage major hazards. Bowties diagrams provide an overview of multiple plausible accident scenarios and identifies the barriers in place to control them. They detail major accident causes and consequences, along with arrangements in place to prevent a feared event from occurring (the left side of the Bowtie diagram), and those used as recovery measures (control and mitigation) to reduce the consequences should the feared event occur (the right side of the Bowtie diagram).

8.3.4.2.1.1 Standard Good Practice Bowtie

All the Bowties for the GTA Phase 1 Project have been prepared with the CGE Risk (2017) Bowtie XP® software package. Bowtie XP is widely used and approved by major oil and gas companies all around the world and applies the latest good practice standards and methodologies for building bowties.

The layout of a typical standard Bowtie generated by Bowtie XP® is detailed in Figure 8-50. The identification of its different components is explained in Table 8-26.

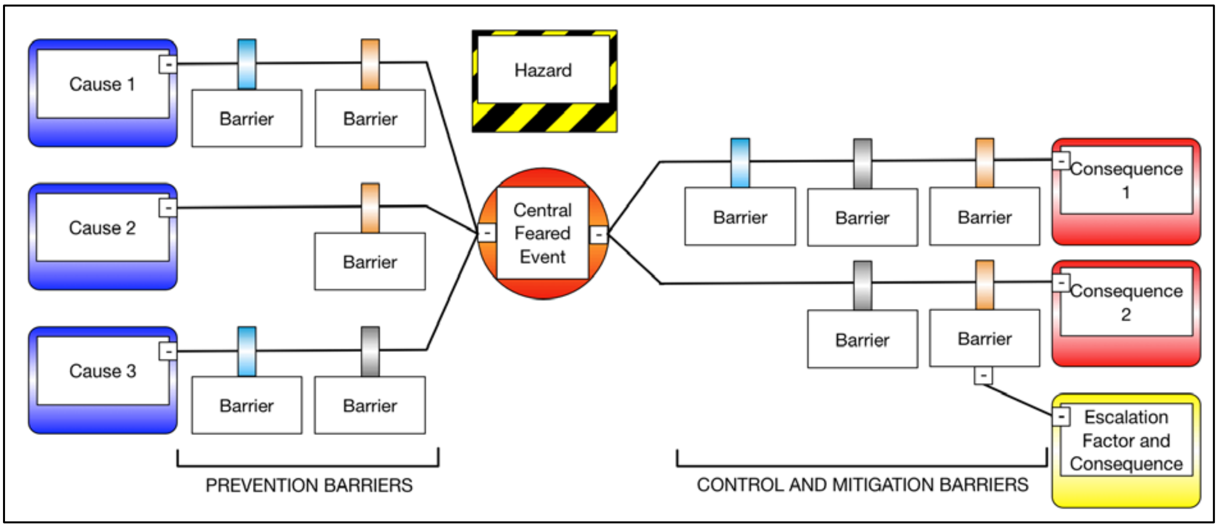
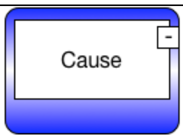
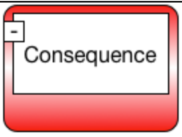
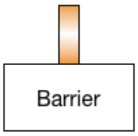
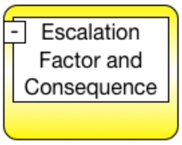


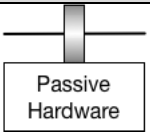
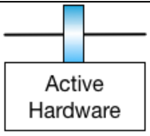
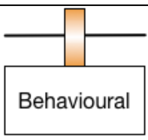
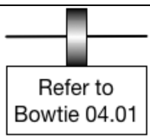
Figure 8-50. Standard Bow Tie Diagram Layout.

Table 8-26. Bowtie XP Symbols.

Symbol	Description
	Each bowtie begins with identification of a hazard that is in, around or part of the facility and has the potential to cause damage. When a hazard cannot be appropriately controlled, it can lead to a major accident event with adverse consequences.
	The moment when control is lost over the hazard is defined as the major accident event or Central Feared Event. When the loss of control initially occurs, there is no damage or adverse impact, but the Consequences are considered imminent.
	Causes are initial events that can lead to occurrence of the Central Feared Event and there can be multiple Causes for each. Causes are identified by reviewing the different scenarios regarding personnel facility interaction, equipment malfunction and external impacts.
	Consequences are the final results from the occurrence of the Central Feared Event and there are often multiple Consequences identified for each. These Consequences are identified based upon the scenarios that have an adverse impact to people, environment and facility.
	Each line item visible in the Bowtie diagram represents a branch of the Bowtie. A branch on the left side of the Bowtie illustrates a potential hazardous scenario initiated by a Cause and resulting in the occurrence of the Central Feared Event. A branch on the right side illustrates a potential hazardous scenario initiated by the occurrence of the Central Feared Event and resulting the specified Consequence.
	On the left side of the Bowtie, preventive Barriers are identified on each branch for each Cause. These Barriers are implemented to prevent or reduce the likelihood of realisation of the hazard by acting against the Cause or threat. On the right side, control and mitigative Barriers are also identified on each branch for each Consequence. These Barriers are implemented to recover from the Central Feared Event by preventing or reducing the severity of the Consequence. Note that the same Barrier can be implemented on more than one branch.
	An Escalation Factor is a condition that could lead to aggravated consequences by reducing the effectiveness of a Barrier. An escalation factor cannot directly cause the central feared event or a consequence, but it increases the likelihood that the chain of events will progress because the associated control will be degraded or fail. Additional Barriers can be identified on the escalation branch linking the failing barrier and the "Escalation Factor and Consequence", to improve the reliability of a Barrier and reduce its failure likelihood. Note that one Barrier can have more than one Escalation Factor.

Barrier categories have been established to identify specific roles in prevention, control and mitigation. The barrier categories are detailed in Table 8-27 below.

Table 8-27. Bowtie Barrier Categories.

Barrier Category and Colour Code		Description
	Gray	Equipment or hardware that is activated permanently or continuously and does not require any additional interaction / activation to perform its function in prevention, control or mitigation (e.g. vessel or line design pressure higher than maximum operating pressure, fire rated bulkheads, escape routes, facility lighting, etc.)
	Blue	Equipment or hardware that requires human interaction/activation or carriers out an executive action in prevention, control or mitigation (e.g. control systems, active fire protection systems, etc.)
	Orange	Policies, plan, procedures and training that requires a human element and/or decision for implementation (e.g. well control procedures, emergency response plans, training, certification, etc.)
	Black	Generic barriers are used to represent one or more barriers presented in detail in another Bowtie. The text inside the box is providing a reference to a Bowtie where all the relevant barriers are presented. Exceptionally, a generic barrier can also be used when no specific detailed information is available at this stage.

8.3.4.2.1.2 Representation of Bowties with Fault and Event Trees

The Republic of Senegal (2005) Risk Study Guide indicates that methods based on the construction of a fault tree for the left side and an event tree for the right side can be used. Diagrams developed following a direct interpretation of this Guide are therefore usually built by incorporating a fault tree logic in the left side and an event tree logic in the right side; these two trees are interconnected in the middle via the central feared event and the full diagram looks like a bowtie.

Bowtie analysis is also used all over the world, but the presentation is different: the left side does not present any Boolean branching and all branches are directly connected to the central feared event; the right side does not present any “Yes/No” branching specific to event tree analysis, and all branches are directly connected to the central feared event. Industry accepted practice for Bowties follows this simplified standard presentation.

Bowtie diagrams prepared for the GTA Phase 1 Project are of a standard type, following industry accepted practice for this kind of analysis. To facilitate the interpretation of these standard diagrams, an additional layer of graphic components (with a green colour) has been added and superimposed on each standard Bowtie to resemble the presentation by fault tree and event tree specific to diagrams built according to the guidelines of the Republic of Senegal (2005) Risk Study Guide.

On the left-hand side of each diagram, a logic gate “OR” was generally added upstream the Central Feared Event to illustrate that each branch could individually lead directly to its occurrence. For one of the Bowties where the occurrence of the Central Feared Event would require the concurrent occurrence of two causes, a logic gate “AND” was added upstream the Central Feared Event. Last, for the *Blowout and Well Release* Bowtie, two “OR” and one “AND” gates were added to illustrate the potential combinations of events that could result in the occurrence of the Central Feared Event.

On the right-hand side, since consequences in the standard Bowties are all linked directly to the Central Feared Event, it is difficult to understand which consequence will occur in absence or presence of ignition, which consequence will have immediate effects, and which one will have delayed effects with potential escalation of consequences. To facilitate the interpretation of the right-hand side of standard Bowties, each Bowtie was built as follows:

- Consequences branches of each standard Bowtie were represented in the same timeline order from top to bottom, where applicable:
  1) Branch 1: Consequence in absence of ignition (usually a marine pollution)
  2) Branch 2: Consequence in presence of ignition – immediate effect (usually immediate fatalities due to jet fire, flash fire or explosion)
  3) Branch 3: Consequence in presence of ignition – escalation effect (usually additional fatalities due to secondary explosion, extension of fire to other areas, failure of structures, etc.)
  4) Branch 4 and following: Consequence in presence of ignition – escalation effect – additional damage following the failure of a barrier (usually, additional fatalities during the egress of personnel, while personnel are mustered in a safe area, or during the evacuation/rescue of personnel)
- Green-color “Event Description Tags” were added and superimposed on each consequence or escalation event to provide the missing event tree information.

The fault tree and event tree symbols, added to facilitate the interpretation of standard Bowties, are described below in Table 8-28.

Table 8-28. Fault and Event Tree Symbol Descriptions Added on Standard Bowties.

Overlay Symbol		Description
AND	“AND” Logic Gate	All initial Causes connected by a branch line to an “AND” gate must occur concurrently for the Central Feared Event to occur
OR	“OR” Logic Gate	Any of the initial Causes connected by a branch line to an “OR” gate can individually lead to the occurrence of the Central Feared Event)
Consequence/ Escalation Event Description	Consequence/ Escalation Event Description	The consequence/escalation event description identifies whether a Consequence is happening after ignition or not, and whether the Consequence is immediate or results from escalation effects/events

To further facilitate the comprehension of standard Bowties with additional fault tree and event tree symbols, an additional Bowtie has been prepared for *Blowout and Well Release*. This Bowtie, given in Appendix O-5, is provided only to facilitate the comparison between the fault/event tree Bowtie format, and the standard good practice Bowtie format used for the GTA Phase 1 Project Risk Study.

8.3.4.2.2 Standard Bowtie Diagrams

Bowtie analysis was undertaken for all major accident events. The specific Bowties developed, along with the major accident events they relate to, are listed in Table 8-29. The table also gives the event severity ranking from the preliminary risk analysis (refer to Section 8.3.3).

Given the size of the Bowtie diagrams, only those major accident events risk ranked with Catastrophic severity (5) in the preliminary risk analysis are presented in the main body of the Risk Study. Bowtie diagrams for those major accident events risk ranked with Critical severity (4) in the preliminary risk analysis are presented in Appendix O-3.

Table 8-29. Major Accident Event Bowties.

Bowtie ID	Major Accident Event (Analysed with a Bowtie)	Major Accident Event (ID / Scenario Assessed in the Detailed Risk Assessment)		Severity Rank
01	Drillship Blowout or Well Release	D-01	Blowout or Well Release	5
		D-02	Gas Release in Mud Processing Area	4
02.01	Drillship Loss of Vessel Stability/Capsize	D-04	Loss of Vessel Stability/Capsize	5
02.02	FPSO Loss of Vessel Stability/Capsize	F-15	Loss of Vessel Stability/Capsize	5
03	Drillship Transportation (Helicopter) Accident	D-05	Transportation (Helicopter) Accident	5
04.01	Drillship Vessel Collision (Passing Vessel)	D-06	Passing Vessel Collision	5
04.02	FPSO Vessel Collision (Passing Vessel)	F-18	Passing Vessel Collision	5
05.01	FPSO Hydrocarbon Riser Release	F-01	Hydrocarbon Release from Production Riser	5
		F-02	Gas Release from Export Gas Risers	5
05.02	Riser Platform Hydrocarbon Riser Release	N-01	Gas Release from Import Gas Riser	5
06.01	FPSO Condensate Storage Tank Release	F-13	Condensate Release from Storage Tank	5
06.02	FPSO Condensate Storage Tank Fire	F-14	Condensate Storage Tank Fire	5
07	FLNG Refrigerant Release	N-13	Gas Release from FLNG SMR Closed Loop	5
		N-14	Liquid/Two Phase Release from FLNG SMR Closed Loop	5
		N-15	Refrigerant Release from FLNG Refrigerant Storage	5
08.01	FLNG/LNGC LNG Release from Storage Tank	N-17	LNG Release from FLNG/LNGC Storage Tanks	5
08.02	FLNG LNG Release during LNGC Loading	N-18	LNG Release during LNGC Loading	4
09	QU Platform Structural Failure/Damage	N-19	Failure of QU Platform Structure	5
10	NSH Vessel Collision (LNGC with Berth)	N-21	LNG Carrier Collision with Berth	5
11	Drillship Well Testing or Clean-up Hydrocarbon Release	D-03	Hydrocarbon Release during Well Testing or Clean-up	4

Bowtie ID	Major Accident Event (Analysed with a Bowtie)	Major Accident Event (ID / Scenario Assessed in the Detailed Risk Assessment)		Severity Rank
12.01	FPSO Hydrocarbon Process Release	F-03	Gas Release from Reception Facilities (Slug Catchers)	4
		F-04	Liquid Release from Reception Facilities (Slug Catchers)	4
		F-05	Gas Release from Gas Processing	4
		F-06	Liquid Release from Gas Processing	4
		F-07	Liquid Release from MP Separator	4
		F-08	Liquid Release from LP Separator	4
		F-09	Liquid Release from LLP Separator	4
		F-10	Gas Release from Flash Gas Compression	4
		F-11	Gas Release from Fuel Gas System	4
12.02	FLNG Hydrocarbon Process Release	N-02	Gas Release from Trestle Feed Gas Flowline/Hose to FLNG	4
		N-03	Gas Release from Trestle Fuel Gas Flowline to QU Platform	4
		N-04	Gas Release from FLNG Inlet Metering and Amine Treatment	4
		N-05	Gas Release from FLNG Dehydration and Regeneration	4
		N-06	Gas Release from FLNG Boil Off Gas/FGC	4
		N-07	Gas Release from FLNG HP Fuel Gas System	4
		N-08	Gas Release from FLNG Fractionation	4
		N-09	Light Hydrocarbon Liquid Releases from FLNG fractionation	4
		N-10	LNG Release from FLNG Liquefaction Process	4
		N-11	LNG Release from FLNG Flash Gas Drum	4
		N-12	BLEVE of Vessel on FLNG Containing Refrigerant	4
13	FPSO Chemical Injection Release	F-12	Injection Chemical Release Topsides	4
14.01	FPSO/NSH Transportation Accident (Crew Boat Founders)	F-16	Transportation (Crew Boat/FROG) Accident	4
		N-20	Transportation (Crew Boat) Accident	4
14.02	FPSO Transportation Accident (Dropped FROG)	F-16	Transportation (Crew Boat/FROG) Accident	4

Bowtie ID	Major Accident Event (Analysed with a Bowtie)	Major Accident Event (ID / Scenario Assessed in the Detailed Risk Assessment)		Severity Rank
15	FPSO Vessel Collision (Condensate Offtake Tanker)	F-17	Condensate Offtake Tanker Collision	5
16	QU Platform Fuel Gas Release	N-16	Gas Release (Fuel Gas) in QU Platform Utility Space/Area	4
17	Security Incident	G-01	Security Incident	5

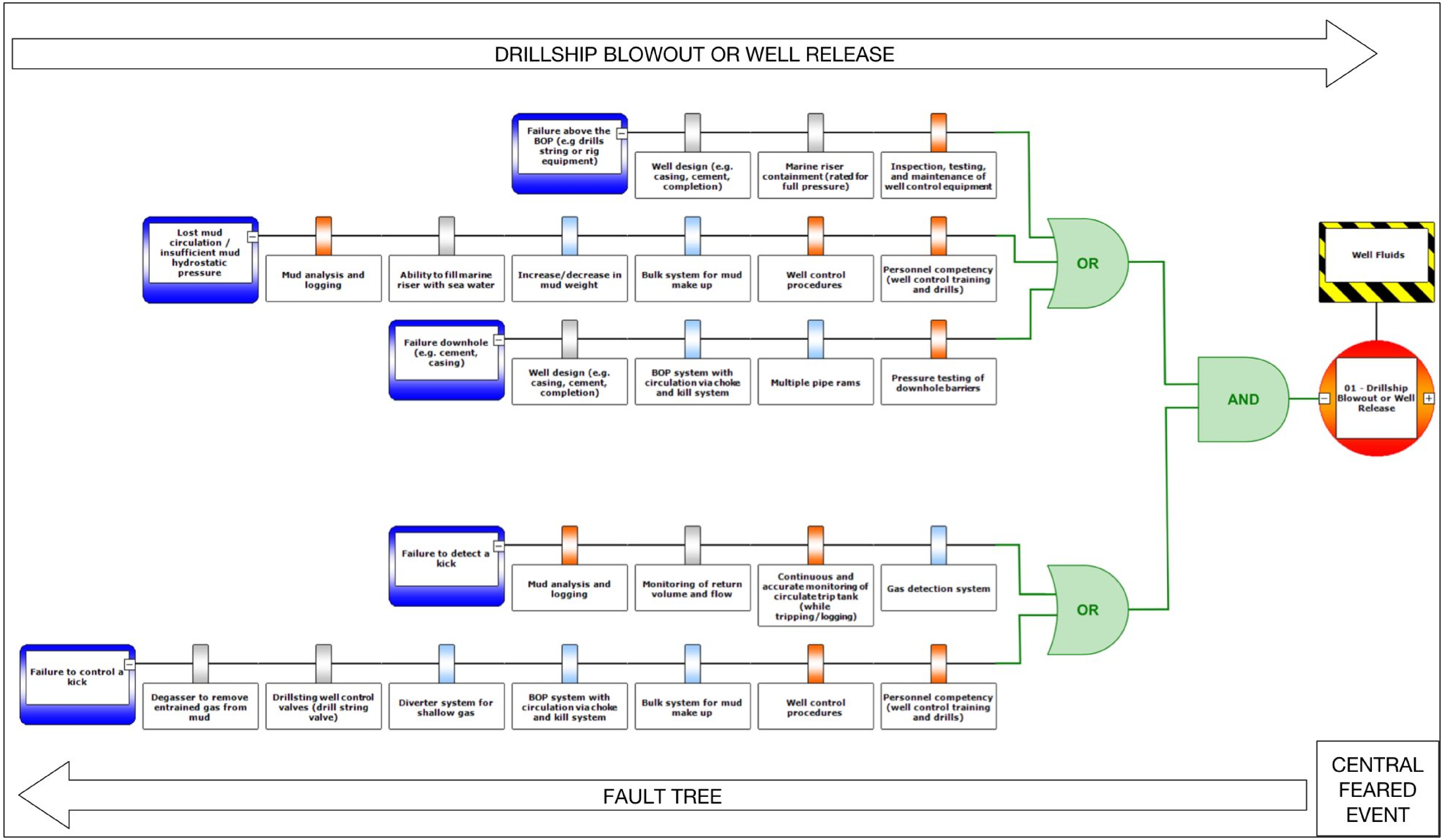


Figure 8-51. Bowtie 01 - Drillship Blowout or Well Release (Left Hand Side).

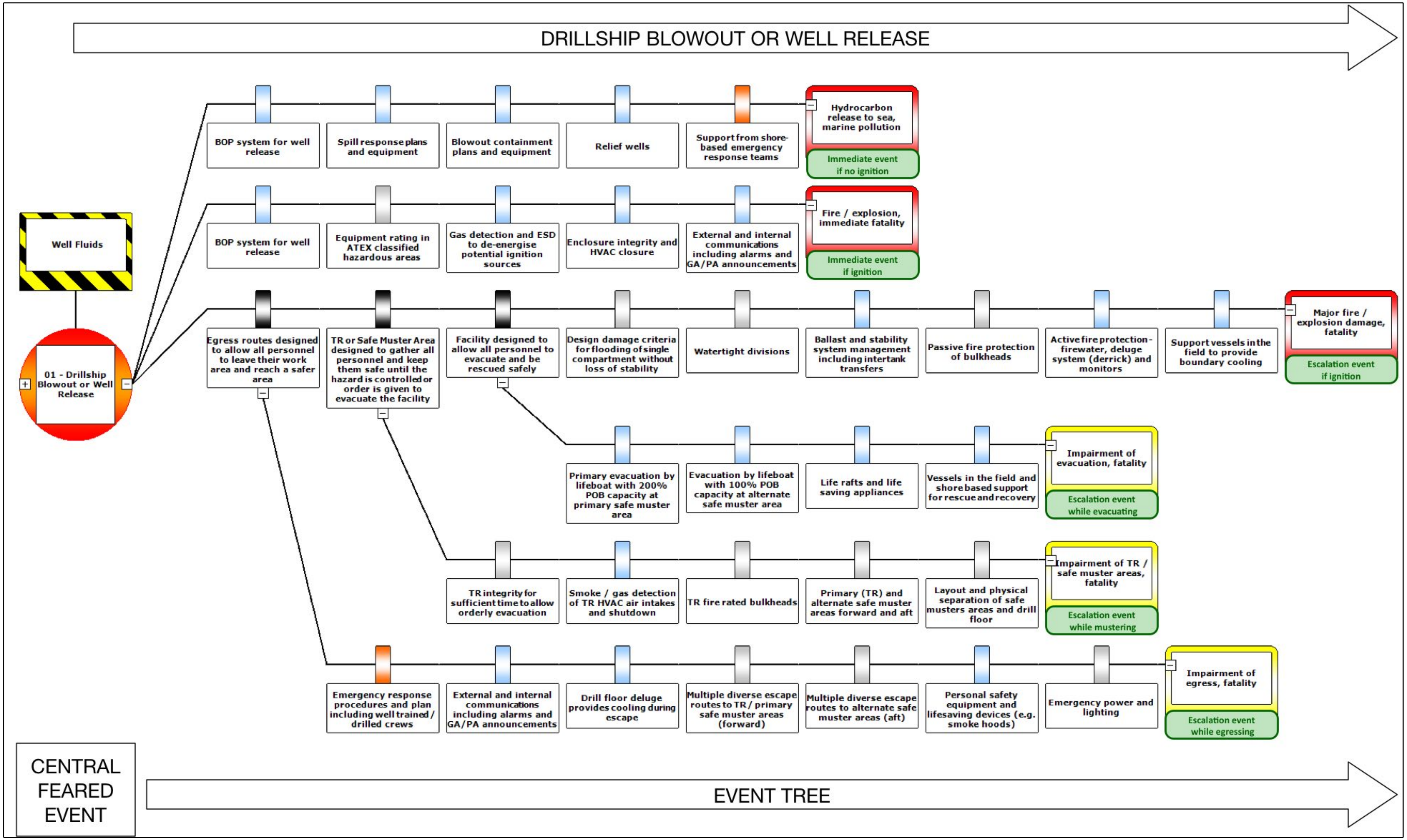


Figure 8-52. Bowtie 01 - Drillship Blowout or Well Release (Right Hand Side).

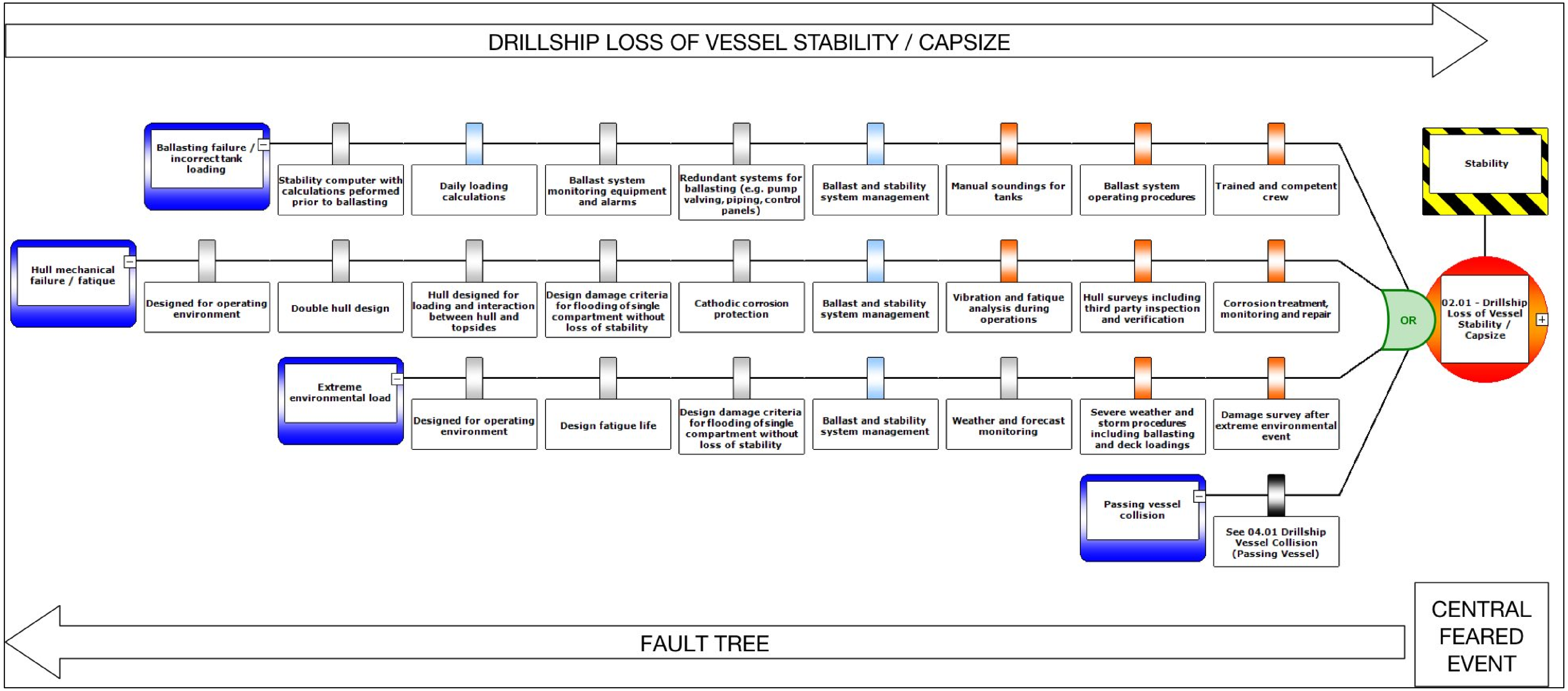


Figure 8-53. Bowtie 02.01 - Drillship Loss of Vessel Stability/Capsize (Left Hand Side).

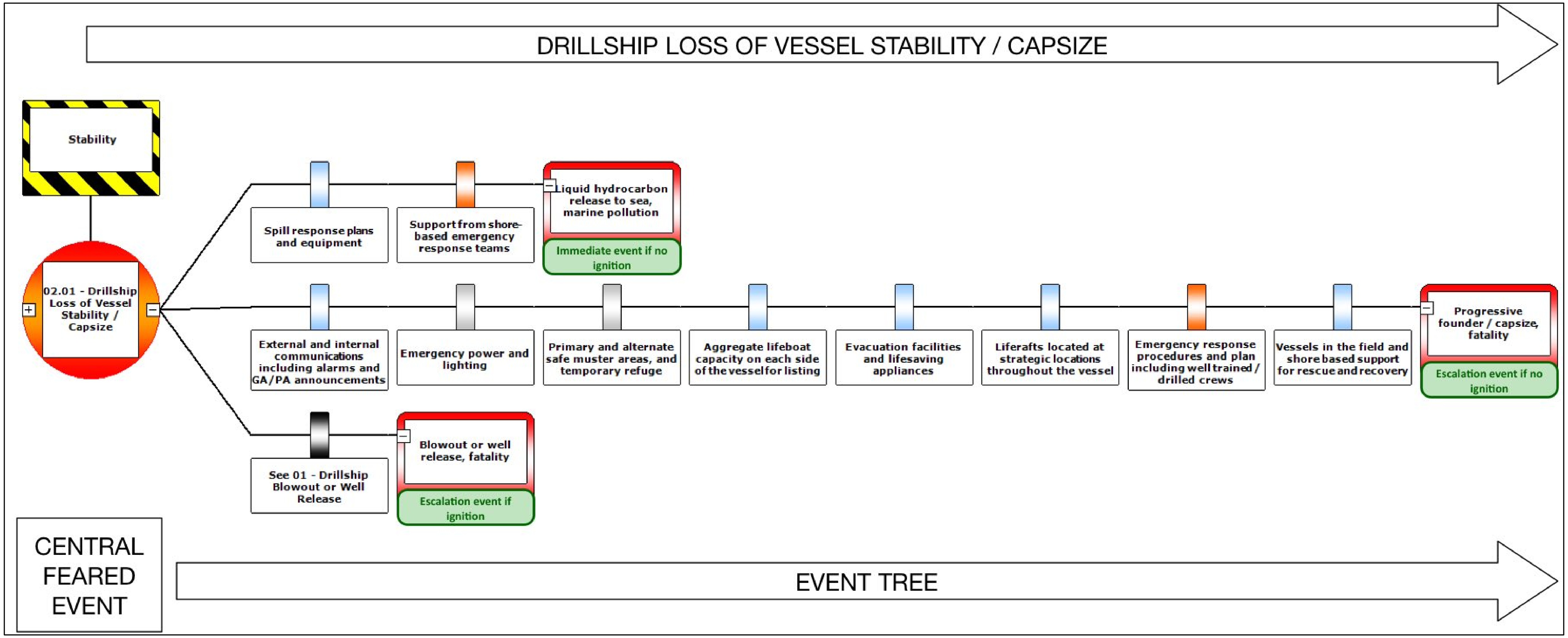


Figure 8-54. Bowtie 02.01 - Drillship Loss of Vessel Stability/Capsize (Right Hand Side).

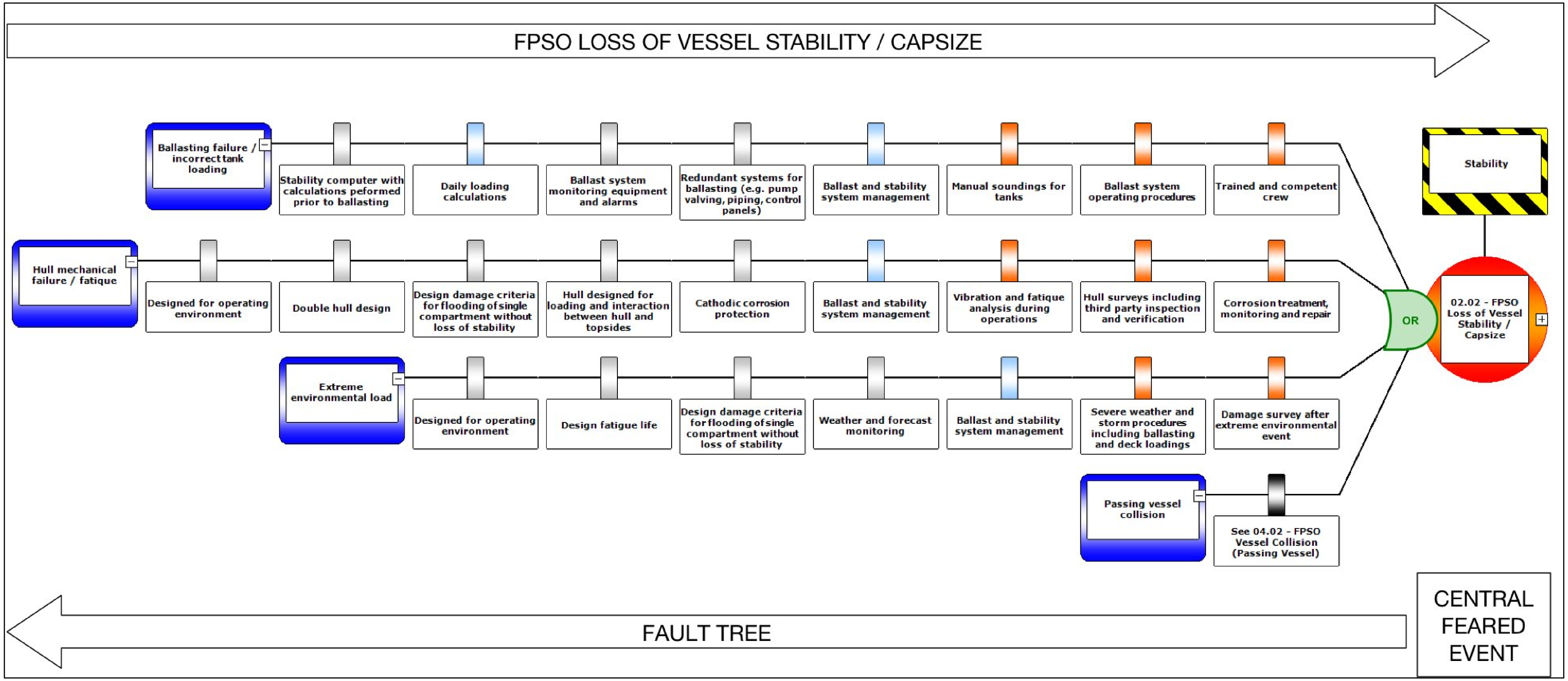


Figure 8-55. Bowtie 02.02 - FPSO Loss of Vessel Stability/Capsize (Left Hand Side).

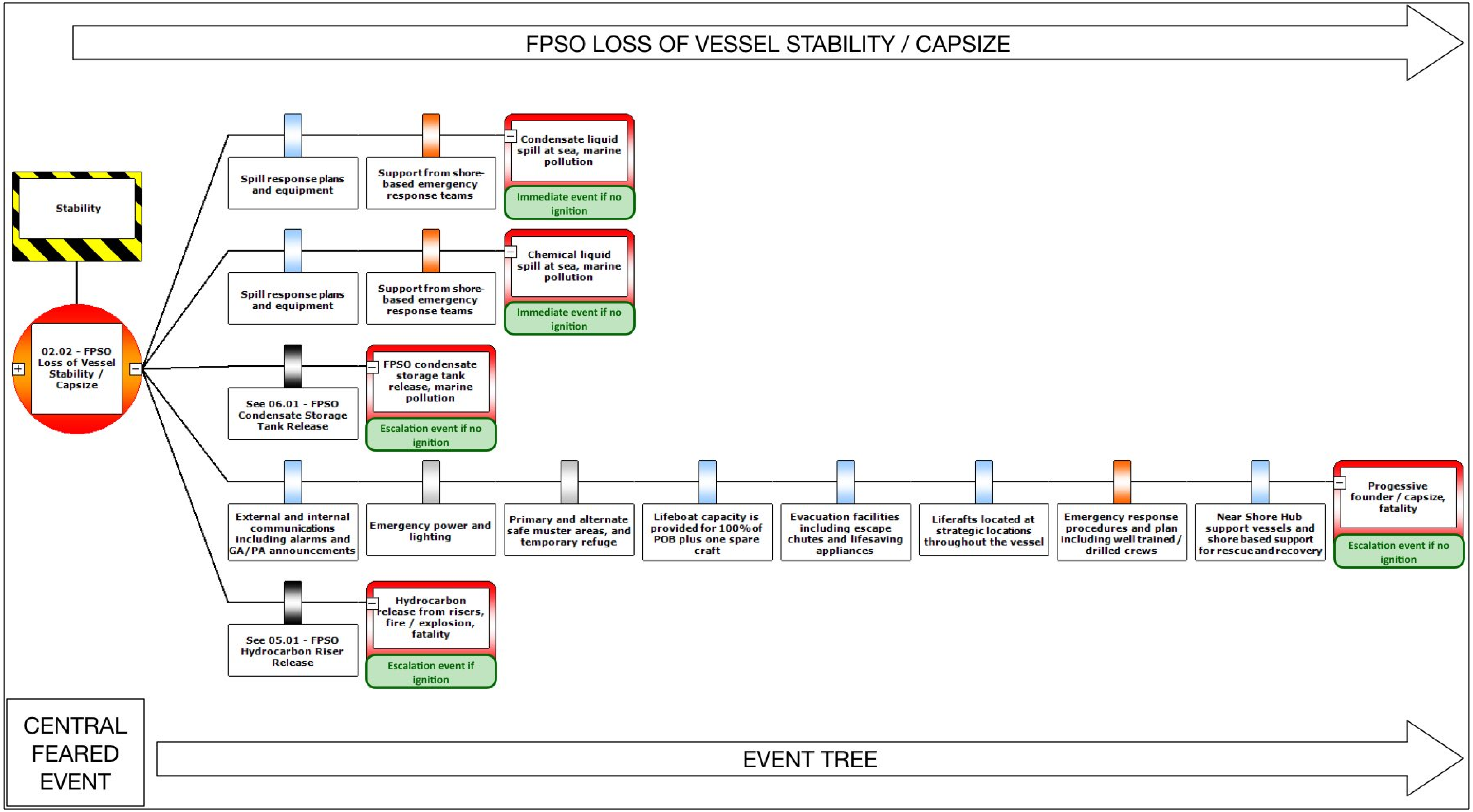


Figure 8-56. Bowtie 02.02 – FPSO Loss of Vessel Stability/Capsize (Right Hand Side).

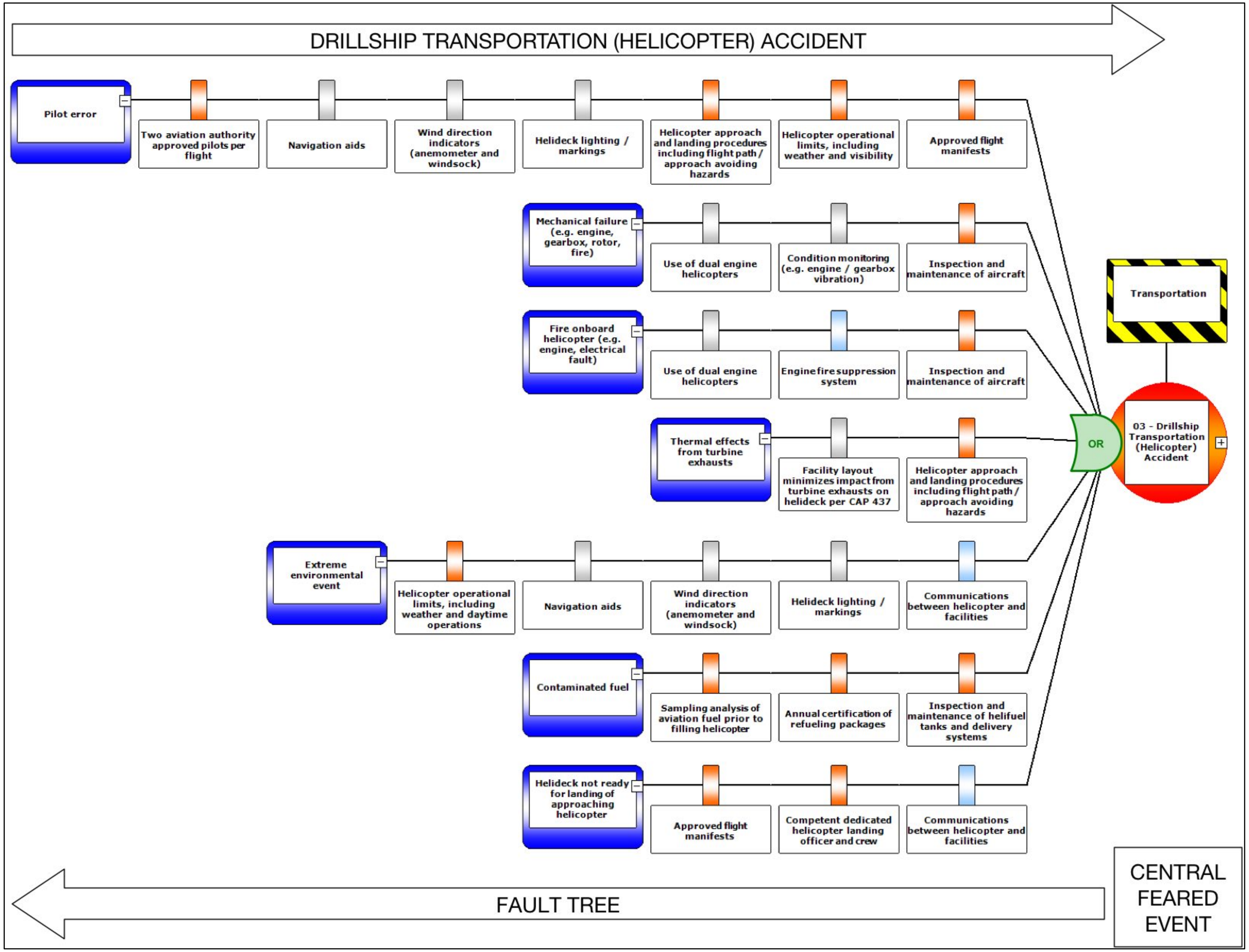


Figure 8-57. Bowtie 03 - Drillship Transportation (Helicopter) Accident (Left Hand Side).

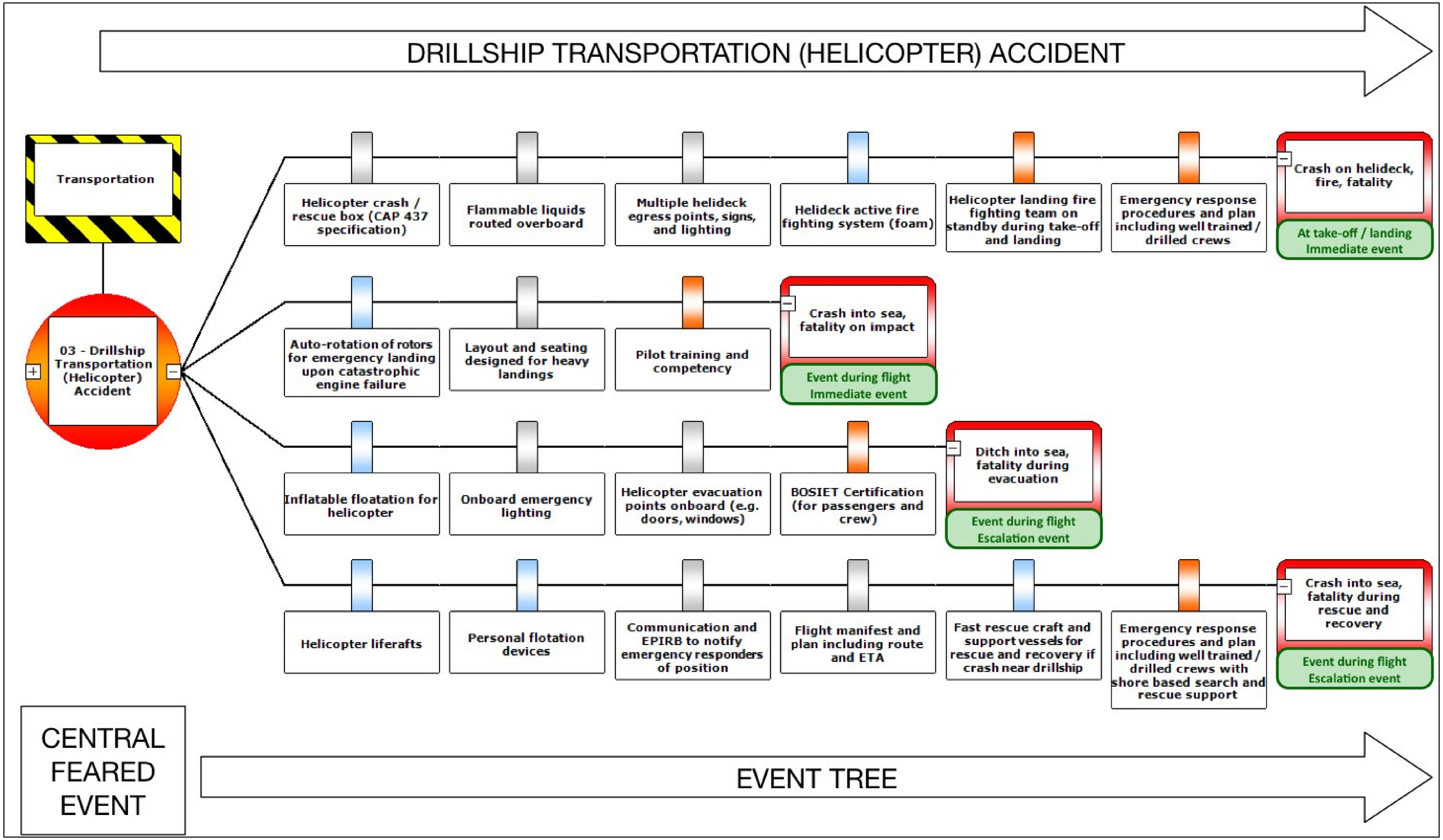


Figure 8-58. **Bowtie 03 - Drillship Transportation (Helicopter) Accident (Right Hand Side).**

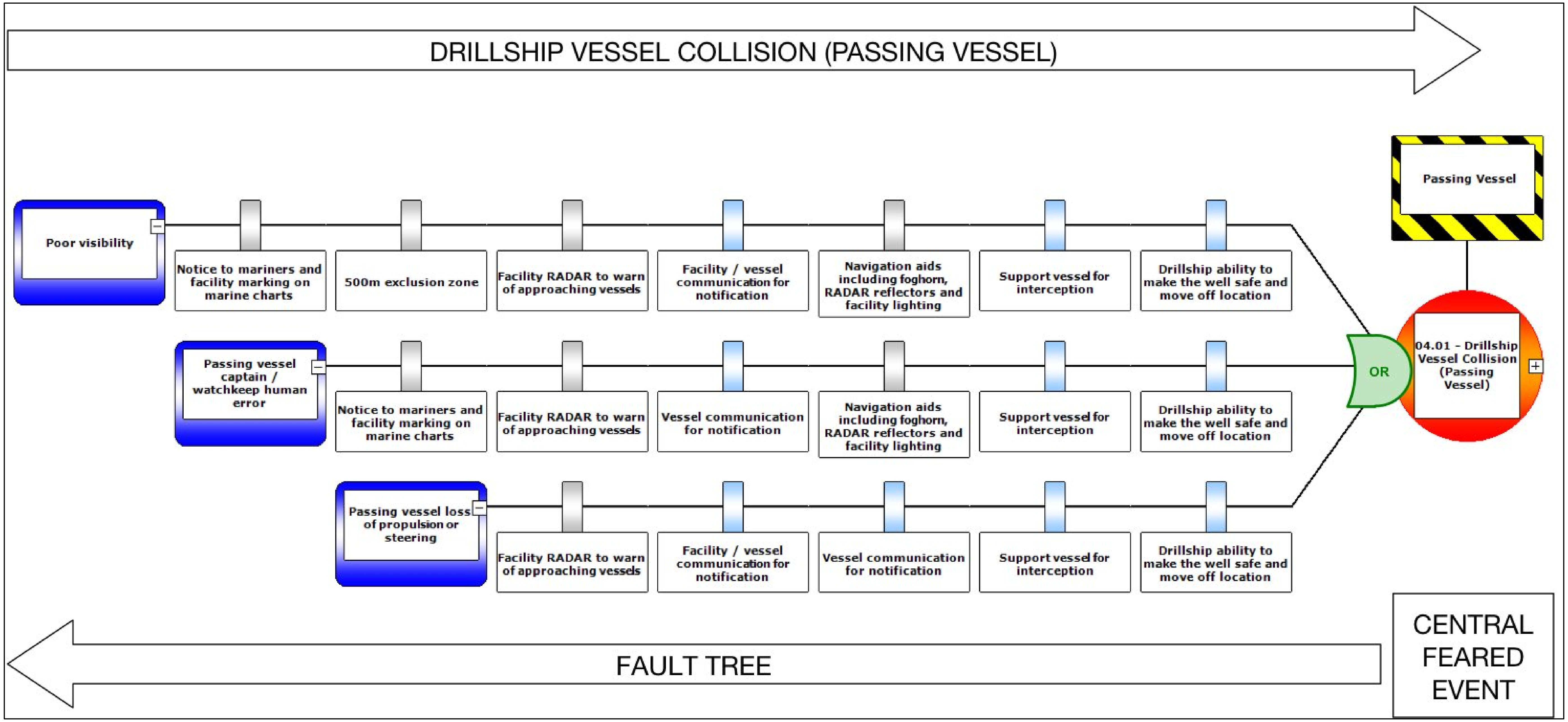


Figure 8-59. **Bowtie 04.01 - Drillship Vessel Collision (Passing Vessel) (Left Hand Side).**

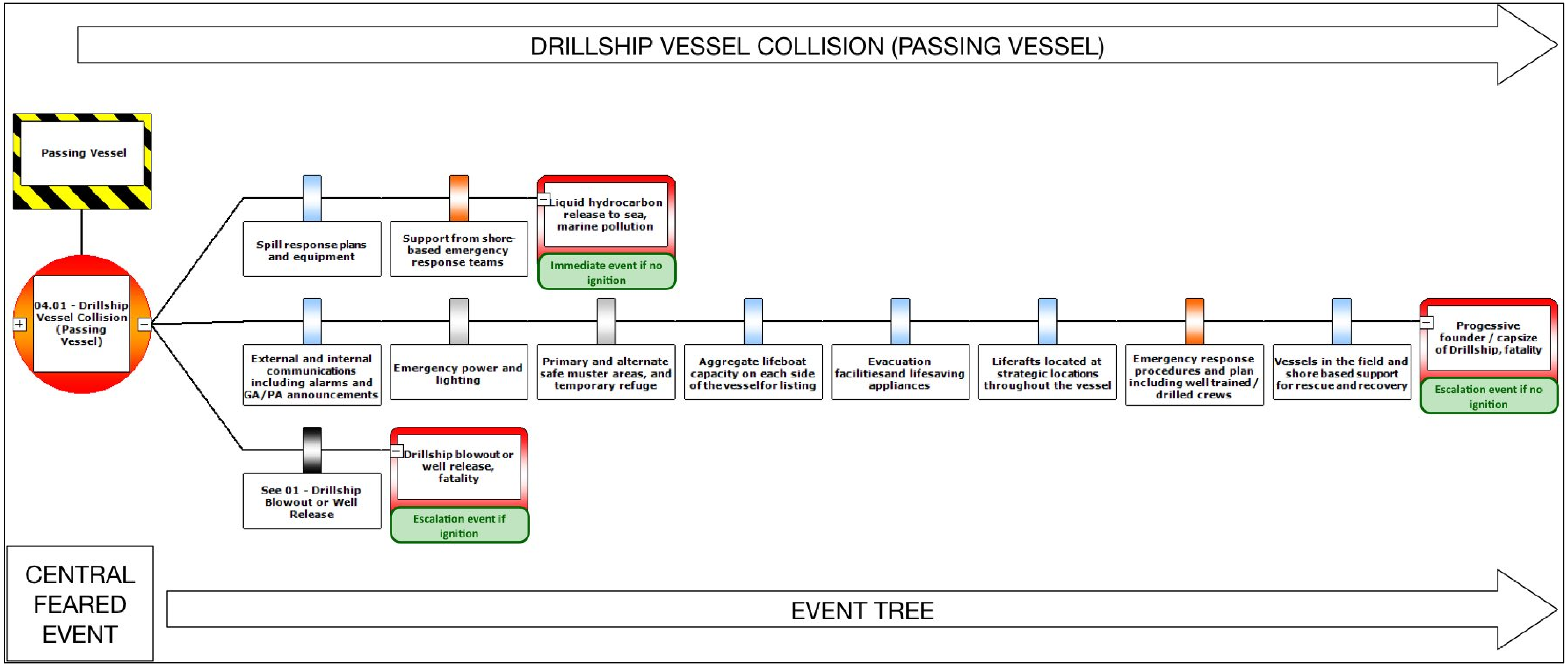


Figure 8-60. **Bowtie 04.01 - Drillship Vessel Collision (Passing Vessel) (Right Hand Side).**

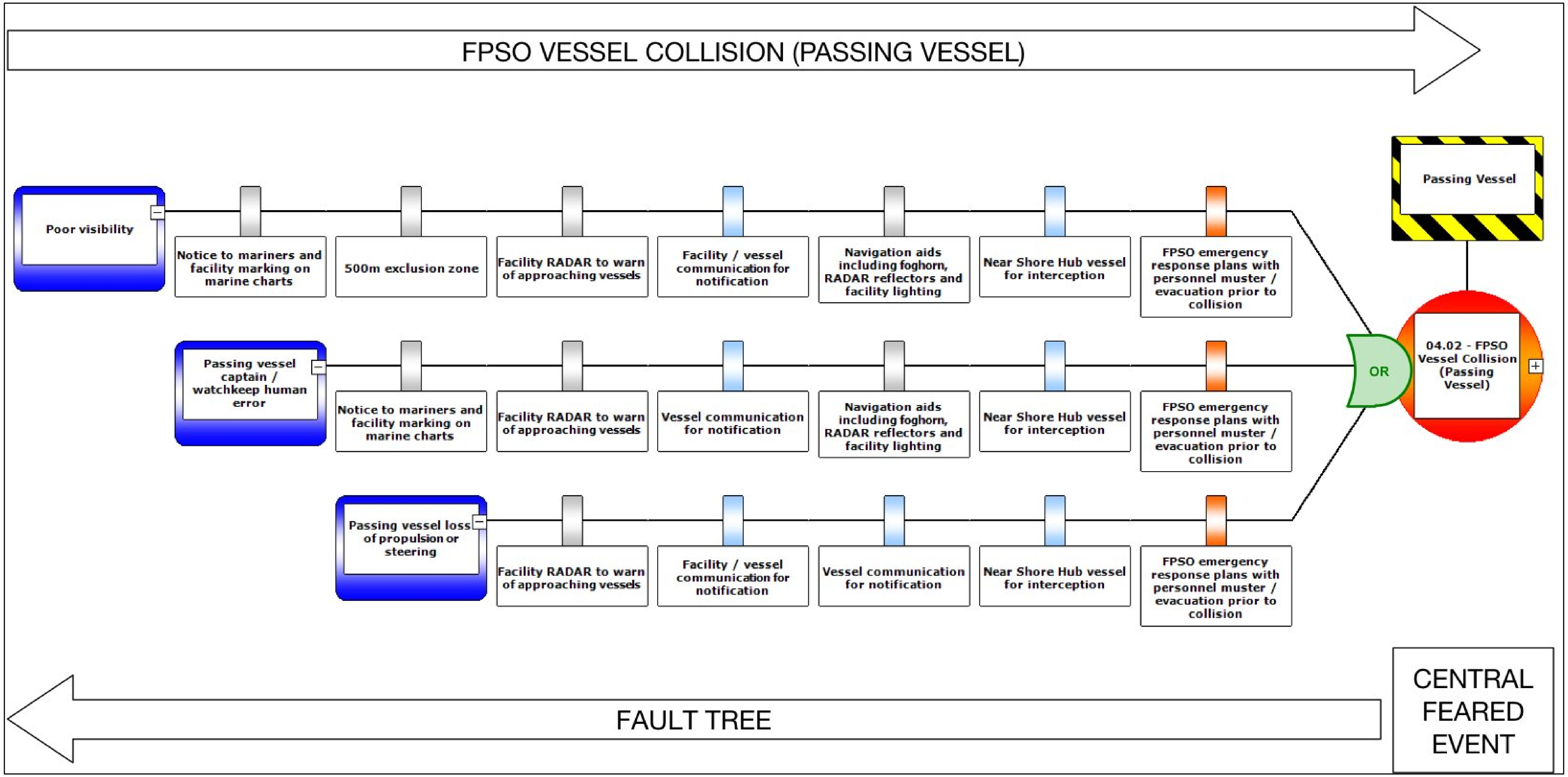


Figure 8-61. Bowtie 04.02 - FPSO Vessel Collision (Passing Vessel) (Left Hand Side).

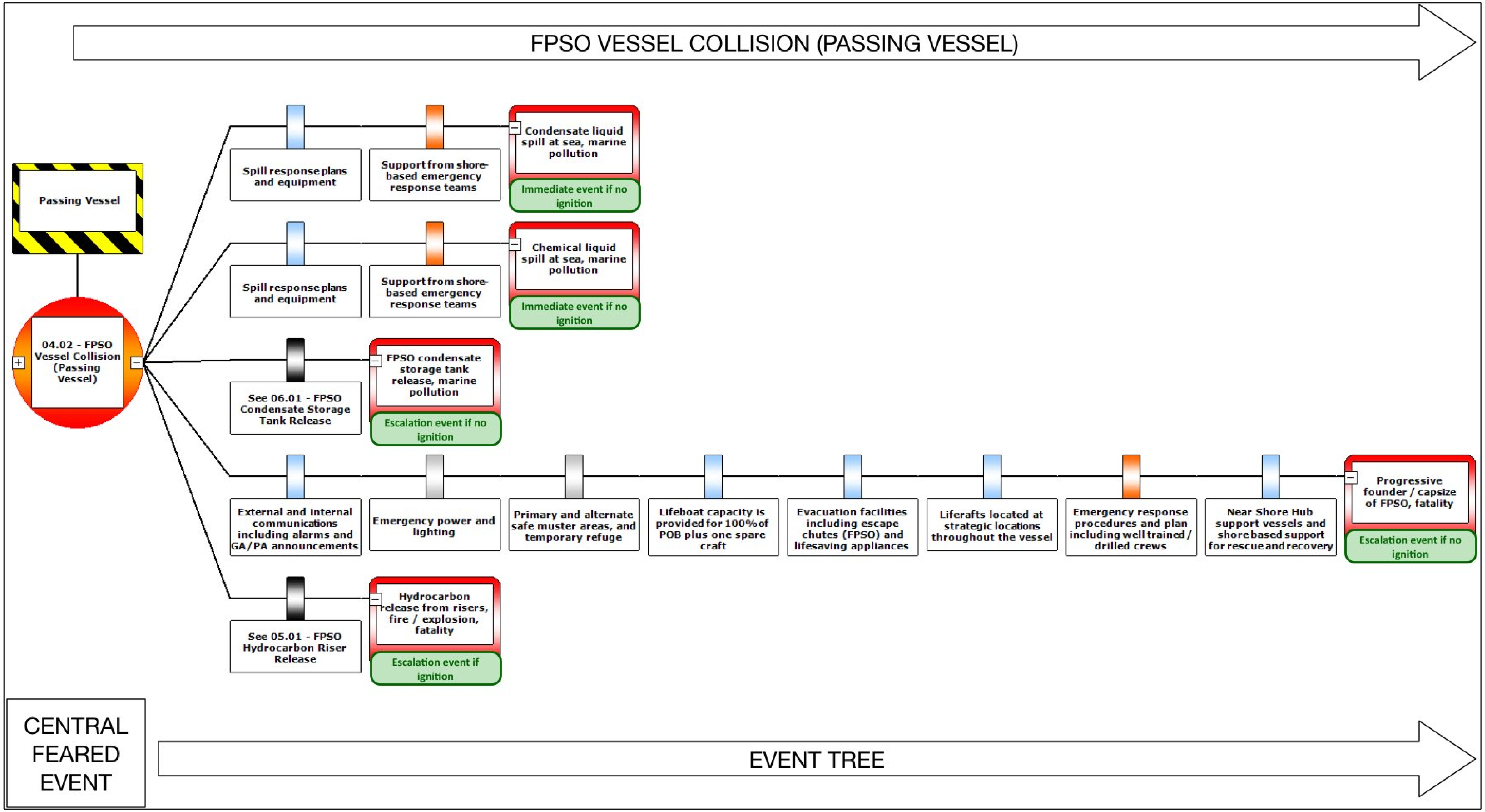


Figure 8-62. Bowtie 04.02 - FPSO Vessel Collision (Passing Vessel) (Right Hand Side).

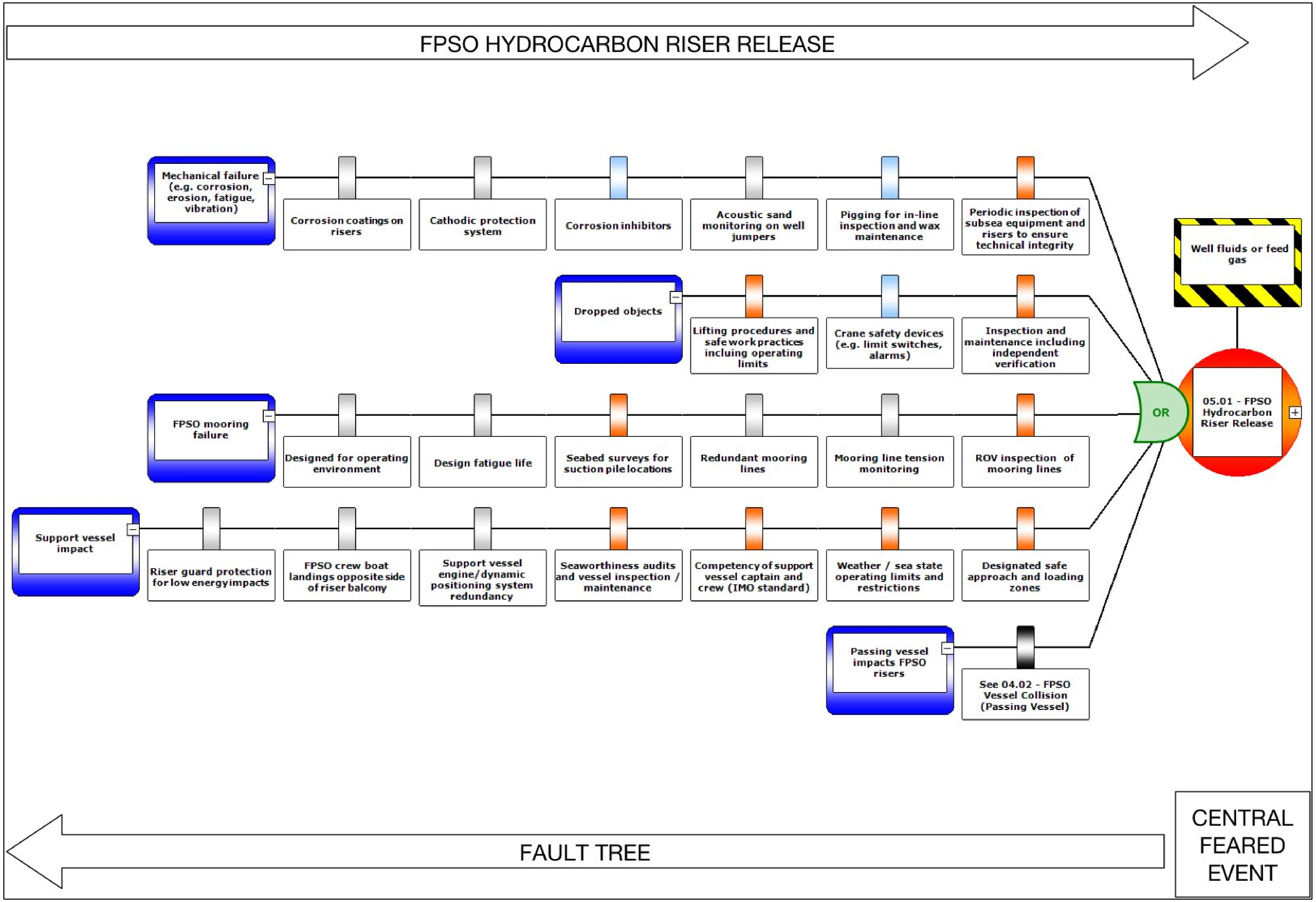


Figure 8-63. Bowtie 05.01 – FPSO Hydrocarbon Riser Release (Left Hand Side).

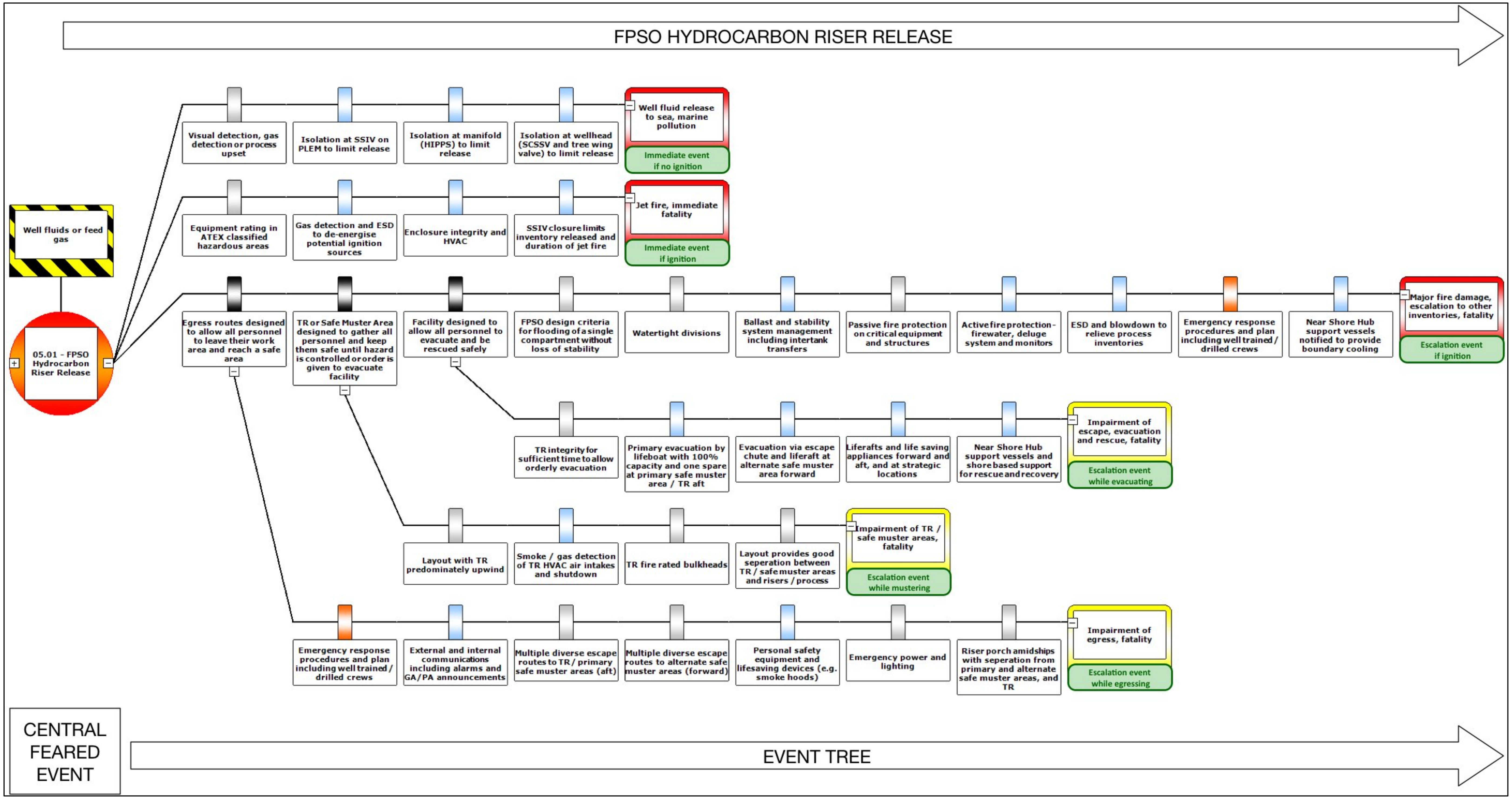


Figure 8-64. Bowtie 05.01 – FPSO Hydrocarbon Riser Release (Right Hand Side).

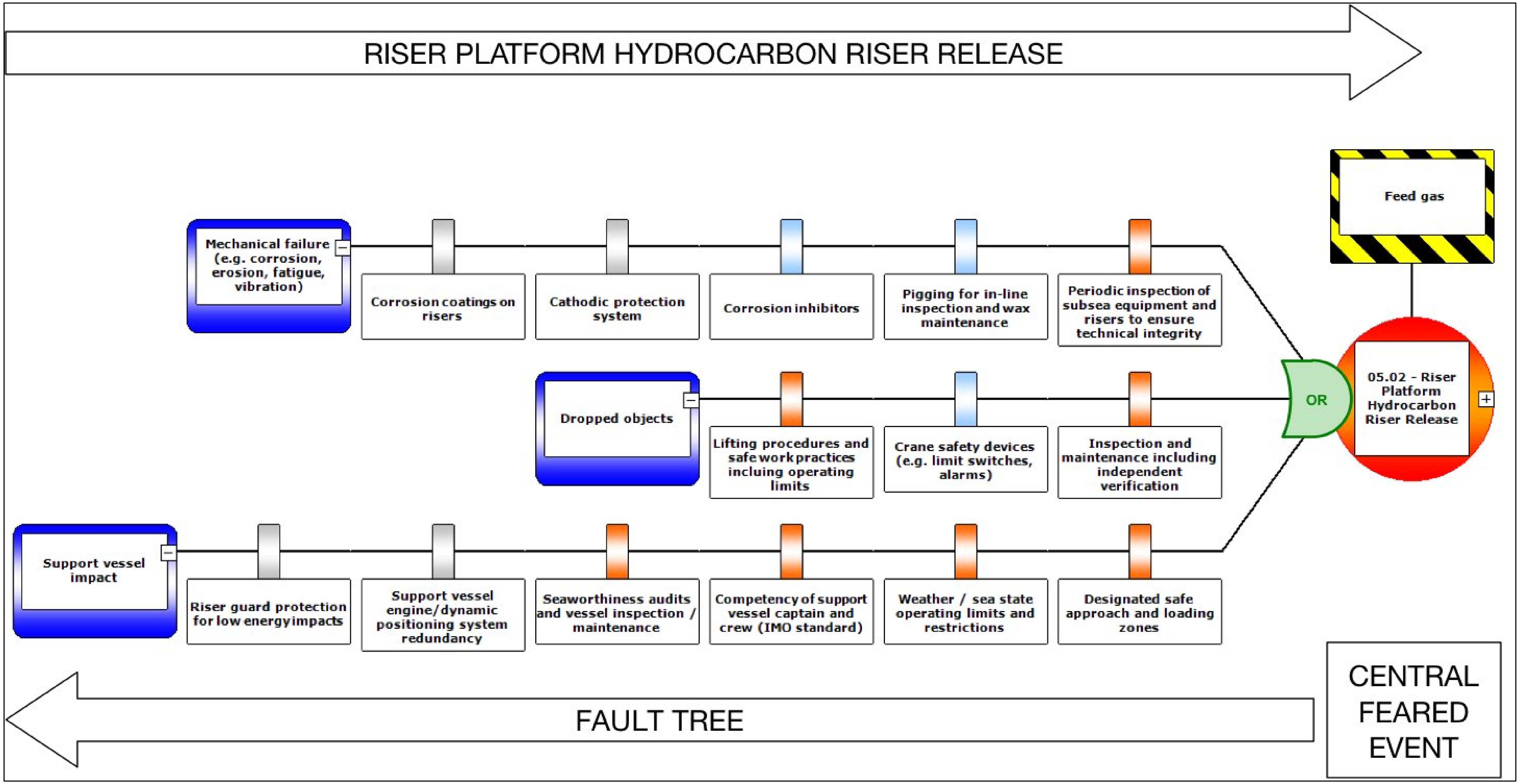


Figure 8-65. Bowtie 05.02 – Riser Platform Hydrocarbon Riser Release (Left Hand Side).

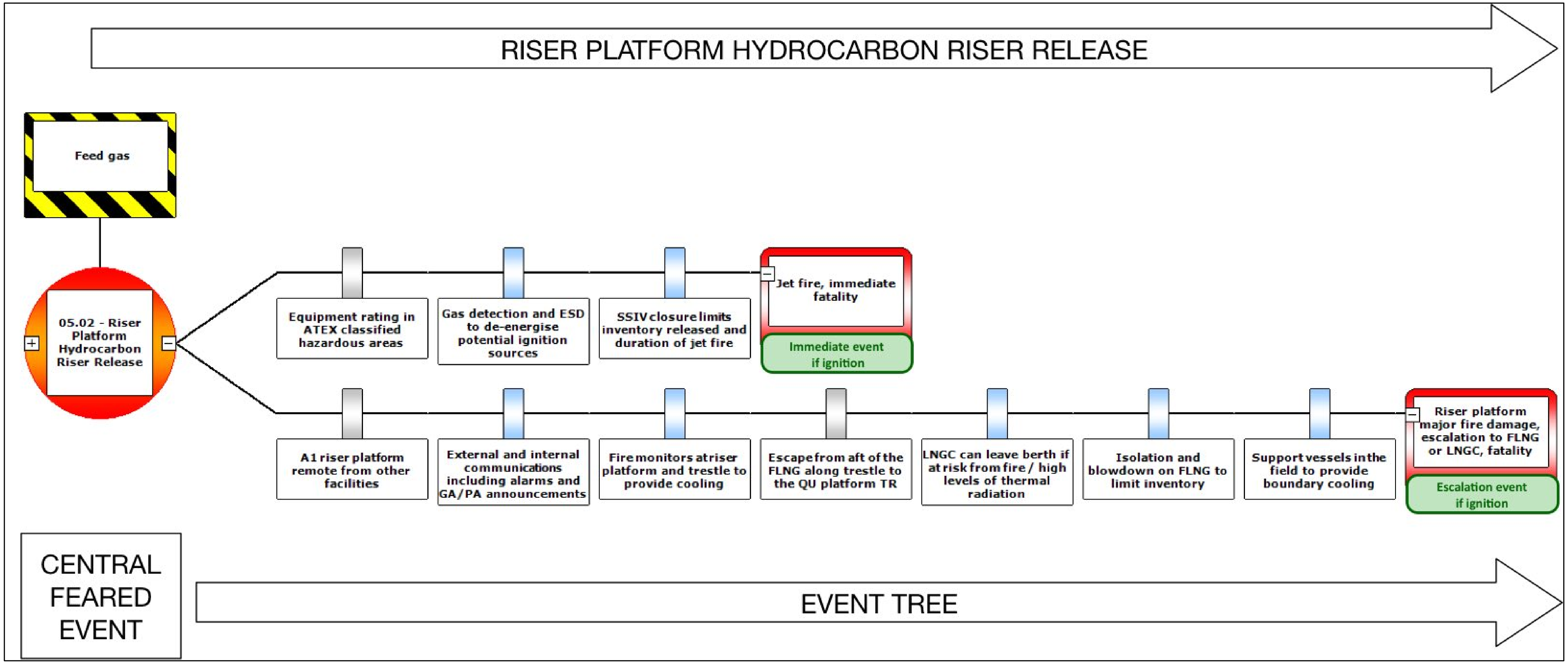


Figure 8-66. Bowtie 05.02 – Riser Platform Hydrocarbon Riser Release (Right Hand Side).

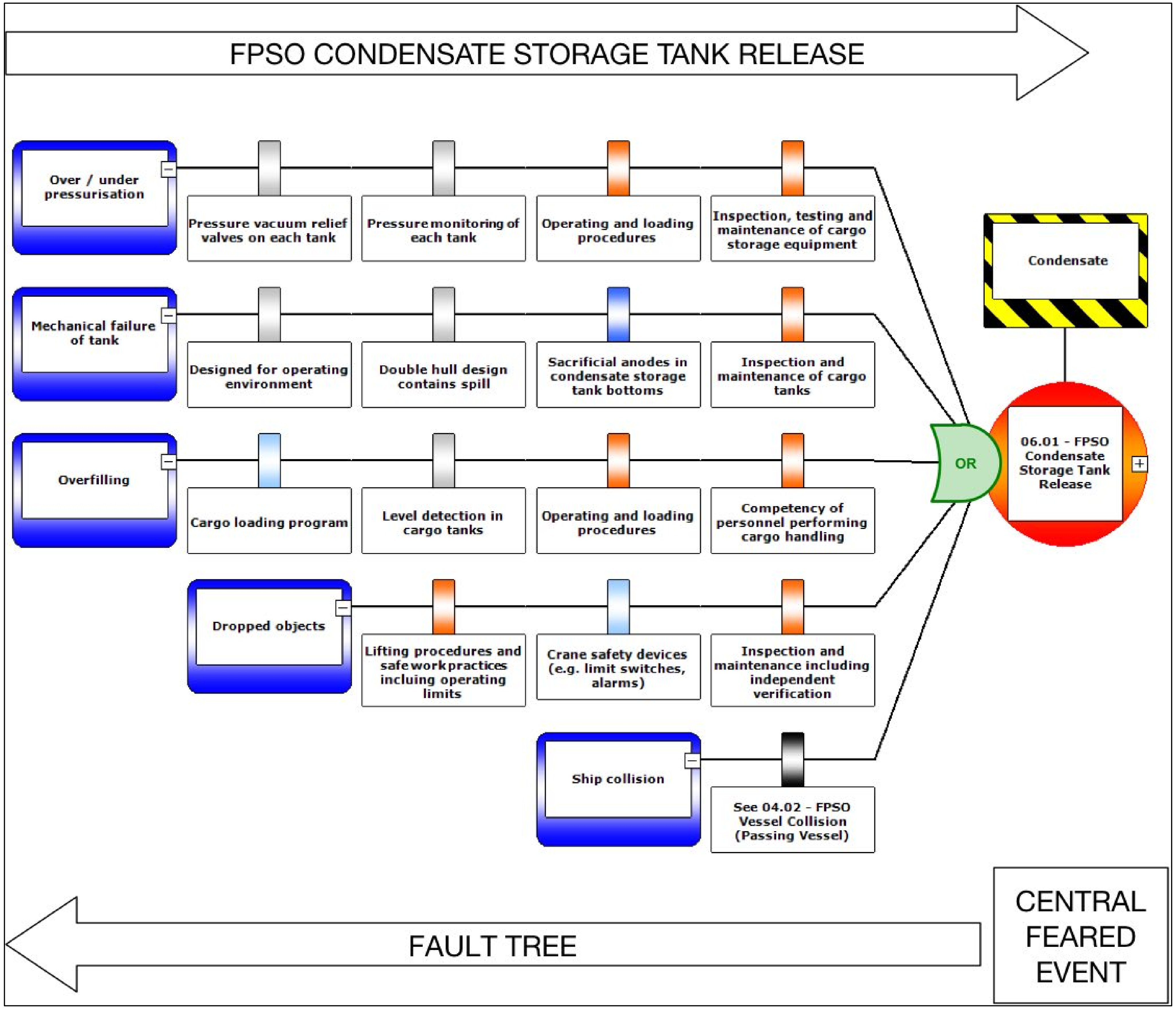


Figure 8-67. Bowtie 06.01 – FPSO Condensate Storage Tank Release (Left Hand Side).

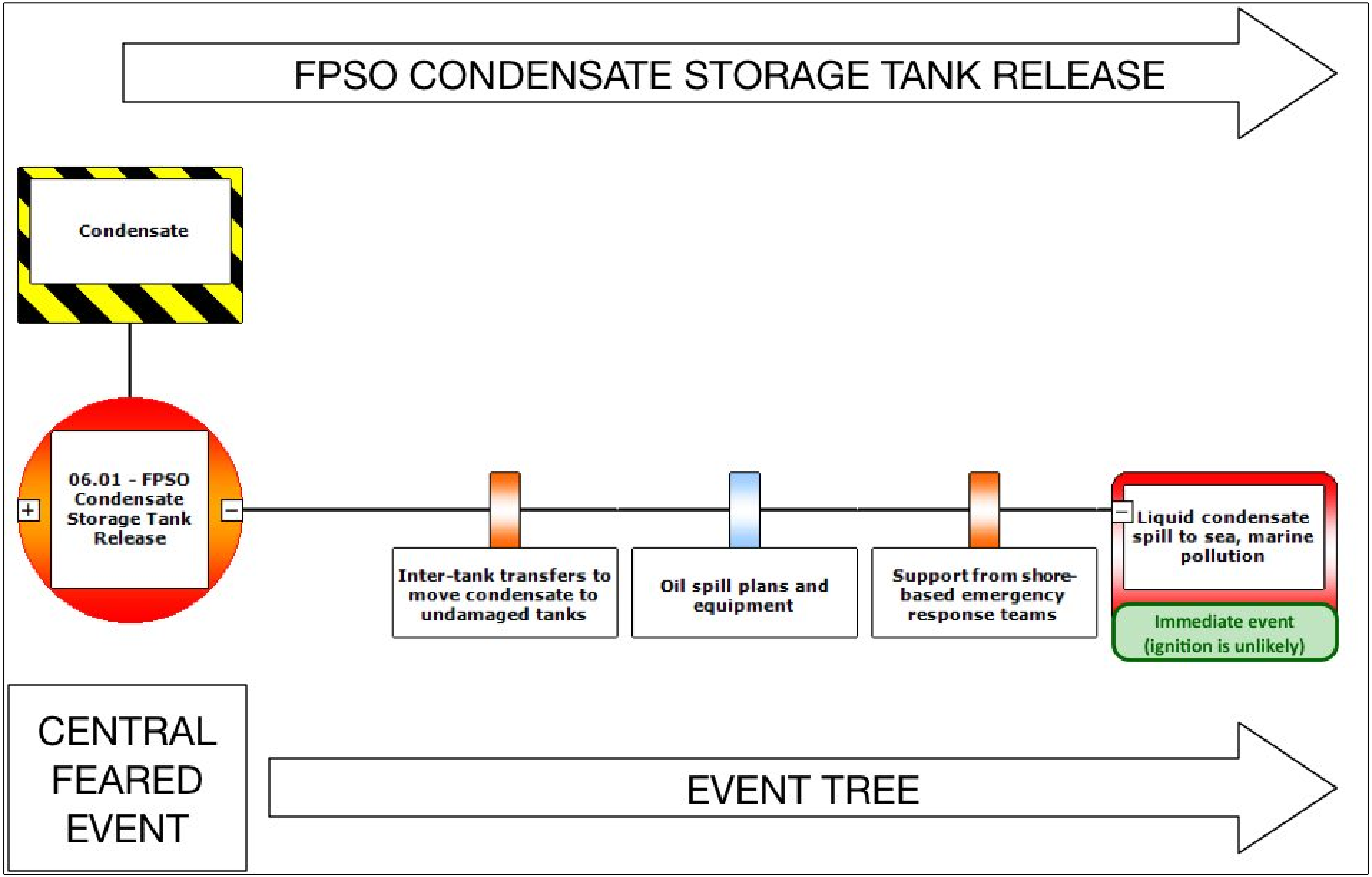


Figure 8-68. Bowtie 06.01 – FPSO Condensate Storage Tank Release (Right Hand Side).

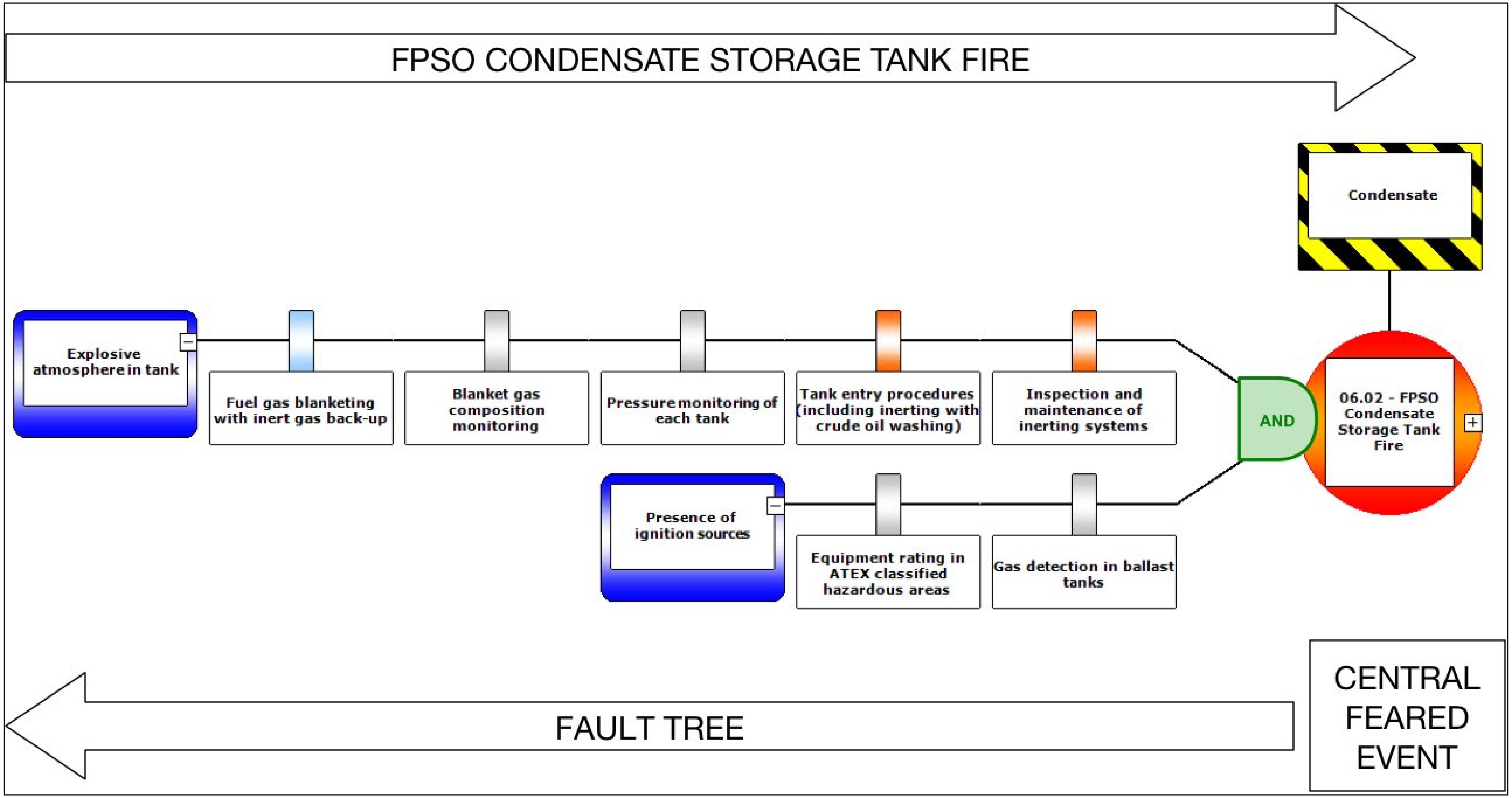


Figure 8-69. Bowtie 06.02 – FPSO Storage Tank Fire (Left Hand Side).

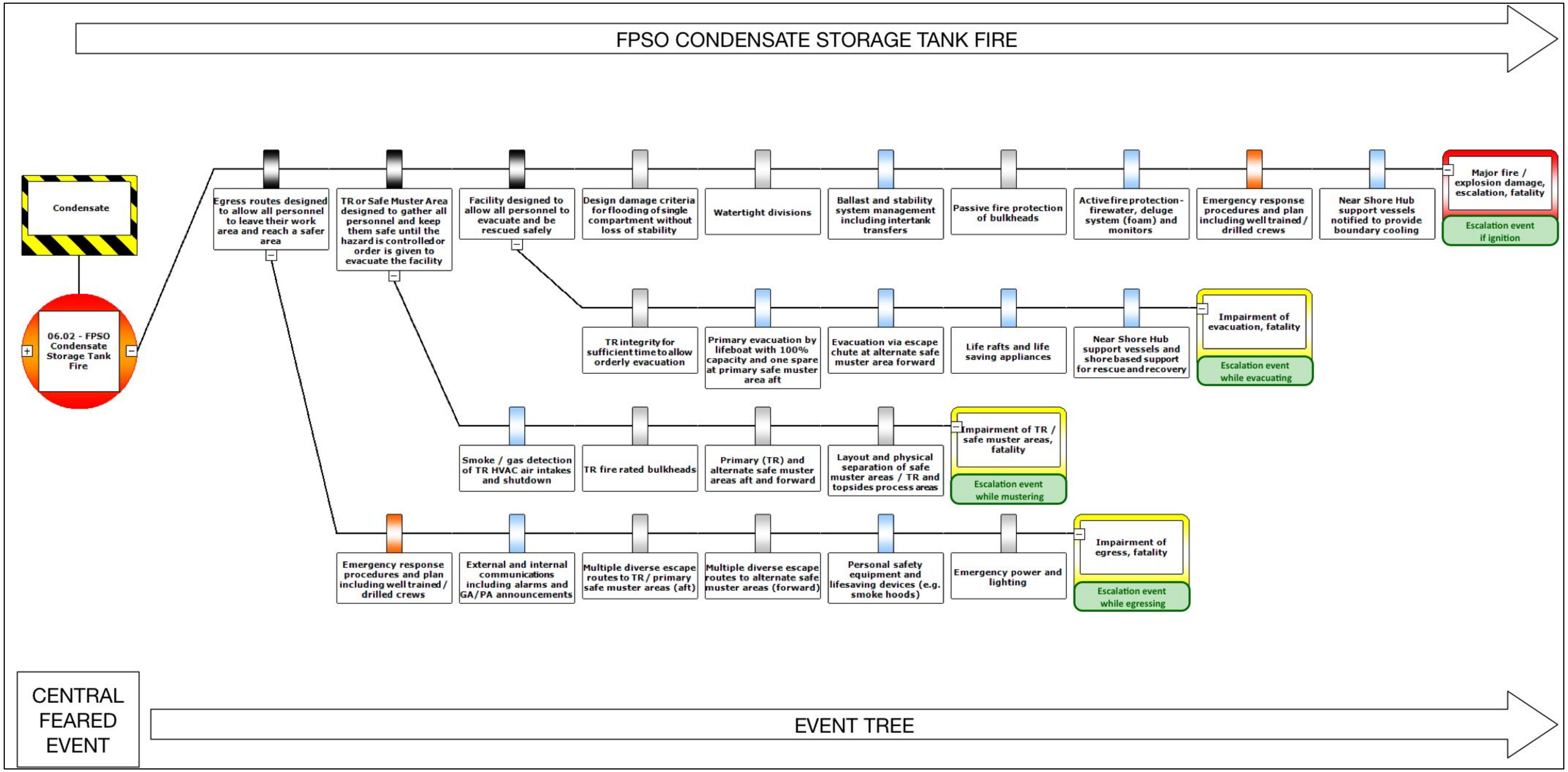


Figure 8-70. Bowtie 06.02 – FPSO Storage Tank Fire (Right Hand Side).

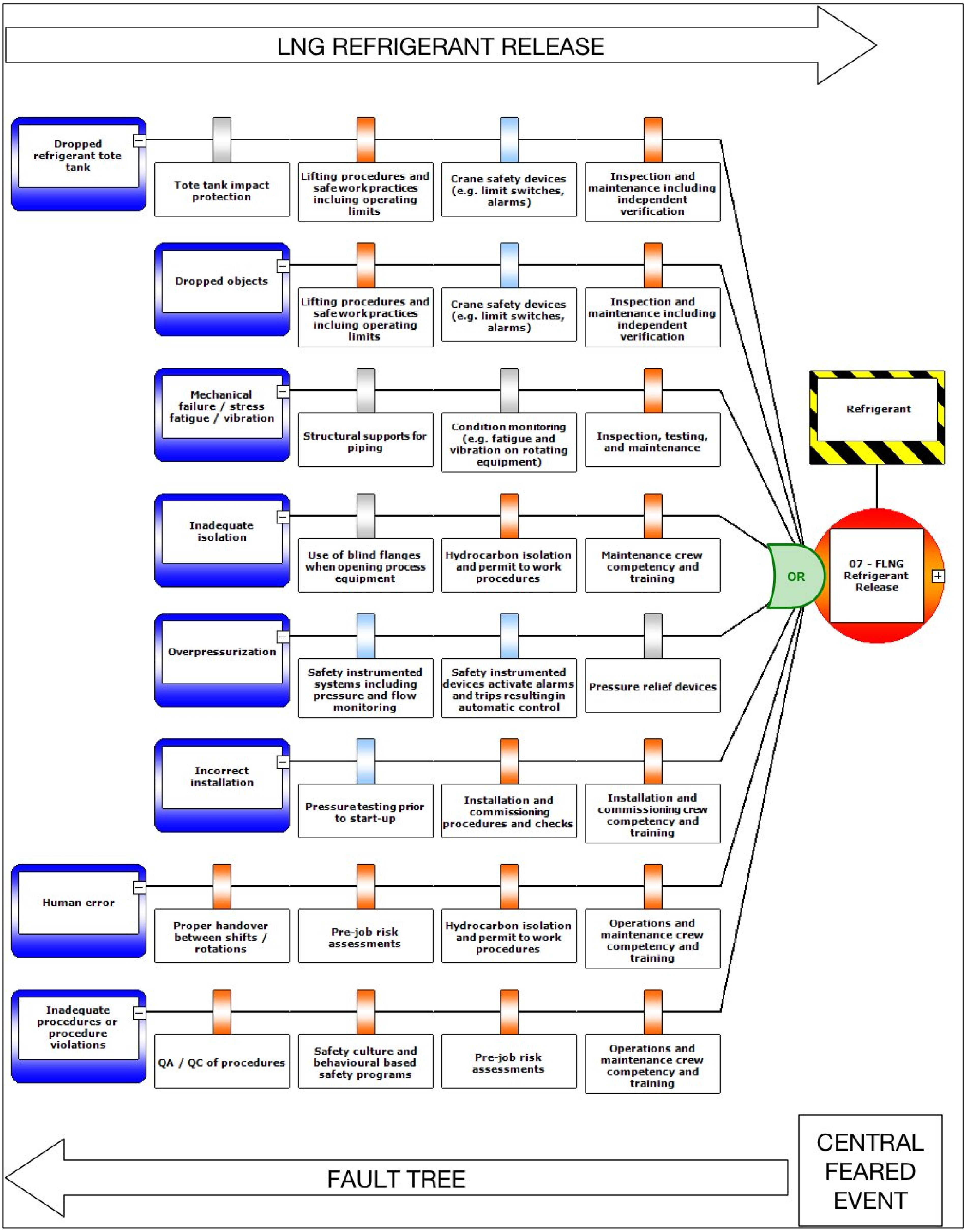


Figure 8-71. Bowtie 07 – FLNG Refrigerant Release (Left Hand Side).

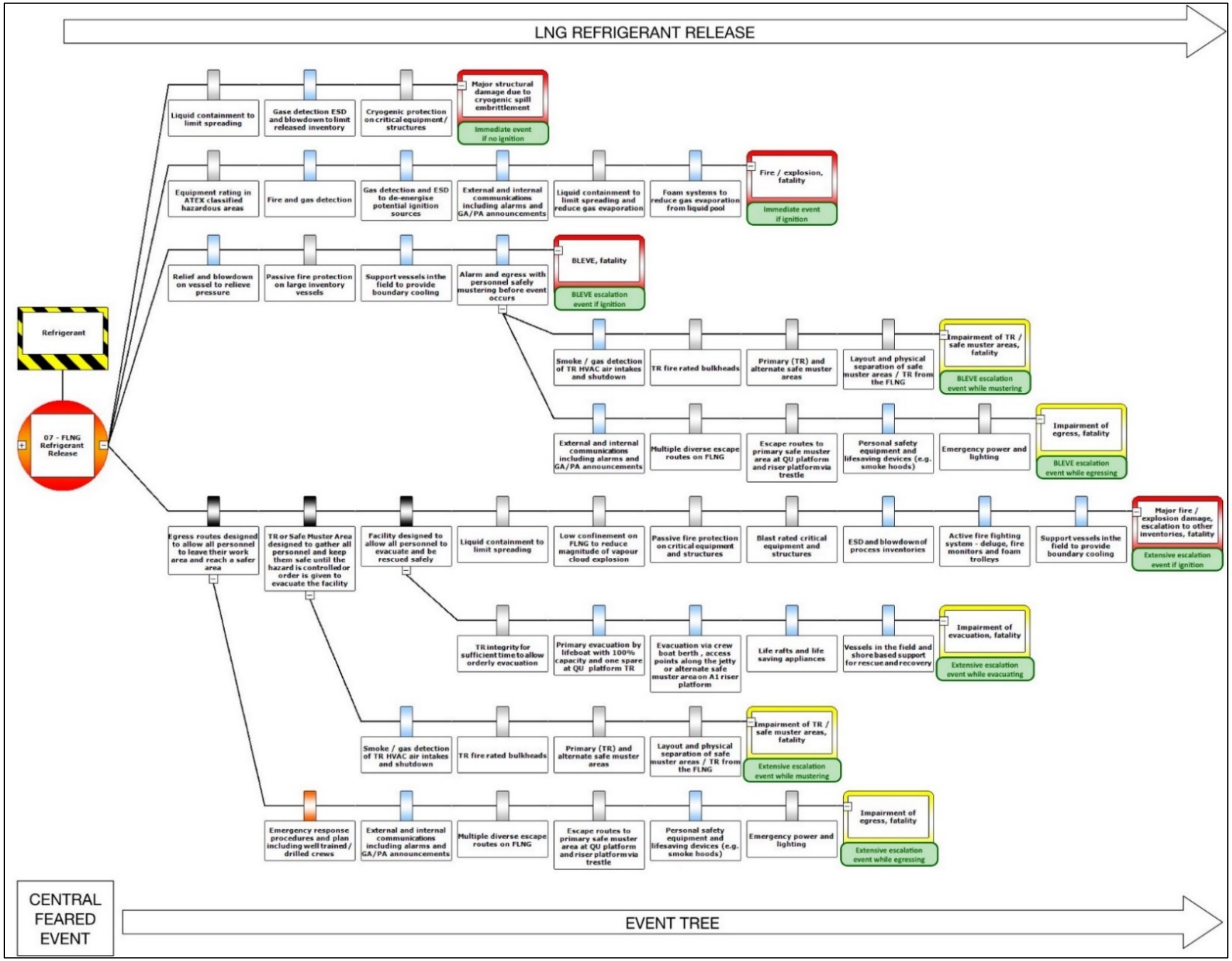


Figure 8-72. Bowtie 07 – FLNG Refrigerant Release (Right Hand Side).

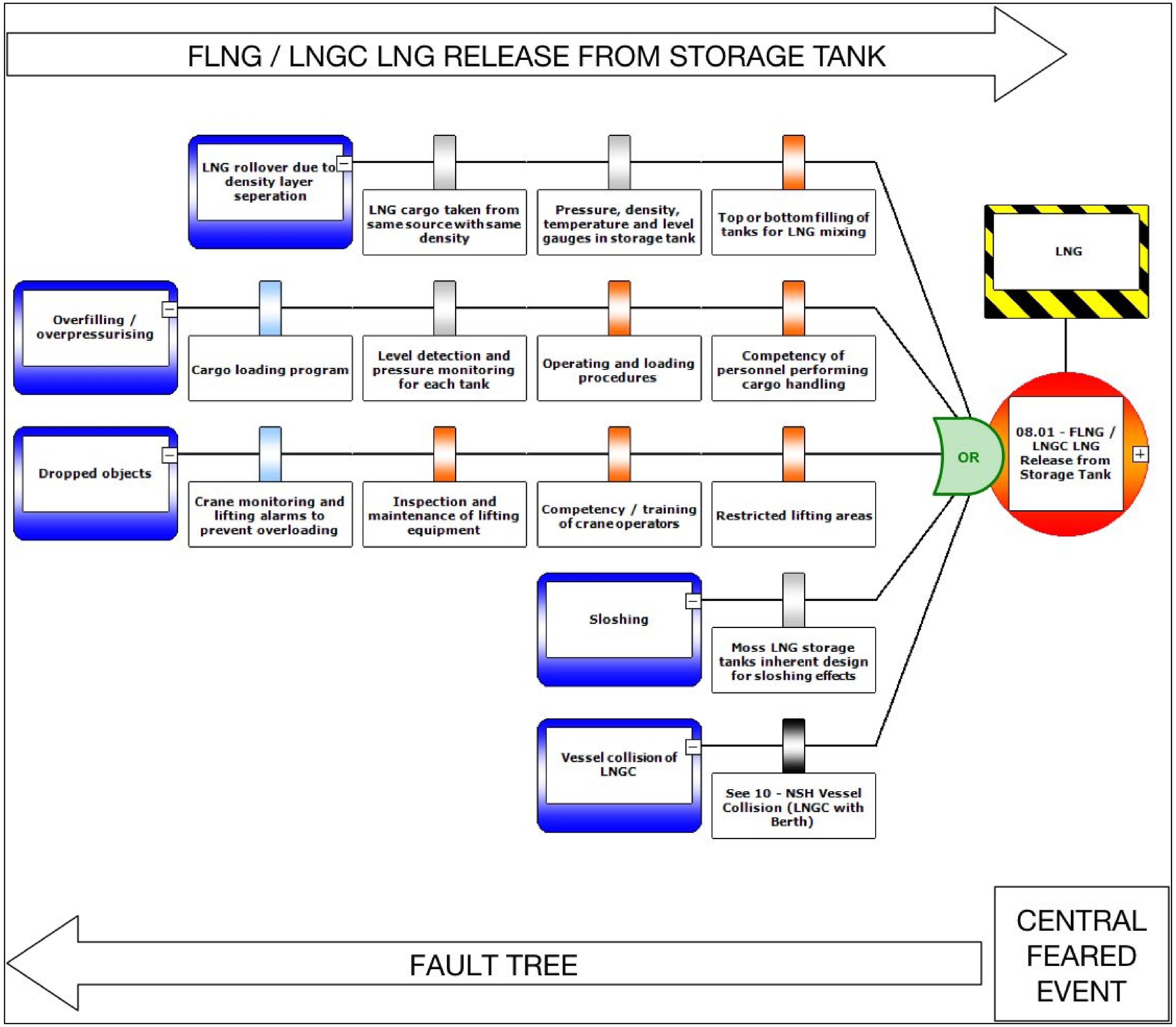


Figure 8-73. Bowtie 08.01 – FLNG/ LNGC LNG Release from Storage Tank (Left Hand Side).

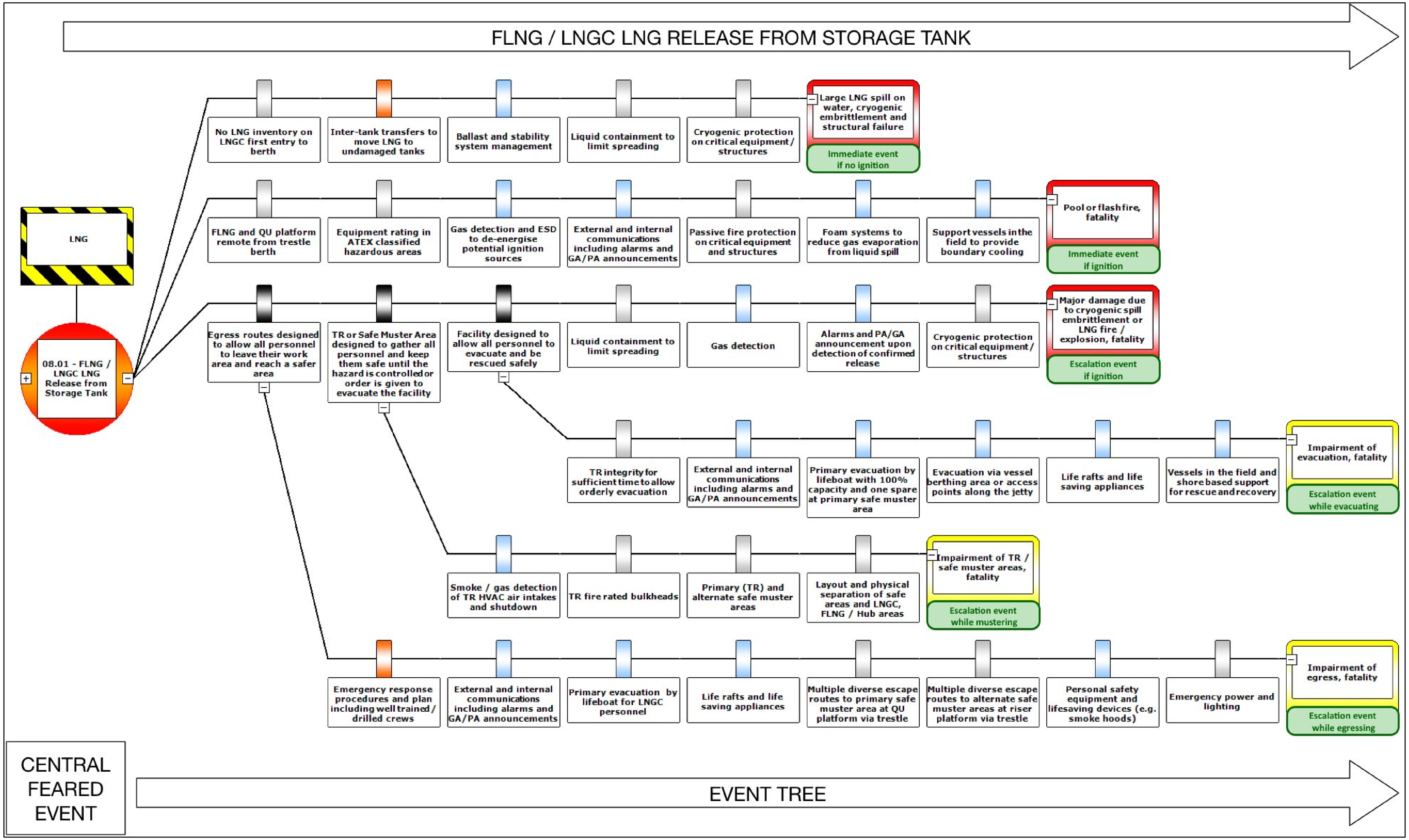


Figure 8-74. Bowtie 08.01 – FLNG/ LNGC LNG Release from Storage Tank (Right Hand Side).

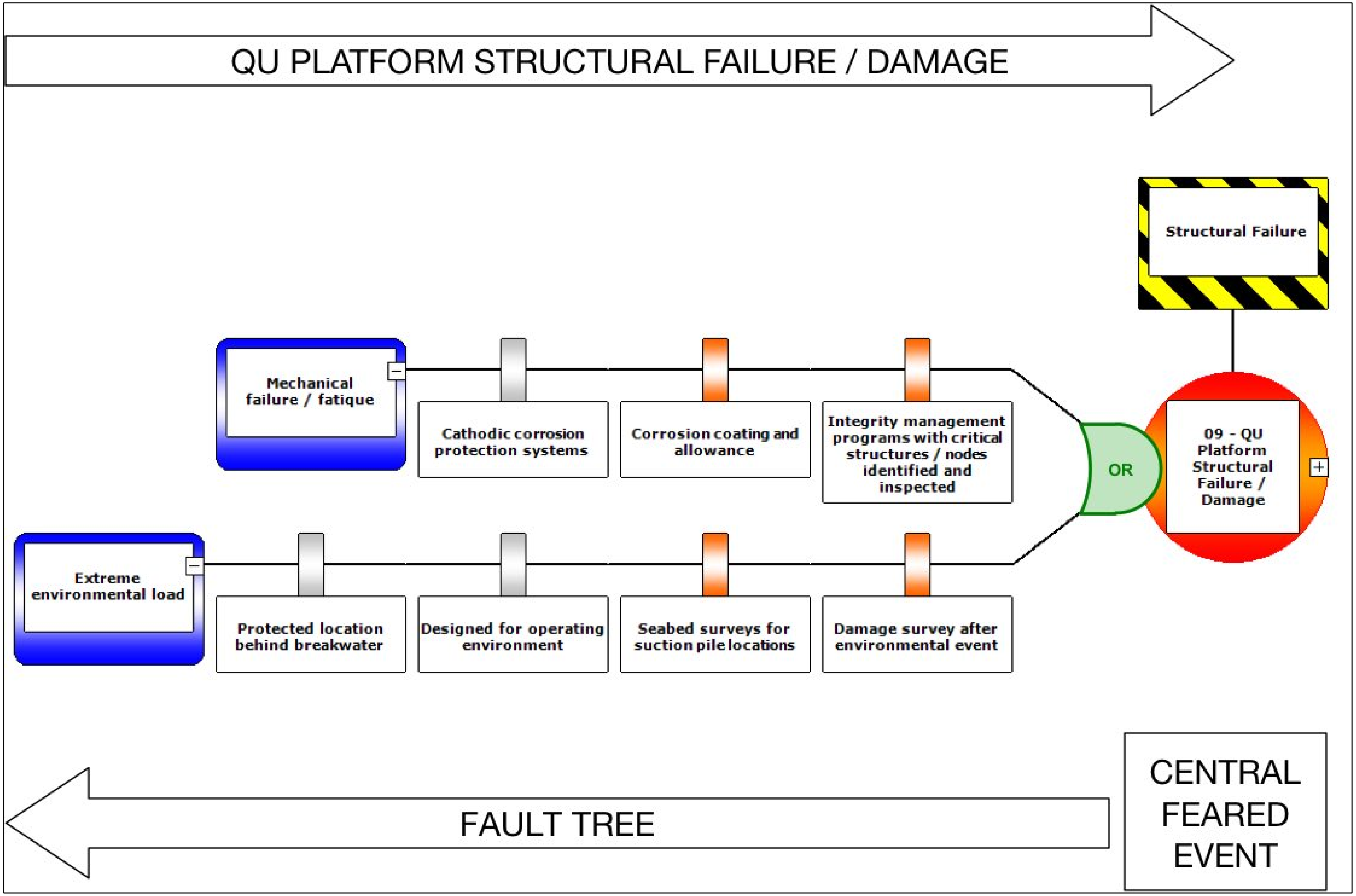


Figure 8-75. Bowtie 09 – QU Platform Structural Failure/Damage (Left Hand Side).

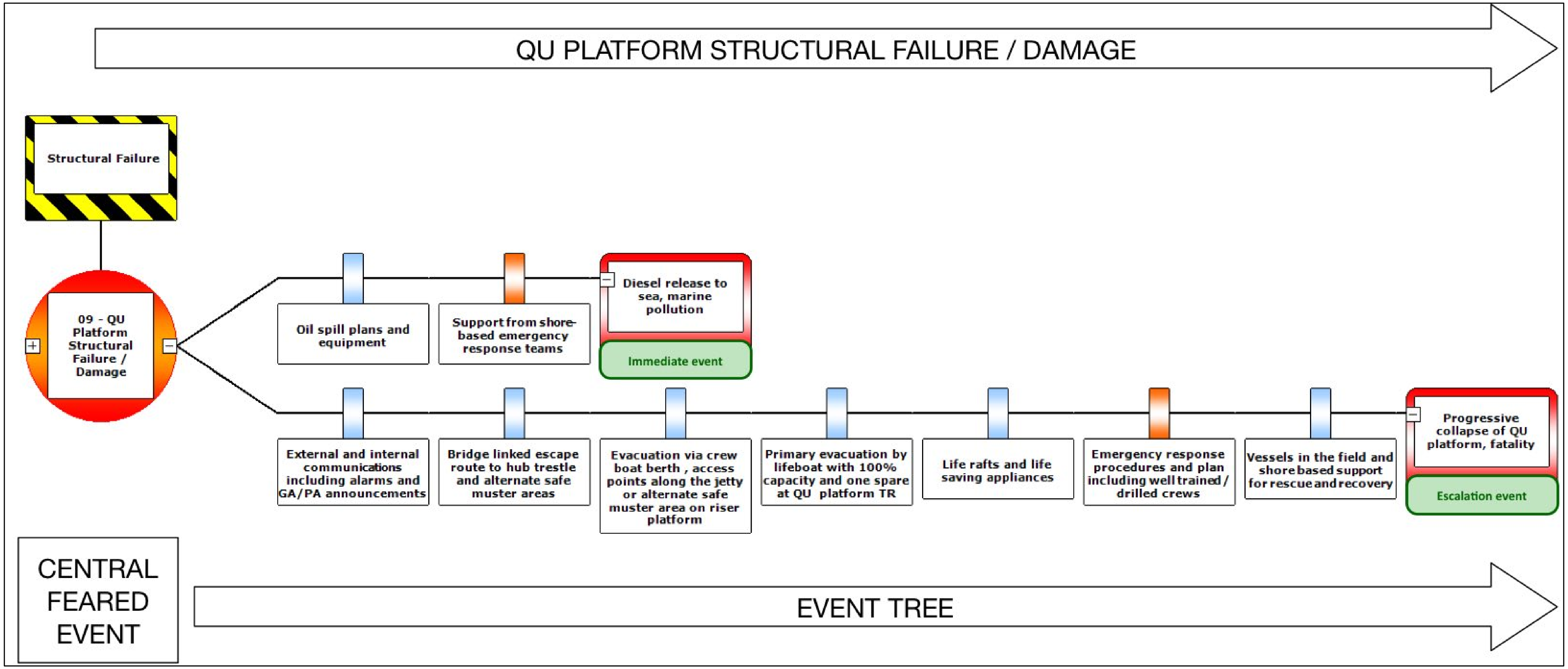


Figure 8-76. Bowtie 09 – QU Platform Structural Failure/Damage (Right Hand Side).

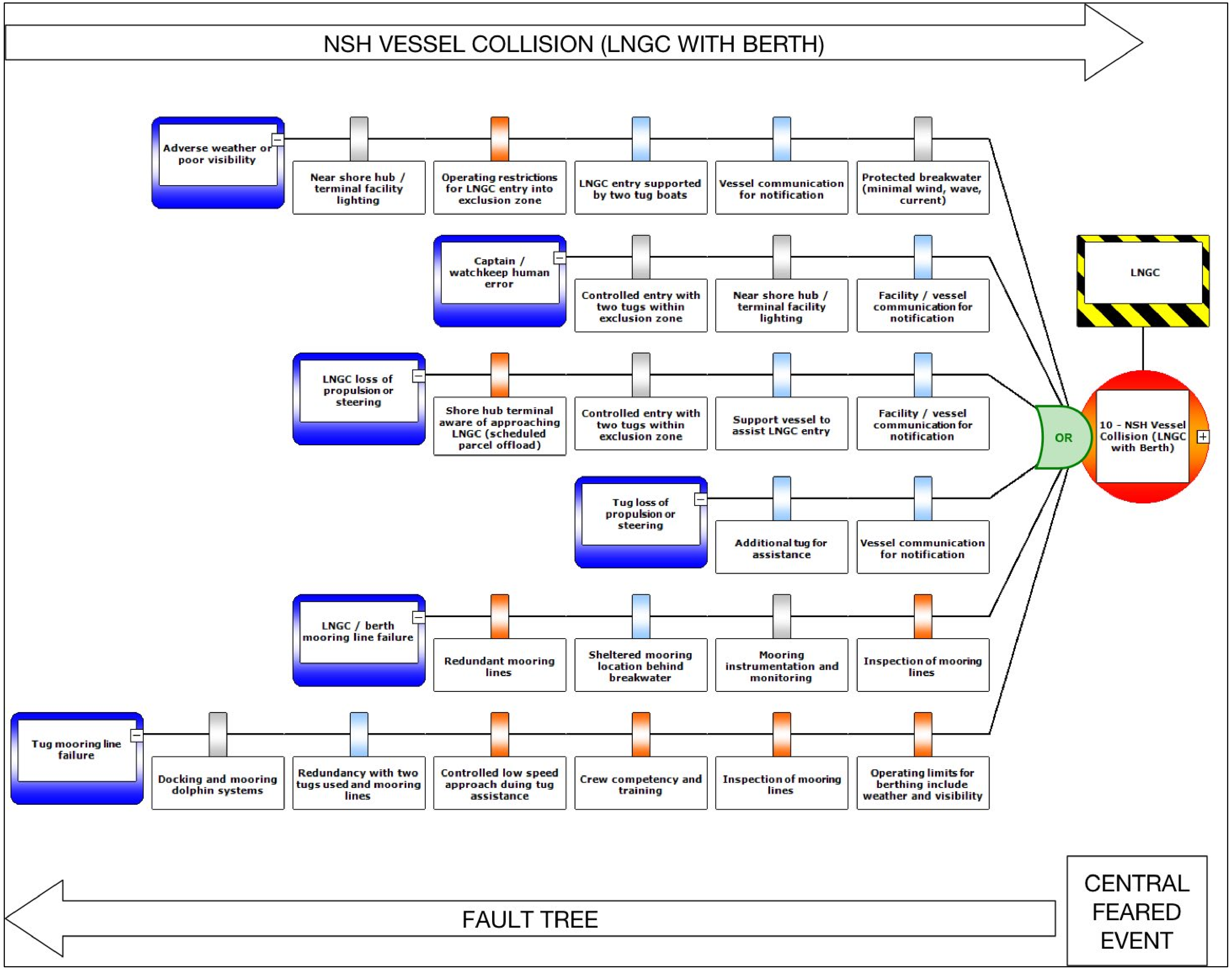


Figure 8-77. Bowtie 10 – NSH Vessel Collision (LNGC with Berth (Left Hand Side).

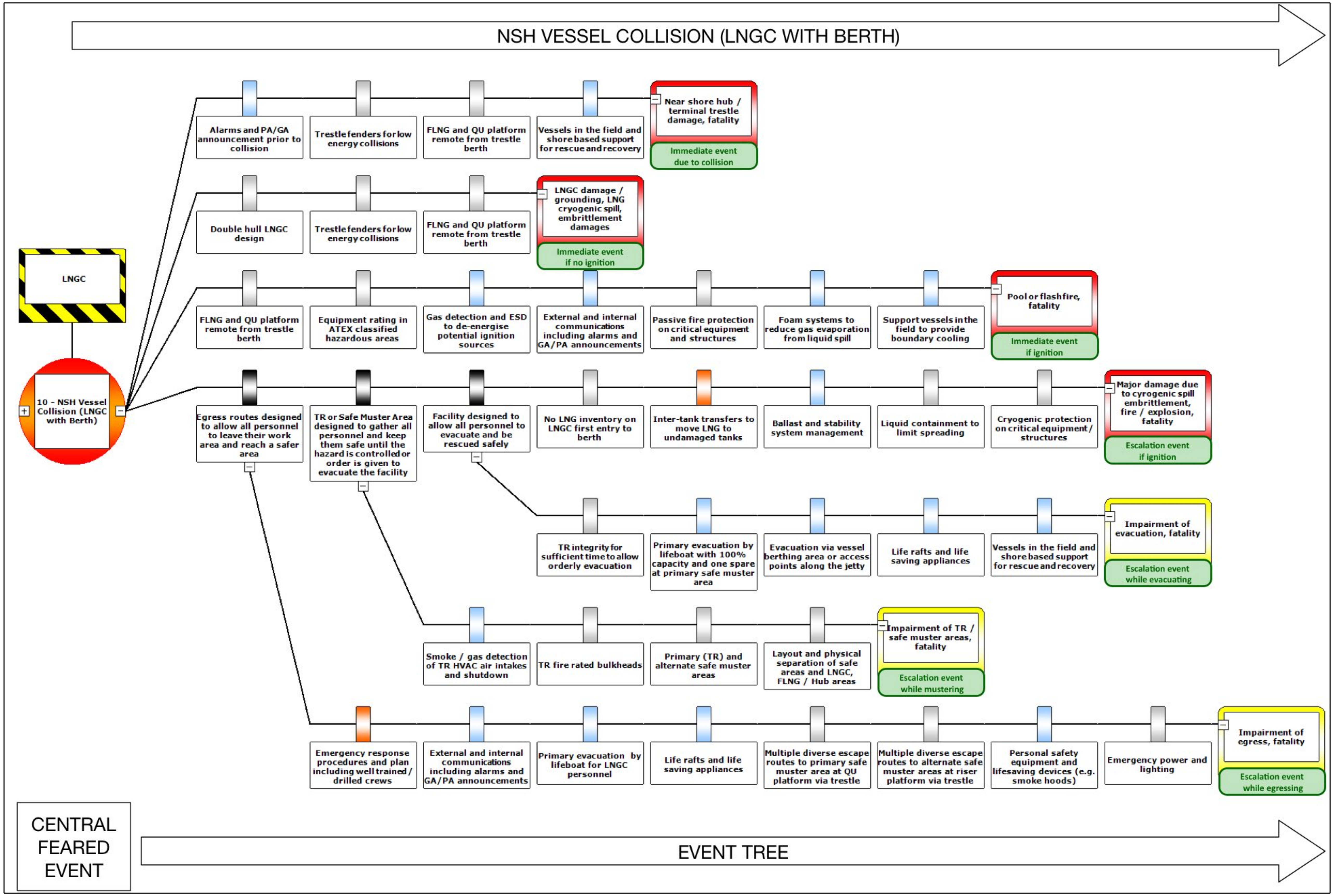


Figure 8-78. Bowtie 10 – NSH Vessel Collision (LNGC with Berth) (Right Hand Side).

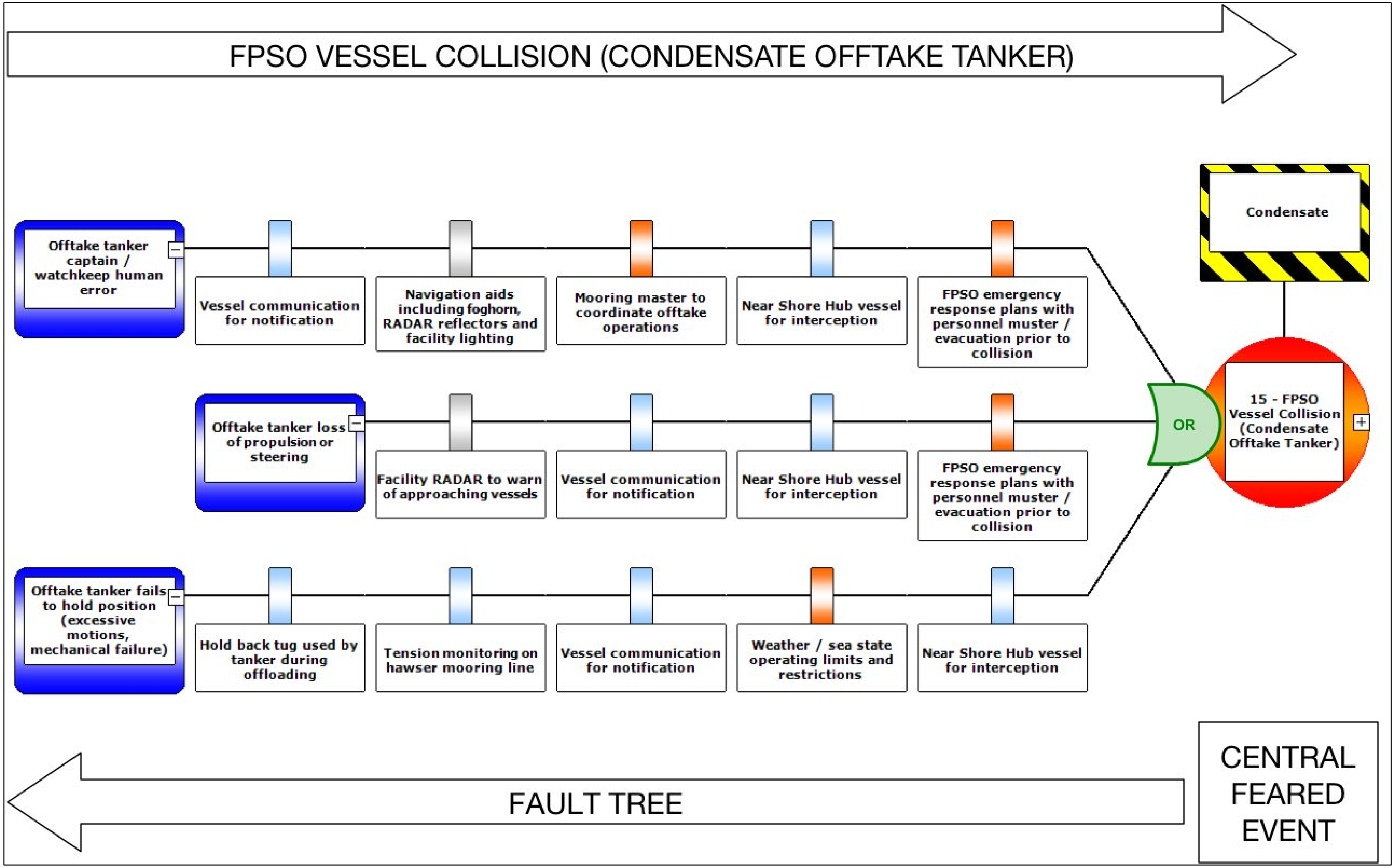


Figure 8-79. Bowtie 15 – FPSO Vessel Collision (Condensate Offtake Tanker) (Left Hand Side).

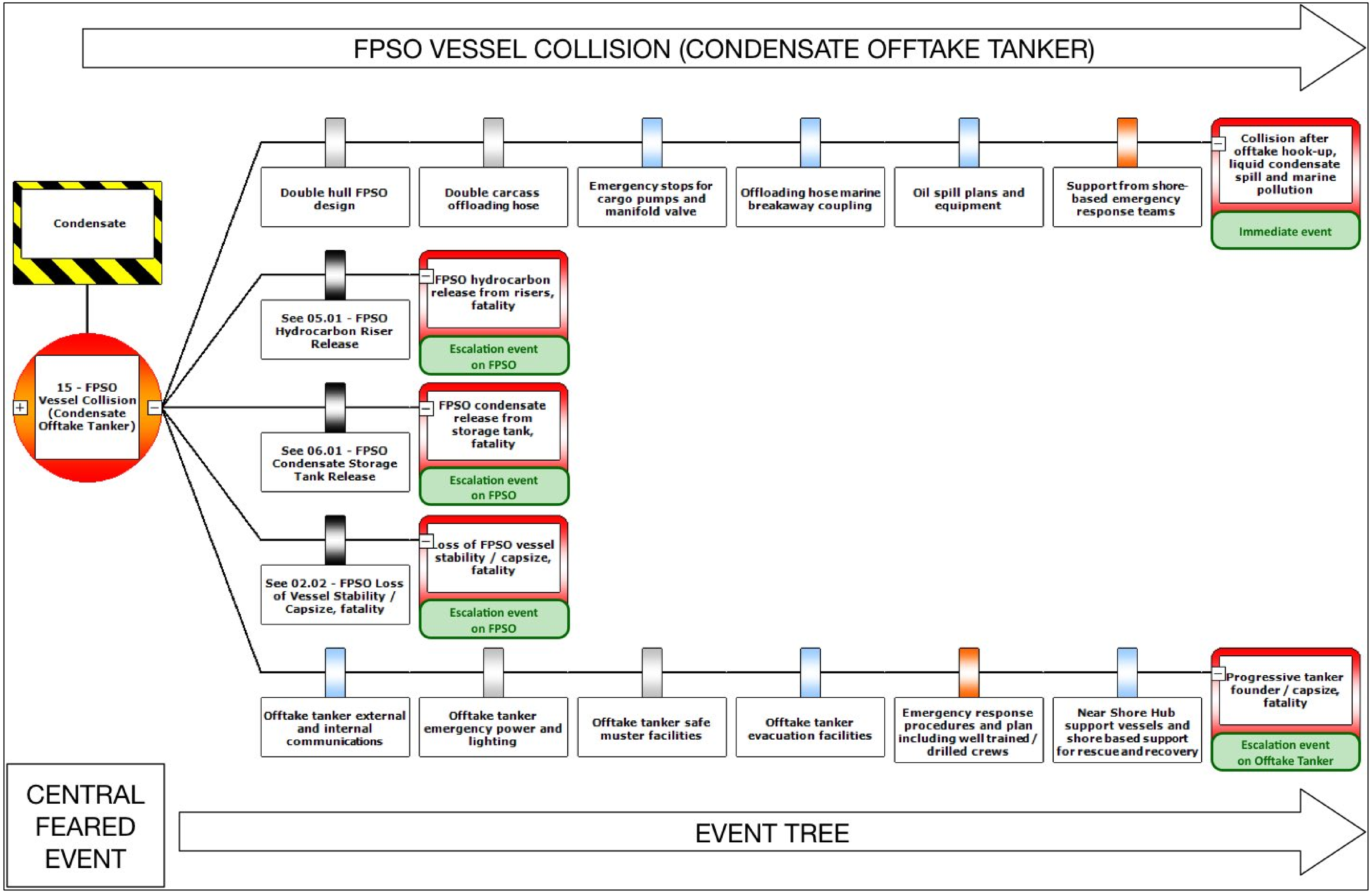


Figure 8-80. Bowtie 15 – FPSO Vessel Collision (Condensate Offtake Tanker) (Right Hand Side).

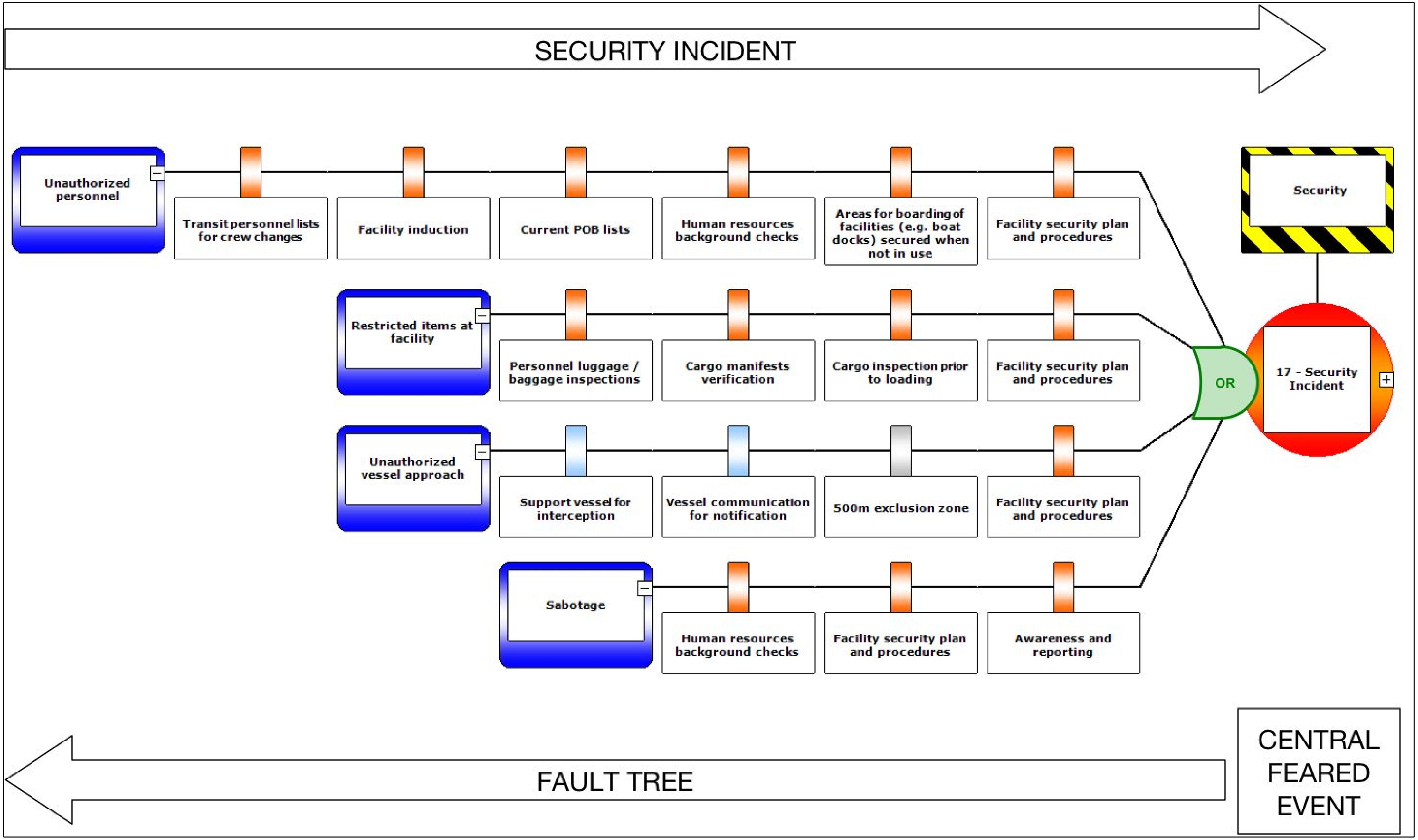


Figure 8-81. Bowtie 17 – Security Incident (Left Hand Side).

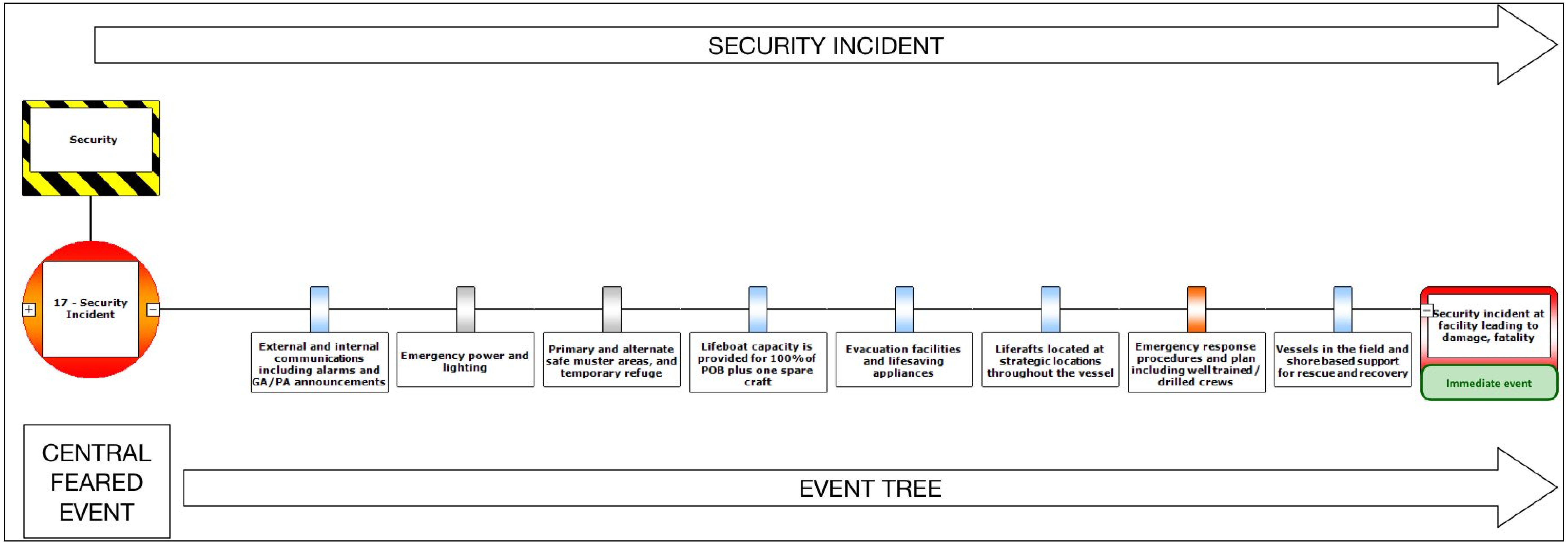


Figure 8-82. Bowtie 17 – Security Incident (Right Hand Side).

8.3.4.2.3 Safety and Environmentally Critical Element Listing

Barriers identified within the Bow Tie diagrams form the basis for the safety and environmentally critical elements (SECE) for all facilities. Barriers are integral to managing major accident events and help ensure that appropriate prevention, control and mitigation measures are adequate for each major accident event. Each barrier identified was reviewed and assigned to a SECE specific to each facility.

The overall listing of SECEs and their type with regards to prevention (P), control (C) or mitigation (M) is provided in Table 8-30.

Table 8-30. Safety and Environmentally Critical Elements.

ID #	Element Name	Type	Drillship	Subsea	FPSO	Near Shore Hub
01	Hull Structure	P	X		X	X
02	Platform Structure	P				X
03	Topside Structure	P	X		X	X
04	Layout and Natural Ventilation	M	X		X	X
05	Dynamic Positioning System	P	X			
06	Mooring Equipment	P			X	X
07	Ballast Systems	M	X		X	X
08	Well Control	P	X			
09	Blowout Preventer	P, C	X			
10	Derrick and Drilling Equipment	P	X			
11	Drilling Marine Risers	P	X			
12	Well Testing Equipment	P	X			
13	Subsea Containment and Isolation	P		X		
14	Corrosion Protection Systems	P		X	X	X
15	Navigation Aids and Collision Avoidance	P	X		X	X
16	Tug Support Vessels	P			X	X
17	Process Hydrocarbon Containment	P		X	X	X
18	Import and Export Risers	P			X	X
19	Hydrocarbon Storage	P			X	X
20	Hydrocarbon Offloading Equipment	P			X	X
21	Diesel Storage	P				X
22	Process Control Systems	P			X	X
23	Blowdown and Emergency Relief Systems	M			X	X
24	Pressure Safety Valves (PSVs)	P			X	X
25	Bunding, Containment and Hazardous Drains	C	X		X	X
26	Equipment designed for being used in Hazardous Areas with explosive atmosphere (ATEX)	C	X		X	X
27	Ignition Prevention	C	X		X	X
28	Fire and Gas Detection	C	X		X	X
29	Passive Fire Protection	M	X		X	X
30	Active Fire Protection	M	X		X	X
31	Helideck Systems	M	X		X[1]	X[1]
32	Personnel Transfer Equipment	P	X		X	X
33	Emergency Power	M	X		X	X
34	Environmental Clean-up Systems	M	X	X	X	X
35	Emergency Communication Systems	M	X		X	X

ID #	Element Name	Type	Drillship	Subsea	FPSO	Near Shore Hub
36	Emergency Shutdown	M	X		X	X
37	Enclosure Integrity and HVAC	C	X		X	X
38	Incident Awareness and Alarms	M				
39	Escape and Evacuation Routes	M	X		X	X
40	Emergency Lighting	M	X		X	X
41	Safe Muster and Temporary Refuge	M	X		X	X
42	Evacuation (Lifeboats, Secondary and Tertiary)	M	X		X	X
43	Life Saving Appliances	M	X		X	X
44	Search and Recovery	M	X		X	X
45	Medical Facilities	M	X		X	X

Note: 'X' denotes SECE is relevant to the facility
[1] Not normally in use - not used for routine crew change operations

8.3.4.2.4 Conclusions

Following bow tie analysis, it was determined that appropriate barriers are in place for each major accident event. Bowtie diagrams provide a visual representation that sufficient barriers are in place to prevent, control and mitigate the events if they occur.

Although barriers in place may not individually prevent, control or mitigate the major accident event, a combination of barriers are utilized to help ensure that suitable measures are in place. These barriers define the SECE. These SECE have detailed performance requirements to help ensure they can perform their function in prevention, mitigation and control of major accident events. Management of SECE is further detailed in Section 8.3.5.5.

8.3.4.3 Quantification of Fatality Effects

8.3.4.3.1 Frequency Analysis

Frequency is defined as a number followed by a unit, used to represent a number of event occurrences, usually per year or per hour, e.g. "a frequency of 0.1 / year, i.e. 0.1 occurrence per year or 1 occurrence every 10 years"). Conversely, probability is defined as a non-dimensional number representing a ratio such as a number of chances in 100, 1000, 10,000, etc.; it is usually expressed in its unitless form or in % or ‰, e.g. "a probability of 5/100 or 0.05, or 5% chance or 5 chances in 100". Last the term "likelihood" is used to represent either a frequency or a probability.

Frequency analysis is used to quantify the likelihood of occurrence major accident events. Frequencies of initiating events are estimated from relevant accident statistics and data. Frequencies of specific consequences are calculated by development of event trees with probabilities assigned to the various branches

Frequencies and probabilities are derived through historical accident data, fault tree analysis or reasonable assumption by the risk analysts. Further detail regarding calculation of frequencies and probabilities is given in supporting studies (Atwood Oceanics. 2014a), (Atwood Oceanics. 2014b), (Atkins. 2018), (Goddard. 2018b), (Goddard. 2018c).

Major accident event frequencies are summarised in in Table 8-31.

For the FPSO, the overall process related release frequency is calculated to be approximately 0.5 per year, with an ignited release frequency of 3.3E-03 per year, or once every 305 years (3.3E-03 is standard scientific notation where E is the exponent and means “times ten raised to the power of”. 3.3E-03 is the same as 0.0033, $3.3x10^{-3}$ or 3.3 x 0.001. Similarly, E-04 is the same as $x10^{-4}$ [x 0.0001] and E-05 is the same as $x10^{-5}$ [x 0.00001]). These frequencies are relatively low, and reflect the simple process on the GTA Phase 1 FPSO.

For the Near Shore Hub, the overall process related release frequency is calculated to be approximately 1.6 per year, with an ignited release frequency of 9.6E-03 per year, or once every 104 years. This frequency is approximately three times higher than the FPSO and reflects a more complex process with higher equipment counts.

For the drillship, the hydrocarbon related release frequencies are much lower, reflective of no hydrocarbon processing onboard. The overall hydrocarbon wellfluid release frequency is calculated to be approximately 0.01 per year, with an ignited release frequency of 9.4E-03 per year, or once every 1,064 years.

Table 8-31. Major Accident Event Initiating Event Frequencies.

Major Accident Event		Event Frequency	Units/Description
Drillship			
D-01	Blowout or Well Release	2.2E-03 [7.0E-04]	Blowout frequency per year [Ignited blowout frequency per year] (four development wells drilled and completed)
D-02	Gas Release in Mud Processing Area	5.3E-04 [1.8E-04]	Release frequency per year [Ignited release frequency per year] (four development wells drilled and completed)
D-03	Hydrocarbon Release during Well Testing or Clean-Up	9.6E-03 [6.0E-05]	Release frequency per year [Ignited release frequency per year] (30 days of well testing per year)
D-04	Loss of Vessel Stability/Capsize	1.0E-04	Loss of stability/capsize frequency per year
D-05	Transportation (Helicopter) Accident	1.1E-05	Accident frequency per hour long flight stage
D-05	Passing Vessel Collision	1.3E-04	High energy collision frequency per year
FPSO			
F-01	Hydrocarbon Release from Production Riser	4.8E-03 [1.2E-04]	Release frequency per year [Ignited release frequency per year]
F-02	Gas Release from Export Gas Risers	9.1E-03 [1.9E-04]	Release frequency per year [Ignited release frequency per year]
F-03	Gas Release from Reception Facilities (Slug Catchers)	2.9E-02 [2.3E-04]	Release frequency per year [Ignited release frequency per year]
F-04	Liquid Release from Reception Facilities (Slug Catchers)	5.9E-02 [7.3E-04]	Release frequency per year [Ignited release frequency per year]
F-05	Gas Release from Gas Processing	1.2E-01 [1.0E-03]	Release frequency per year [Ignited release frequency per year]
F-06	Liquid Release from Gas Processing	7.5E-03 [6.3E-05]	Release frequency per year [Ignited release frequency per year]
F-07	Liquid Release from MP Separator	2.8E-02 [2.0E-04]	Release frequency per year [Ignited release frequency per year]
F-08	Liquid Release from LP Separator	2.3E-02 [4.9E-05]	Release frequency per year [Ignited release frequency per year]
F-09	Liquid Release from LLP Separator	3.7E-02 [9.4E-05]	Release frequency per year [Ignited release frequency per year]
F-10	Gas Release from Flash Gas Compression	1.6E-01 [5.5E-04]	Release frequency per year [Ignited release frequency per year]
F-11	Gas Release from Fuel Gas System	2.0E-02 [6.2E-05]	Release frequency per year [Ignited release frequency per year]
F-12	Injection Chemical Release Topsides	1.5E-02 [4.6E-05]	Release frequency per year [Ignited release frequency per year]

Major Accident Event		Event Frequency	Units/Description
F-13	Condensate Release from Storage Tank	N/A	Negligible release frequency except when caused by other events such as explosion/fire in tank (F-14), loss of stability (F15), or vessel collision (F-17 and F-18)
F-14	Condensate Storage Tank Fire	1.6E-03	Fire frequency per year
F-15	Loss of Vessel Stability/Capsize	1.0E-04	Loss of stability/capsize frequency per year
F-16	Transportation (Crew Boat/FROG) Accident	2.7E-07 2.1E-06	Frequency dropped FROG per lift Accident frequency per hour in boat
F-17	Condensate Offtake Tanker Collision	3.7E-04	Collision frequency per year
F-18	Passing Vessel Collision	4.8E-04	High energy collision frequency per year
Near Shore Hub			
N-01	Gas Release from Import Gas Riser	2.6E-02 [2.7E-04]	Release frequency per year [Ignited release frequency per year]
N-02	Gas Release from Trestle Feed Gas Flowline/Hose to FLNG	2.9E-03 [3.0E-04]	Release frequency per year [Ignited release frequency per year]
N-03	Gas Release from Trestle Fuel Gas Flowline to QU platform	2.9E-02 [2.6E-04]	Release frequency per year [Ignited release frequency per year]
N-04	Gas Release from FLNG Inlet Metering and Amine Treatment	9.3E-02 [9.1E-04]	Release frequency per year [Ignited release frequency per year]
N-05	Gas Release from FLNG Dehydration and Regeneration	3.7E-01 [3.8E-03]	Release frequency per year [Ignited release frequency per year]
N-06	Gas Release from FLNG Boil Off Gas/FGC	2.2E-01 [3.7E-04]	Release frequency per year [Ignited release frequency per year]
N-07	Gas Release from FLNG HP Fuel Gas System	7.6E-02 [2.2E-04]	Release frequency per year [Ignited release frequency per year]
N-08	Gas Release from FLNG Fractionation	5.7E-02 [4.7E-04]	Release frequency per year [Ignited release frequency per year]
N-09	Light Hydrocarbon Liquid Releases from FLNG fractionation	1.3E-01 [8.6E-04]	Release frequency per year [Ignited release frequency per year]
N-10	LNG Release from FLNG Liquefaction Process	5.9E-03 [9.8E-05]	Release frequency per year [Ignited release frequency per year]
N-11	LNG Release from FLNG Flash Gas Drum	4.6E-02 [7.8E-05]	Release frequency per year [Ignited release frequency per year]
N-12	BLEVE of Vessel on FLNG Containing Refrigerant	3.0E-04	BLEVE frequency per year
N-13	Gas Release from FLNG SMR Closed Loop	2.9E-01 [8.8E-04]	Release frequency per year [Ignited release frequency per year]
N-14	Liquid/Two Phase Release from FLNG SMR Closed Loop	2.1E-01 [9.8E-04]	Release frequency per year [Ignited release frequency per year]
N-15	Refrigerant Release from FLNG Refrigerant Storage	7.0E-06 [2.8E-07]	Release frequency per year [Ignited release frequency per year]

Major Accident Event		Event Frequency	Units/Description
N-16	Gas Release (Fuel Gas) in QU platform Utility Space/Area	4.7E-03 [3.1E-05]	Release frequency per year [Ignited release frequency per year]
N-17	LNG Release from FLNG/LNGC Storage Tanks	8.0E-06 [4.0E-07]	Release frequency per year [Ignited release frequency per year]
N-18	LNG Release during LNGC Loading	8.2E-03 [5.7E-05]	Release frequency per year [Ignited release frequency per year]
N-19	Failure of QU platform Structure	1.0E-04	Structural failure frequency per year
N-20	Transportation (Crew Boat) Accident	2.1E-06	Accident frequency per hour in boat
N-21	LNG Carrier Collision with Berth	8.0E-04	Frequency of minor collision with berth per year. No LNG cargo loss of containment, minor damage to FLNG hull
General			
G-01	Security Incident	N/A	N/A

8.3.4.3.2 Risks Analysis

Major accident risk is quantified in three ways:

- Potential loss of life (PLL) – PLL is a calculation of number of worker fatalities that can be expected on board a facility during a given year, based on the facility specific hazards and risks and the number of persons on board.
- Individual Risk per Annum (IRPA) – IRPA is the risk that a worker (or group of workers exposed to similar hazards) may be fatally injured during a given year. IRPA takes account of the amount of time the worker spends on the facility, and the time exposed to facility specific hazards and risks.
- Location specific individual risk (LSIR) – The LSIR is a hypothetical individual's risk of suffering a fatal injury at a specific location assuming they are present for 24 hours a day, 365 days a year (i.e. an occupancy of 100%). LSIR is used to assess impacts on far field and has only been undertaken for the Near Shore Hub/Terminal due to the different facilities present and the potentially significant hazard effect ranges for FLNG related events. While LSIR is not typically assessed for offshore facilities, for the Near Shore Hub, they provide a useful basis for comparison in terms of facility layout and safety zone limit.

Risk is then presented by facility. Risks are calculated based on consequence and frequency analysis, considering facilities specific layouts and design safeguards.

The calculated PLL and IRPA for the Drillship is summarized in Table 8-32. IRPA is presented for the most exposed/most at risk worker(s) (members of the Drill Crew).

Table 8-32. Calculated PLL and IRPA for the Drillship.

Drillship Major Accident Event		PLL		Maximum IRPA
		Value	% Total	
D-01	Blowout or Well Release	2.4E-03	7.5%	1.5E-05
D-02	Fire or Explosion in the Mud Processing Area	3.5E-04	1.1%	7.1E-05
D-03	Hydrocarbon Release During Well Testing	4.0E-05	0.1%	4.0E-06
D-04	Loss of Vessel Stability/Capsize [1]	9.0E-03	28.1%	4.5E-05
D-05	Transportation (Helicopter) Accident	2.0E-02	62.4%	1.0E-04
D-06	Passing Vessel Collision	2.7E-04	0.8%	1.3E-06
Total		**3.2E-02**	**100%**	**2.4E-04**

[1] Not explicitly calculated in the Drillship QRA. Risk similar to FPSO Loss of Vessel Stability/Capsize (F-15) major accident event with same facilities POBs

From the above, helicopter transportation and loss of drillship stability/capsize major accidents dominate the major accident event risk profile. Blowout fatality risks are relatively low in comparison, reflective generally of warning and alarm in serious well control situations, and prior to any blowout occurring.

The estimated PLL of 0.032 can also be expressed as a long-term average of approximately one fatality per 30 years of operation. However, it is important to note that this figure is based on major accidents that may potentially result in multiple fatality and that happen much less frequently.

The calculated PLL and IRPA for the FPSO is summarized in Table 8-33 assuming normal manning. IRPA is presented for the most exposed/most at risk worker(s) (members of the Outdoor Crew).

Table 8-33. Calculated PLL and IRPA for the FPSO (Normal Manning).

FPSO Major Accident Event		PLL		Maximum IRPA
		Value	% Total	
F-01	Hydrocarbon Release from Production Riser	1.6E-03	4.5%	1.1E-05
F-02	Gas Release from Export Gas Risers	3.1E-03	9.0%	2.3E-05
F-03	Gas Release from Reception Facilities (Slug Catchers)	4.0E-04	1.2%	3.1E-06
F-04	Liquid Release from Reception Facilities (Slug Catchers)	8.2E-04	2.4%	6.3E-06
F-05	Gas Release from Gas Processing	1.7E-03	5.0%	1.3E-05
F-06	Liquid Release from Gas Processing	1.0E-04	0.3%	8.0E-07
F-07	Liquid Release from MP Separator	4.0E-04	1.1%	3.0E-06
F-08	Liquid Release from LP Separator	3.3E-04	0.9%	2.5E-06
F-09	Liquid Release from LLP Separator	5.2E-04	1.5%	4.0E-06
F-10	Gas Release from Flash Gas Compression	2.2E-03	6.3%	1.7E-05
F-11	Gas Release from Fuel Gas System	2.7E-04	0.8%	2.1E-06
F-12	Injection Chemical Release Topsides	8.3E-05	0.2%	7.0E-07
F-13	Condensate Release from Storage Tank	-	-	-
F-14	Condensate Storage Tank Fire	6.4E-04	1.8%	4.5E-06
F-15	Loss of Vessel Stability/Capsize	9.0E-03	25.9%	4.5E-05
F-16	Transportation (Crew Boat/FROG) Accident	1.2E-03	3.4%	5.9E-06
F-17	Condensate Offtake Tanker Collision	3.4E-04	1.0%	1.7E-06
F-18	Passing Vessel Collision	1.2E-02	34.7%	6.0E-05
Total		**3.5E-02**	**100%**	**2.0E-04**

From the above, passing vessel collision and loss of vessel stability/capsize major accidents are the major risk contributors. While both facilities are located on / near the periphery of identified shipping lanes, unlike the Drillship, the FPSO cannot disconnect and move off location in case of impending passing vessel collision. Of the hydrocarbon events, the risers (gas export and production), gas processing and flash gas compression events are the most significant contributors to the risk. Fatalities from hydrocarbon events are dominated by the immediate effects of an ignited release (immediate fatality over 80% of the risk). This reflects the separation between the accommodation and the process and riser areas, and the resulting low likelihood of TR impairment.

The estimated PLL of 0.035 can also be expressed as a long-term average of approximately one fatality per 30 years of operation. As with the Drillship, it is important to note that this figure is based on major accidents that may potentially result in multiple fatality and that happen much less frequently.

The calculated PLL and IRPA for the Near Shore Hub/Terminal (excluding the LNGC) is summarized in Table 8-34. IRPA is presented for the most exposed/most at risk worker(s) (members of the FLNG Crew).

Table 8-34. Calculated PLL and IRPA for the Near Shore Hub.

Near Shore Hub/Terminal Major Accident Event		PLL		Maximum IRPA
		Value	% Total	
N-01	Gas Release from Import Gas Riser	1.3E-04	0.5%	1.1E-06
N-02	Gas Release from Trestle Feed Gas Flowline/Hose to FLNG	3.5E-03	14.1%	3.1E-05
N-03	Gas Release from Trestle Fuel Gas Flowline to QU platform	4.3E-05	0.2%	3.3E-07
N-04	Gas Release from FLNG Inlet Metering and Amine Treatment	1.2E-03	5.0%	1.1E-05
N-05	Gas Release from FLNG Dehydration and Regeneration	3.5E-03	13.8%	3.3E-05
N-06	Gas Release from FLNG Boil Off Gas/FGC	1.9E-04	0.8%	1.9E-06
N-07	Gas Release from FLNG HP Fuel Gas System	1.3E-04	0.5%	1.2E-06
N-08	Gas Release from FLNG Fractionation	3.5E-04	1.4%	3.3E-06
N-09	Light Hydrocarbon Liquid Releases from FLNG fractionation	1.1E-03	4.6%	1.1E-05
N-10	LNG Release from FLNG Liquefaction Process	3.1E-04	1.2%	3.0E-06
N-11	LNG Release from FLNG Flash Gas Drum	3.3E-04	1.3%	3.2E-06
N-12	BLEVE of Vessel on FLNG Containing Refrigerant	3.4E-03	13.6%	3.4E-05
N-13	Gas Release from FLNG SMR Closed Loop	9.6E-04	3.8%	8.1E-06
N-14	Liquid/Two Phase Release from FLNG SMR Closed Loop	1.5E-03	5.9%	1.3E-05
N-15	Refrigerant Release from FLNG Refrigerant Storage	7.8E-06	0.0%	6.2E-08
N-16	Gas Release (Fuel Gas) in QU platform Utility Space/Area	5.5E-05	0.2%	-
N-17	LNG Release from FLNG/LNGC Storage Tanks	7.7E-06	0.0%	1.6E-08
N-18	LNG Release during LNGC Loading	4.7E-03	18.7%	4.1E-05
N-19	Failure of QU platform Structure	3.4E-03	13.8%	1.6E-05
N-20	Transportation (Crew Boat) Accident	1.6E-04	0.6%	9.5E-07
N-21	LNG Carrier Collision with Berth	6.7E-07	0.0%	-
Total		**2.5E-02**	**100%**	**2.1E-04**

From the above, hydrocarbon events are major risk contributors with gas treatment (inlet metering, amine treatment, dehydration and regeneration) comprising approximately 19% of the overall risk. These systems comprise significant equipment items and are at relatively high pressure. BLEVE risk is also assessed as a major contributor, however, little credit is given for personnel escaping prior to the BLEVE occurring which is conservative. The feed gas flowline/hose to the FLNG and LNG loading are also significant risk contributors. This is largely due to the trestle area being used/manned a significant proportion of the time, and the historical leak frequencies associated with hose transfers and LNG loading arms. Immediate fatalities from fire and explosion events are dominant, compared to escalation related fatality (TR or evacuation). This reflects the separation between the QU platform and process areas (FLNG, loading berth and riser platform) and the resulting low likelihood of TR impairment.

QU platform structural failure risks are also assessed as a significant risk contributor. While the likelihood of structural collapse is low, the QU platform houses all Near Shore Hub/Terminal personnel. Structural failure and vessel collision risks are lower for the Near Shore Hub/Terminal compared to the other facilities as facilities are in shallow water, remote from any shipping lanes and protected by the breakwater.

Transportation risks are low, reflecting crew transfer to the Near Shore Hub/Terminal (and FPSO) via crew boat with a protected berth, not helicopter.

The estimated PLL of 0.025 can also be expressed as a long-term average of approximately one fatality per 40 years of operation. As with the Drillship and FPSO, it is important to note that this figure is based on major accidents that may potentially result in multiple fatality and that happen much less frequently.

The calculated LSIR for the Near Shore Hub/Terminal is presented in Figure 8-83. From the figure, the lowest frequency of fatality contour (1E-06 – one in a million) extends some 500-600 m from the FLNG but remains within the proposed safety zone limit (500 m-600 m) for the Near Shore Hub/Terminal facilities.

Risk levels as they correspond to relevant established risk tolerability criteria are then discussed in the subsequent section.

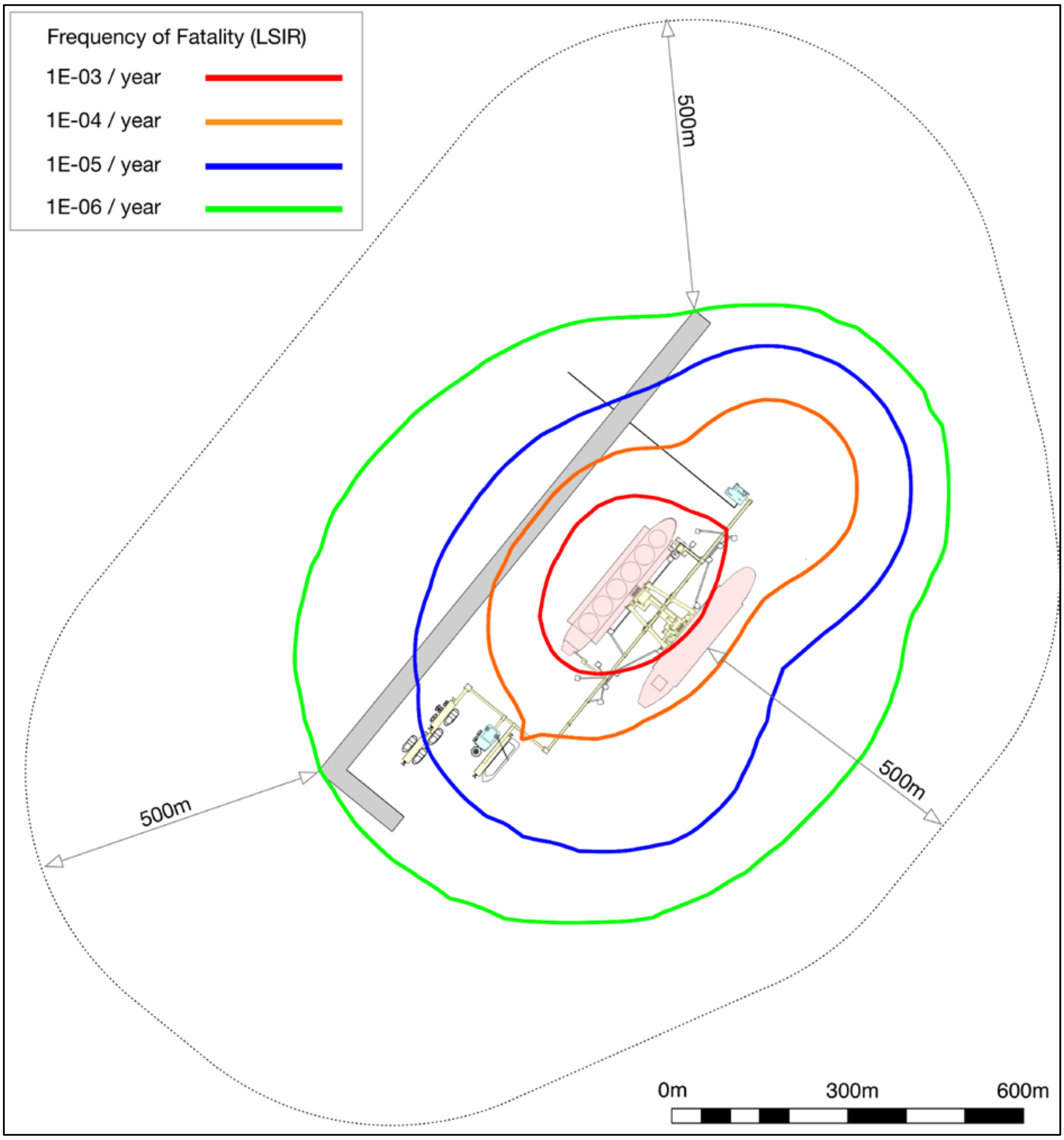


Figure 8-83. LSIR for Near Shore Hub.

8.3.4.3.3 Comparison with Relevant Established Risk Tolerability Criteria

Tolerability, for the purposes of the relevant established risk tolerability criteria, refers to the willingness to live with a risk to secure certain benefits in the confidence that the risk will be properly controlled. To tolerate a risk does not mean it is regarded as negligible, nor is it something that can be ignored. Rather the risk is something that needs to be kept under continual control and review, and where practicable, reduced further.

Relevant established risk tolerability criteria are summarised in Table 8-35 (UK HSE. 2001), (UK HSE. 2014), (NSW Government Planning and Infrastructure, 2011), (European Maritime Safety Agency. 2013).

Table 8-35. Relevant Established Risk Tolerability Criteria.

Description		Criteria / Year
IRPA	Maximum offshore oil and gas risk to workers	1E-03
LSIR	Maximum onshore process risk to adjacent industrial land use	5E-05
	Maximum onshore process risk to public	1E-06
	Maximum onshore process risk to adjacent residential, motel, hotel, tourist resort land use	1E-06
TR	Maximum frequency of Temporary Refuge (TR) impairment	1E-03

GTA Phase 1 Project facilities worker maximum IRPA are of the order of 3E-04 per year. This is below the relevant established risk tolerability criteria of 1E-03 per year adopted by the UK HSE for offshore workers.

Note that while part of the FLNG lies within the 1E-03 LSIR contour, this is not reflective of the IRPA for FLNG facility workers. The LSIR assumes exposure to the hazards and risks 24 hours a day, 365 days a year. IRPA takes account of an individuals' exposure to the hazards and risks, including their time not working offshore, and in protected areas such as the QU platform accommodation. Therefore, once this exposure is considered, individual risk levels to FLNG workers is below the relevant established risk tolerability criteria.

Regarding LSIR, risk levels at the limit of the Near Shore Hub/Terminal facilities safety zone are less than 1E-06 per year (this is the same as 1x10-6 or one in a million). An LSIR of 1E-06 per year is below the relevant established risk tolerability criteria.

The QU platform accommodation is located just within the 1E-05 per year contour (this is the same as $1x10^{-5}$ or one in one hundred thousand). The criteria for residential land use given in Table 8-35 is at the 1E-06 per year level. However, this criterion applies to public residences and other similar buildings. With respect to offshore accommodations and TR, the QU platform is constructed to offshore standards, which include specific design requirements for fire and blast protection.

The UK HSE has established risk tolerability criteria for impairment of TR of 1E-03 per year. The frequency of impairment of the FPSO TR/accommodations has been assessed at approximately 2E-04 per year. The QU TR/accommodation has an estimated impairment frequency of 5.9E-07 per year from process events. The frequency of structural failure for the QU platform is of the order of 1E-04 per year. TR impairment frequencies are therefore below UK HSE tolerability criteria.

While GTA Phase 1 Project facilities risks are well below relevant established risk tolerability criteria, they can only be considered ALARP provided further risk reduction is impracticable, or the cost of implementing risk reduction measures is grossly disproportionate to the benefit gained. Further assessment of whether there are opportunities for further risk reduction is ongoing as part of GTA Phase 1 Project design process, as described further in subsequent sections.

8.3.5 Measures Taken to Manage Major Hazards and Risk

8.3.5.1 Introduction

Major hazards and risks are managed through implementation of the BP Operating Management System (OMS) (BP. 2016c) & (BP. 2016d), covering all anticipated design and operational aspects.

During design, inherent safety principles are applied to eliminate identified hazards and risks wherever possible, or reduce risk effects. Detailed hazard and risk analysis is also undertaken with results used to inform design requirements for prevention, control and mitigation measures. These measures are identified as SECE. SECE requirements are documented, monitored, tested and verified to help ensure they perform their required function.

The following sections then describe key elements of the above in more detail, specifically:

1) The BP Operating Management System (OMS)

2) Major hazard management as part of the design process

3) Major hazard management during operation

4) Management of safety and environmentally critical elements

5) Specific control and mitigation measures (SECE)

8.3.5.2 The BP Operating Management System

All BP facilities and operations are managed through the implementation of an overarching Operating Management System (OMS). OMS is relevant to all BP projects, as well as facilities, sites, and operations, and provides a framework that incorporated BP's standards, processes and practices under a single management system (BP. 2016c). The OMS encompasses all the elements of a strong and thorough risk management system, including leadership commitment; hazard analysis and risk identification and management for ongoing risk reduction; training of both management and site personnel; management system audits; and the use of leading and lagging key performance indicators (KPIs) to track progress and guide change.

The OMS is based upon eight interdependent Elements of Operating as illustrated by Figure 8-84. These describe how people, process, plant and performance operate within BP. Each of the Elements of Operating is divided into sub-elements, which need to be selectively and systematically managed.

Each BP entity has a local OMS which describes how it delivers its operating activities. This is developed, implemented and sustained locally. The local OMS translates business needs, relevant legal and regulatory requirements, and BP overarching OMS requirements, into practical plans to reduce risk and deliver strong, sustainable performance.

Within the GTA Phase 1 project operational boundary, where contractors undertake activities on behalf of BP using their own operational management system arrangements (for example, the drillship and FLNG), these arrangements will meet BP's contractual and OMS framework requirements.

BP's Safety and Operational Risk (S&OR) professionals work with the local entities to help them manage risk through OMS, including the application of relevant standards and practices, and by providing tools, guidance and support for ongoing conformance with OMS. including independent assurance.

Each OMS Element has a main Principle, supported by sub-element principles. These Principles, and sub-element principles, describe the intent of the Element, provide guidance, and support decision making. OMS Principles are given in Figure 8-85.

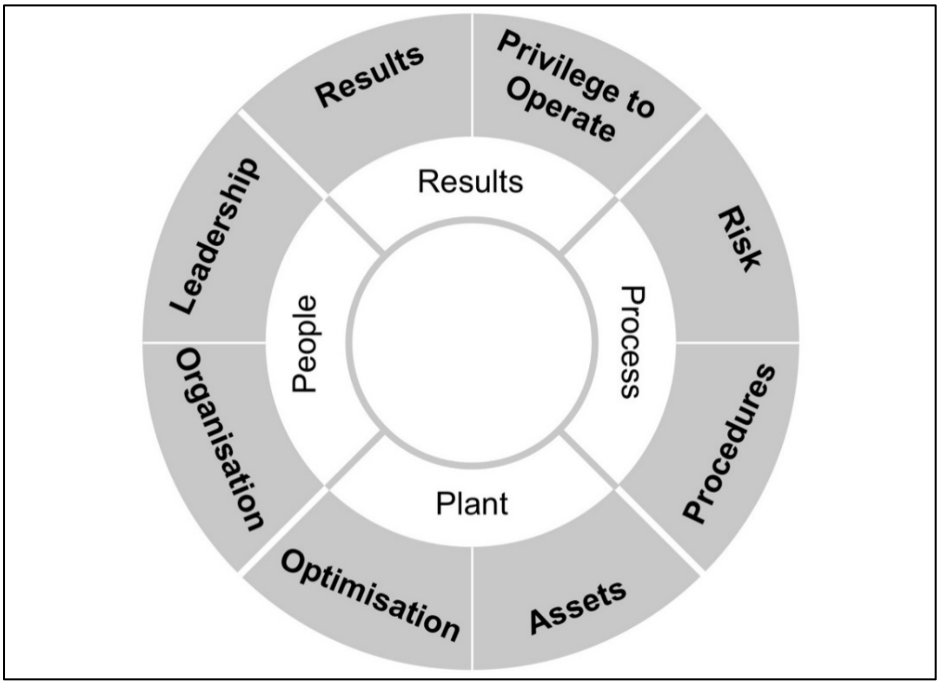


Figure 8-84. BP OMS Elements of Operating.

1. Leadership
Our operating leaders are competent, exhibit visible, purposeful and systematic leadership and are respected by the organisations they lead.
2. Organisation
We have fit for purpose and agile organisations staffed with competent people and teams.
3. Risk
The workforce at all levels of our organisation understands and manages operating risk to prevent accidents and harm to people, to reduce damage to the environment and to achieve competitive performance.
4. Procedures
We document and rigorously follow procedures for safe, reliable and compliant operations.
5. Assets
Our plants, facilities, assets and floating systems are fit for purpose throughout the lifecycle of the operation.
6. Optimisation
Our operations are continuously optimized to improve performance and delivery from our assets.
7. Privilege to Operate
We deliver what is promised and address issues raised by our key stakeholders.
8. Results
Measurement is used to understand and sustain performance.

Figure 8-85. BP OMS Principles.

Principles and sub-principles are supported by Group Essentials (BP. 2016d) which define operating requirements. The Group Essential are themselves supported by Group Defined Practices (GDP). These detail business processes to be implemented as part of the local OMS.

OMS also includes a performance improvement cycle that systematically drives and sustains risk reduction and business improvement. This is applied at each entity on at least an annual basis.

8.3.5.3 Major Hazard Management as Part of the Design Process

The project HSSE Management Plan (BP. 2017b) defines overall HSSE management requirements and activities for the GTA Phase 1 Project, including relevant requirements from OMS.

The primary objectives the HSSE Plan are to:

- Set expectations and requirements for how HSSE is managed during the Preparation phase of the project
- Describe the major risks and how they are managed
- Describe how BP works with its contractors to help ensure safe project execution
- Communicate project HSSE management requirements to the wider project team

The overall process by which GTA Phase 1 Project facilities major accident hazards and risks are managed through the design process is illustrated by Figure 8-86. The following key aspects are then described in more detail:

- Inherent safety, and the priority of hazard and risk control
- Major Accident Risk (MAR) assessments
- Process safety management

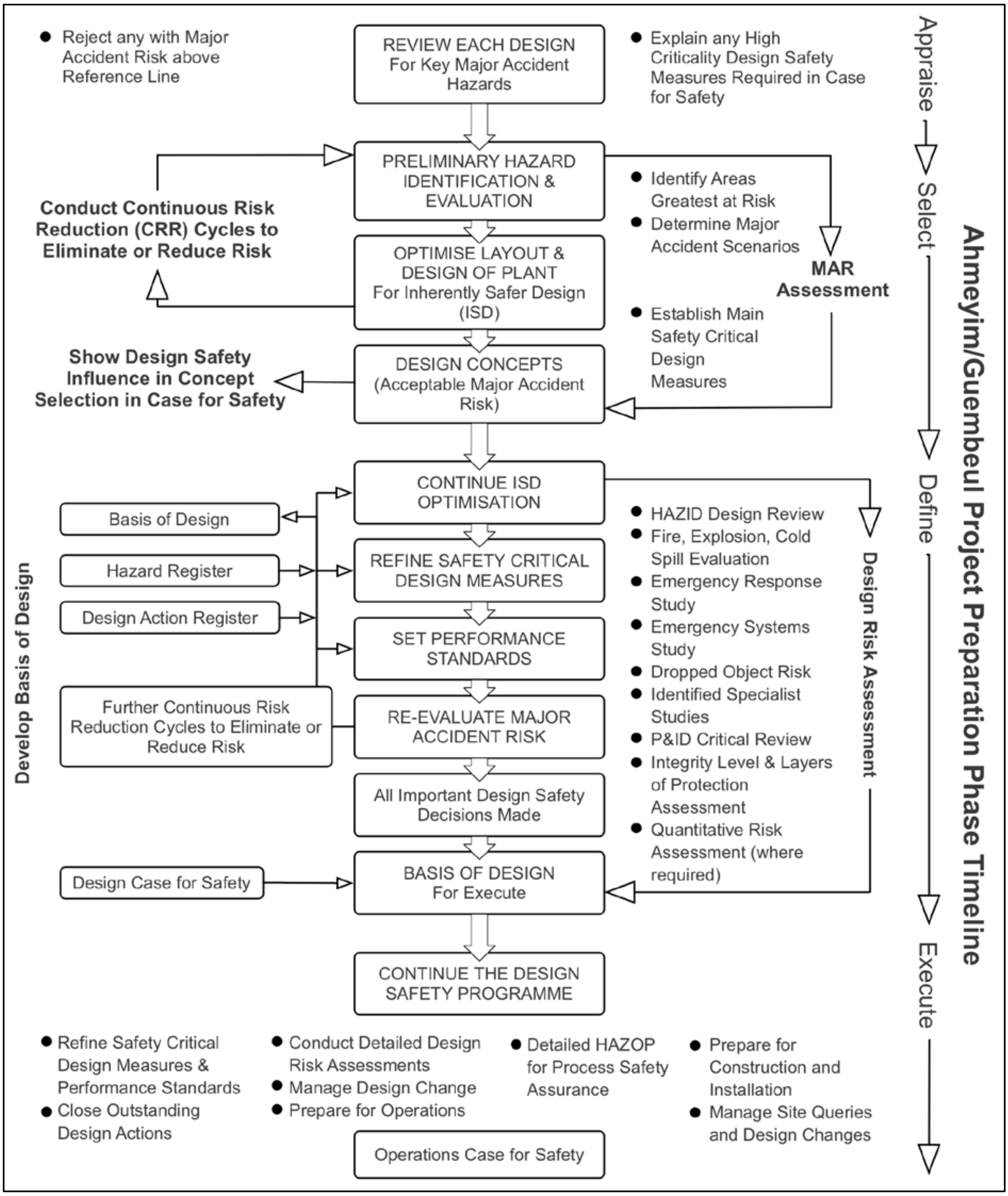


Figure 8-86. Design HSSE Risk Management Process.

8.3.5.3.1 Inherent Safety, and the Priority of Hazard and Risk Control

Hazard management approaches are generally based on the following four main principles:

1) AVOIDANCE – Measures taken to eliminate or reduce the hazard at source

2) PREVENTION – Measures taken to reduce the likelihood of a hazard being realised

3) CONTROL – Measures taken to keep the hazard within the design envelope, either by containment or control systems, or to actively react to events that could result in an accident

4) MITIGATION – Measures taken to deal with the hazard once the accident has occurred, either to bring the hazard back under control or to limit its effects

Typical control and mitigation systems such as overpressure relief, emergency isolation, fire water and blast walls are often the most visible, and expensive, side of hazard management. The visibility of these systems can result in designs where safety focus is on control and mitigation, rather than avoidance or prevention. The concept of “inherently safe” focuses attention on elimination and reduction, leading to safer facilities.

BP places significant emphasis on inherently safe design (ISD) (BP. 2016e). For the GTA Phase 1 Project, focus on inherent safety starts with conceptual design, where the greatest opportunities exist to eliminate or reduce hazards.

As design progresses, opportunities to eliminate hazards may no longer be available, and the focus turns to engineered safety (managing risk by adding layers of protection to mitigate the hazard). During operation, the opportunities to address hazards includes additional layers of protection and procedural controls. However, these engineered and procedural layers of protection cannot achieve the same level of inherent safety as elimination of the hazard. The overall approach is illustrated in Figure 8-87.

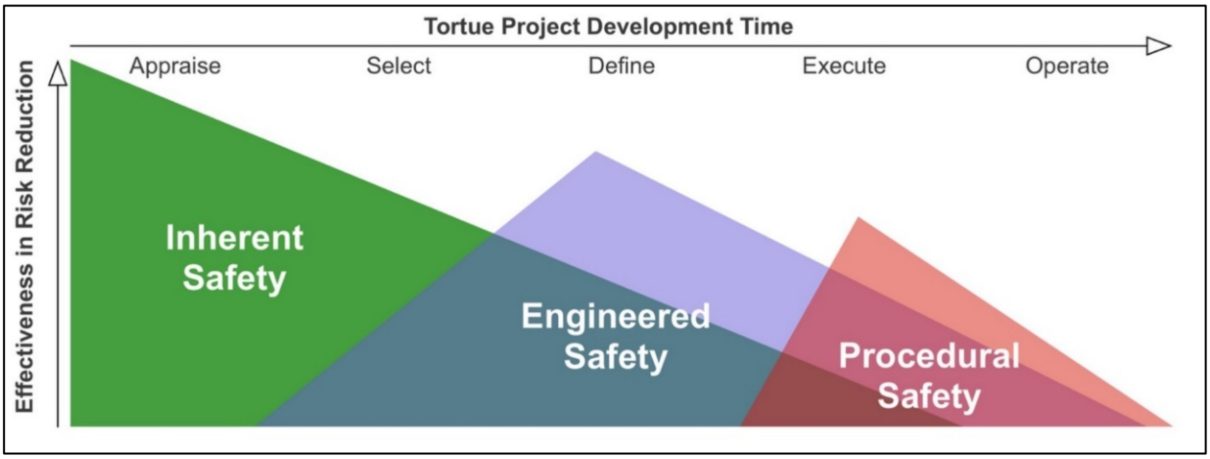


Figure 8-87. BP Focus for Risk Reduction Through Project Lifecycle.

Application of ISD for the for the GTA Phase 1 Project includes:

1) Early setting of ISD goals/criteria and development of a ISD Plan.

2) Early and thorough hazard identification, including ISD optimisation workshops (BP, KBR. 2017e), (BP, KBR. 2017f), (BP, KBR. 2017g).

3) An ISD register in which ISD opportunities and risks are reported and documented. This register is a live document which records and allows for formal management (tracking and close out) of ISD relevant opportunities and risks throughout the Preparation phase of the project.

4) Continued focus on ISD strategies as conceptual choices are progressively made at development, system, and component level.

5) Consideration of lifecycle impacts of alternatives if choices are being made.

6) Articulating ISD delivery status at each internal stage gate

7) Developing an ISD policy for facility modifications and changes in operation

Specific ISD design measures incorporated by the GTA Phase 1 Project include:

- Removal of accommodations (and TR) from the FLNG with the provision of a QU platform at the Near Shore Hub/Terminal.
- Separation of the QU platform from other Near Shore Hub/Terminal major hazard sources such as the riser platform, FLNG and LNG loading berth.
- Layout of the Near Shore Hub/Terminal minimising the number of non-LNG related vessels required to enter LNG loading area. This reduces the potential for collisions with the LNGC.
- The Near Shore Hub/Terminal breakwater/jetty/vessel arrangement reduces tidal, current and wind loading on the FLNG, and associated LNGC operations. This reduces the potential of extreme environmental events impacting facilities and causing/contributing to a major accident event.
- Initial gas processing done on the FPSO, this makes the FLNG smaller, less complex, with smaller inventories, and reduced escalation potential (unlike some other large FLNG facilities where gas processing is done on the FLNG).
- The high-pressure feed gas from the riser platform is routed to the FLNG via the bow and does not pass near the loading or QU platform.
- The jetty and berthing arrangement provides separation of the FLNG from the LNGC. This along with the berthing arrangement reduces the potential for a collision of the LNGC with the FLNG.
- The Near Shore Hub/Terminal riser platform located to the north side of trestle to reduce risk of LNGC collision.
- Near Shore Hub/Terminal and FPSO locations eliminate the need for crew change using helicopter (a major risk contributor for offshore workers) with crew boats used instead.
- Minimal processing on the FPSO with large deck area. This provides for significant physical separation of people (i.e., the accommodation/Temporary Refuge – TR) and primary evacuation facilities from process hazards, and reduces the potential for significant explosion overpressures and escalation. Further, simplification of process has removed requirement for import and export gas compression.
- The FPSO orientated with respect to prevailing winds (upwind) to reduce the potential for smoke and gas at the accommodation/TR and primary evacuation facilities.
- FPSO crane locations reduces dropped objects hazards with respect to process systems and are remote from flexible risers.
- FPSO risers located on starboard side only, remote from supply vessel and crane operations.
- FPSO upper process decks and grated, while lower decks are plated. This reduces confinement to reduce potential explosion overpressures, while still providing for containment of liquid spills.

- Large gap between hull and process deck (6m). This reduces congestion/confinement between the process deck and hull to reduce potential explosion overpressures.
- Forward offloading of condensate from the FPSO remote from the accommodation/TR and primary evacuation facilities.
- FPSO high pressure MEG injection system moved to process modules and remote from the accommodation/TR and primary evacuation facilities.

8.3.5.3.2 Major Accident Review Assessments

The BP MAR assessment process is a high level quantitative risk assessment that is consistently applied to all BP operations with the potential for a major accident.

The MAR process provides an understanding of risk early on during the early Preparation phase of the project, and where to focus risk reduction efforts. Inherent in the MAR approach is the principle of continuous risk reduction.

For the GTA Phase 1 Project, a MAR assessment was conducted at a very early stage of the project, when different concepts were being evaluated and selected. This assessment provided valuable input into early risk reduction focus and inherently safer design. The MAR assessment involved the following main steps:

- Identify a representative range of hypothetical major accident events (i.e. accidents that could result in three or more fatalities, or a major environmental consequences)
- Quantify the likelihood of these events
- Quantify the potential physical effects from these events and assess their consequences
- Evaluate risk, taking account of both the severity of the range of outcomes and the frequency at which they are predicted to occur. This is presented in graphical representation as the frequency and cumulative severity of outcome for:
- Risk to the onsite population
- Risk to the offsite population
- Cumulative frequency of environmental events
- Evaluate of options to mitigate the likelihood and/or consequences of the events considered

8.3.5.3.3 Process Safety Management

Process safety is the disciplined framework for managing the integrity of operating systems and processes handling hazardous substances by applying good design principles, engineering, and operating practices.

Design process safety reviews, formal safety assessments, and associated activities are an integral part of managing operational risk. They evaluate risk in detail, verify the design intent, and assist with making key design decisions regarding major accident prevention, control and mitigation.

Within all BP projects, accountability for process safety rests with the Engineering team, and BP's Process Safety Guide (BP. 2014) defines implementation of process safety requirements. Project team members support the Engineering team to implement actions resulting from process safety reviews, formal safety assessments, and associated activities. They also provide specialist advice on verification of process safety barriers, where needed.

For the GTA Phase 1 Project, key process safety reviews, formal safety assessments and associated activities include:

- Consequence and risk analysis conducted in support of the ESIA and Risk Study in Appendix N-1 and N-2, (Atkins. 2018), (Goddard. 2018b), (Goddard. 2018c). These analyses provide a conservative evaluation and quantification of major hazard risk.
- The drillship HSE Case and supporting studies (Atwood Oceanics. 2014a), (Atwood Oceanics. 2014b), (Atwood Oceanics. 2016). These informed the design of the drillship and formed the basis for assessment of drilling accident hazards and risks in the Risk Study.
- Hazard and operability studies (HAZOPs). HAZOPs to be undertaken during front-end engineering and detailed design phases of the project to identify potential hazards and problems with the process design, and to provide design verification/assurance.
- Layer of protection analyses (LOPA)/Safety Integrity Level (SIL) Assessments to be undertaken during front-end engineering design. LOPA/SIL define the correct functioning, and required reliability, of safety-instrumented systems (SIS) and other risk reduction measures such as safety instrumented systems, alarm systems and basic process control systems.
- Hazard identification studies (HAZIDs). HAZIDS are undertaken during the front end-engineering and detailed design phases phase of the project to identify all hazards and risks and provide early input into design. This includes early FPSO and Near Shore Hub/Terminal HAZIDs (BP, KBR. 2017a), (BP, KBR. 2017b), and when sufficiently developed, 3D model reviews.
- Fire, explosion and cold spill (cryogenic release) hazards analyses to be undertaken during front-end engineering. This analysis takes place when the design is sufficiently progressed to utilize 3D CFD models, and feeds into design requirements (DALs) for fire, explosion, and cold spill prevention, control and mitigation.
- Emergency systems studies to be undertaken during front-end engineering. These studies assess and verify the performance of emergency systems for the major accident events for which they are required to function, and provide input into DAL for fire, explosion, and cold spill prevention, control and mitigation.
- Emergency preparedness and response studies to be undertaken during front-end engineering. These studies assess and verify the performance of escape, temporary refuge (TR), evacuation and field rescue facilities, and provide input into design to help ensure personnel can reach a place of safety during any major accident event.

In addition, other analyses will be undertaken to evaluate facilities and location specific risks, such as dropped objects and vessel collision. Specific consequence and risks analyses may also be conducted to evaluate options and assist in decision making. Further, during the detailed engineering phase of the project, key studies will be updated to reflect the final design.

8.3.5.4 Major Hazard Management During Operation

During all phases of the project, all facilities will operate under comprehensive management system arrangements that help ensure activities are conducted safely with minimal environmental impact, and with hazards and risks continually identified, assessed, eliminated and/or minimised.

These management system arrangements incorporate many interrelated elements and requirements. Key aspects as they relate to GTA Phase 1 Project operational major hazard management during operations include:

- Safe operating procedures and limits
- Change management

- Asset integrity management
- Training and competence

Safe Operating Procedures and Limits

Written procedures cover all operations. These procedures provide documented processes for control of hazards and risks to personnel and the environment, and are an integral part of the overall management system. In addition, operational boundaries and limits are clearly defined. This includes:

- Operational boundaries and restrictions for simultaneous operations. These defines activities that can or cannot be undertaken concurrently, along with any restrictions. For example, crane and helicopter operations are not permitted to occur concurrently.
- Environmental limits for at risk activities and operations. These define safe environmental/working limits for wind, sea state, visibility, lightning etc. where operations will be halted, or additional safeguards are required for activities to be conducted safely. For example, cease cargo loading/offloading operations if the support vessel deck crew are unable to see the crane operator clearly
- Loss of function of SECE. These define requirements/restrictions should an SECE be out of service, or fail to meet its specified performance standard during inspection or testing. For example, helicopter operations are not permitted if the helideck foam fire-fighting system is out of service.

Change Management

Formal management of change (MOC) process and procedures are in place to help ensure that proposed changes to assets, systems, documentation, personnel and operations, are evaluated (including hazard identification and risk assessment), managed, documented and approved at the appropriate level, to help ensure that safety, health and environmental risks arising from such changes are identified and controlled. Changes controlled using the MOC process include:

- Changes to facilities SECE and protective systems, including alarm and trip setting, and overrides; control system and emergency shutdown logic; safety-critical information technology systems and software, including communications systems; and software updates.
- Changes to chemicals and feedstocks, including use or removal of process chemicals or additives; or operation of process streams at specifications (beyond original design intent); and increased inventory of hazardous materials (beyond original design intent).
- Changes to materials and equipment, for example, pipe, valve size, or materials of construction; repair or replacement using non-original equipment manufacturer (OEM) parts; new or modified equipment items or wells, including removal or permanent isolation.
- Changes to inspection or maintenance intervals.
- Changes to stability of structural, marine and floating systems.
- Changes involving temporary facilities or procedures to facilitate planned maintenance or construction
- The cumulative effect of creeping “changes”, such as ageing of reservoirs (e.g. increased water content); gradual topsides weight gain due to multiple modifications; and progressive deterioration or ‘ageing’ of equipment which is used during and beyond its original design life.
- Changes to people, including staffing levels and organisation structure; and changes involving key positions including recruitment, removal or addition, and responsibilities.
- Changes processes and procedures, including emergency response plans; process conditions outside established safe operating limits; revised operating and maintenance procedures; operating control philosophies; and testing and inspection procedures

Asset Integrity Management

Asset integrity management is the means of ensuring that facilities and equipment function effectively and efficiently, whilst protecting health, safety and the environment. Essential for the integrity of the GTA Phase 1 Project facilities are the SECE. SECE are any part of the facilities or plant whose failure will either cause or contribute to a major accident event (prevent), or the purpose of which is to stop or limit the effects of a major accident event (control and mitigate). The integrity of GTA Phase 1 Project facilities SECE is assured through specific arrangements for change management; inspection, testing and maintenance; along with verification of element performance. Management of SECE is discussed further in Section 8.3.5.5.

Facilities use computerized procurement and maintenance management systems (MMS) to manage asset integrity, including inventory information, preventive maintenance job plans and scheduling, equipment history, purchasing and supply chain information. They also incorporate maintenance and inspection requirements for equipment and systems as determined by manufacturer requirements, industry standards and practices, regulatory requirements and/or SECE performance standards. All inspection, testing, maintenance, calibration and repair actions are issued from and documented within the MMS. Defects or deficiencies are also recorded within the MMS to provide visibility and to help ensure they are corrected and tracked through to closure.

Training and Competence

Personnel are selected based on the skills, experience and aptitude required for a given position with specific requirements defined within detailed Job Descriptions for all positions

Training requirements are specified by position and documented in training matrices. This includes internal (facility-based) and external HSE training; skill-based training; and certification or licensing requirements. External training courses, including refresher training, are delivered through approved third-party providers. Managers and supervisors are trained to a level of competence commensurate with their position. This includes safety leadership, job planning, supervising and personnel engagement skills.

All facilities implement competency assurance programs, which include HSE and operational competency requirements for all employees. Personnel are evaluated and must meet competency expectations within a pre-defined time, defined by the position and specific competency requirements. Skills and knowledge are assessed through a combination of on-the-job demonstration, simulation and questioning, as appropriate. Where personnel are deemed ‘not yet competent’, task restrictions are applied and the individual is subject to further training and supervisory oversight. To help ensure competency programs remain up to date, competency criteria are periodically reviewed for alignment with current processes, equipment changes, and industry good practice.

Training and competence are managed through computerised systems to track training requirements and competency assessment results for each person, with compliance reported on regular performance scorecards.

8.3.5.5 Management of Safety and Environmentally Critical Elements

The characteristics of the major accidents are summarised in Bowtie diagrams (see Section 8.3.4.2). These diagrams define main causes; and potential consequences; along with prevention, control and mitigation measures. From the Bowtie diagrams, the SECE are defined.

SECE are any part of the facilities or plant whose failure will either cause or contribute to a major accident event (prevent), or the purpose of which is to stop or limit the effects of a major accident event (control and mitigation)

For SECE, performance standards are developed detailing the performance required of the element (or its component systems) to prevent, control or mitigate the major accident event. Typical information defined within an SECE performance standard is given in Table 8-36.

Table 8-36. Typical SECE Performance Standard Information.

Safety and Environmentally Critical Element Performance Standard Layout		
Performance Standard: Reference #	Safety and Environmentally Critical Element Name	
Performance Objective: Describes the overall hazard management role of the SECE in the prevention, detection and control of the major accident		
System Overview: Describes the components and limits of the SECE. Includes what equipment items are included, and where the interfaces or beginning and end points exist		
Performance Criteria	**Basis**	**Assurance**
Functional: The minimum performance necessary to fulfill the performance objective (what is it required to do) **Reliability:** The performance on demand (how likely is it to function on demand) **Availability:** The maximum allowable downtime in a fixed period (for what proportion of time is it capable of performing) **Survivability:** The severity of the event that it should survive (only required if the system is critical to managing the event to which it is exposed)	Reference for criteria	Activities or tasks undertaken to confirm that the SECE meets the specified performance criteria
Interactions/Dependencies: Defines the interactions with other SECE and how a system interacts and/or depends on other SECE for functionality or support		

SECE performance standards are developed during the Preparation phase of the project and used as a basis for project assurance and verification activities. These activities check and verify that SECE perform their intended function. Activities include:

- Internal design checks
- Selective third-party design checks
- Factory acceptance tests
- Offshore construction and installation checks and tests
- Pre-start up audits and checks

SECE should also be able to perform their intended function with the required availability and reliability throughout their operational service. As part of preparing for Operation, operational performance standards are developed. Operational SECE performance is then managed through:

1) Identifying maintenance, inspection and testing requirements to maintain SECE in suitable condition
2) Ensuring that maintenance, inspection and testing is carried out at the appropriate time by competent personnel
3) Maintaining a record of these activities and any findings that arise
4) Addressing any deficiencies (i.e., failure of SECE to meet its specified performance standard) through formal change management processes, including risk assessment and temporary actions to manage risk until rectified
5) Independent verification of integrity maintenance, inspection and testing system and SECE performance

8.3.5.6 Specific Control and Mitigation Measures (SECE)

SECE are designed to perform their function to prevent the occurrence of major accident events. In the unlikely event a major accident events occurs, SECE function to provide control and mitigation of major event consequences. The following SECE provide functions related to control and mitigation and are described further (BP, KBR. 2017c) & (BP, KBR.2017d):

- Layout and Natural Ventilation
- Ballast Systems
- Blowout Preventer
- Blowdown and Emergency Relief Systems
- Bunding, Containment and Hazardous Drains
- Hazardous Areas with explosive atmosphere (ATEX)
- Ignition Prevention
- Fire and Gas Detection
- Passive Fire Protection
- Active Fire Protection
- Helideck Systems
- Emergency Power
- Environmental Clean-up Systems
- Emergency Communication Systems
- Emergency Shutdown
- Enclosure Integrity and HVAC
- Incident Awareness and Alarm
- Escape and Evacuation Routes
- Emergency Lighting
- Safe Muster and Temporary Refuge (TR)
- Evacuation (Lifeboats, Secondary and Tertiary)
- Lifesaving Appliances
- Search and Recovery
- Medical Facilities

8.3.5.6.1 Layout and Natural Ventilation

The layout and natural ventilation design of the drillship, FPSO and Near Shore Hub/Terminal facilities is intended to mitigate the effects of accidental gas releases, and reduce the potential for escalation of fire and explosion events.

The fundamental aspects of the layout and natural ventilation include:

- Optimisation of natural ventilation, and dispersion of hydrocarbon gaseous releases from the facilities, accounting for prevailing wind direction, strength and seasonal changes.
- Reducing the potential for equipment damage during normal operations that could lead to a loss of containment. For example, siting of cranes and laydown areas to reduce dropped object risk to live process, risers and pipelines.
- Limiting escalation potential for a fire or blast event through orientation of equipment separation, equipment orientation, and reducing congestion and confinement.
- Providing separation and protection of accommodations, temporary refuges (TR) and critical emergency function control equipment from major hazard sources.
- Providing a diversity of escape and evacuation facilities to reduce the likelihood of impairment during a major accident event.

8.3.5.6.2 Ballast Systems

Ballast systems are provided onboard the drillship, FPSO and FLNG to help ensure facilities maintain stability under all operating conditions, including adverse weather, damaged conditions, and cargo loading/unloading.

In the occurrence of a major accident impacting the hull or topsides, ballast operations may be required to add or transfer ballast to prevent further escalation or capsizing. Ballast systems comprise:

- Storage tanks
- Tank vents
- Pumps
- Distribution piping
- Valves
- Control Stations

Ballast systems are designed with inherent redundancy and facilities are designed to withstand the flooding of any single water-tight compartment.

Ballast systems are provided with continuous monitoring of ballast tanks including level indication with alarm and volume indications. They are designed to operate with multiple configurations to help ensure safe ballasting in the event of single equipment failure. This includes multiple pumps, and piping for distribution of ballast water. All critical ballast valves fail to a predefined safe state (whether open, closed or ‘as is’). Control stations allow for both local and remote activation and are supplied with emergency power in the event of main power loss.

8.3.5.6.3 Blowout Preventer

During drilling, the primary barrier to the well is the mud system. Should this barrier fail, a subsea BOP stack (and lower marine riser package – LMRP) is provided for secondary well control.

The BOP stack comprises several elements, including rams, annulars, and control pods, giving full functionality for the range of required well control activities. This includes pressure testing; and well control; including circulation of returns via the choke and kill system, and completely sealing the wellbore. The BOP stack includes:

- Two 10k (10,000 psi) annular BOPs as part of the LMRP (used for pressure testing and sealing the marine riser annulus in case of disconnection of the LMRP)
- One 15k (15,000 psi) casing shear ram (used to seal the well in case of blowout)
- Two 15k blind shear rams (used to completely seal the well in case of blowout)
- Two 15k variable pipe rams (used to seal the annulus in well control situations)
- One 15k fixed pipe ram (used to seal the annulus in well control situations)
- One 15k subsea stack test valve (SSTV) ram (used to seal the annulus for BOP pressure testing)

The BOP is controlled electro-hydraulically from the surface. Redundant subsea multiplex control pods provide the electrical to hydraulic interface required to monitor and control the various BOP stack components. Hydraulic power is provided by redundant subsea accumulators which can be replenished from surface hydraulic systems. Surface control and communication is via driller and toolpusher panels. Surface power is from main power, backed up by redundant uninterruptible power supplies in case of main power failure.

In case of loss of surface control, BOP functions can also be activated at the stack using a Remotely Operated Vehicle (ROV).

8.3.5.6.4 Blowdown and Emergency Relief Systems

The blowdown and emergency relief systems onboard the FPSO and FLNG, and at the Near Shore Hub/Terminal, reduce the duration of any hydrocarbon gas release and reduce the risk of escalation. Shutdown valves are also located throughout the process areas to appropriately isolate inventories.

In the event of a confirmed fire in a process area or manual blowdown pushbutton activation, blowdown valves are opened to allow hydrocarbon gas and liquid collection via the HP and LP flare system headers. Hydrocarbon gas and liquid are routed to flare drums for liquid collection and gas is routed to the appropriate flare stack.

8.3.5.6.5 Bunding, Containment and Hazardous Drains

The bunding and hazardous drain systems on the drillship, FPSO and Near Shore Hub/Terminal facilities provide equipment to help ensure spills are prevented and appropriately contained.

Systems provide for:

- Valving that can be closed during chemical filling or transfer
- Plating in areas that have a high potential for spills or many valves/connections
- Bunding and deck coaming for chemical and hydrocarbon containing equipment
- Designation of both open and closed drains (for safe and hazardous area headers)
- Impound basin provided on the FLNG at the loading arms

For cryogenic spills, containment areas are arranged to limit the spread of liquid spills and surface area, thereby reducing vaporisation.

8.3.5.6.6 Hazardous Areas with Explosive Atmosphere (ATEX)

All areas onboard the facilities are designated hazardous or non-hazardous dependent on the expected flammable atmosphere during normal operations. Classification is based on recognised industry standards including the Energy Institute (EI) 15 (EI. 2015), IMO Mobile Offshore Drilling Unit (MODU) Code (IMO. 2009), DNV Rules for Classification of Offshore Drilling and Support Units (DNV. 2012), The International Electrotechnical Commission 60079 (IEC. 2017), and American Petroleum Institute Recommended Practice 505 (API. 1997).

Classification of these areas is established to provide:

- Locations for flammable vents based on dispersion analysis for vent design rates
- Locations of doors, HVAC air inlets and combustion equipment away from potential flammable leak sources
- Rating for electrical and mechanical equipment for ignition prevention
- Controlling hot work permits during normal operations

The hazardous areas identified are divided into the following zones:

- Zone 0: An area in which an explosive gas atmosphere is present continuously or for long periods or frequently
- Zone 1: An area in which an explosive gas atmosphere is likely to occur in normal operation occasionally
- Zone 2: An area in which an explosive gas/air mixture is not likely to occur in normal operation but, if it does occur, will persist for a short period only

Hazardous area drawings for each facility are developed during design with zone boundaries and the location of HVAC, vents and exhausts.

8.3.5.6.7 Ignition Prevention

To prevent ignition, all electrical equipment onboard the facilities is suitably rated for the hazardous area zone classification for which it is located in. Electrical equipment is designed and located in accordance with accepted industry practice including IEC 60079 Explosive Atmosphere Standards (IEC. 2017) (refer also to Section 8.3.5.6.6).

All equipment in external areas carries a Zone 2 rating at a minimum, and equipment in hazardous areas is suitable for gas group IIB Temperature Class T3 for a 200ºC maximum surface temperature.

8.3.5.6.8 Fire and Gas Detection

The fire and gas detection systems installed for each facility provides function to:

- Automatically and rapidly detect flammable or toxic gas clouds or fires
- Provide the location of the gas cloud or fire
- Initiate an appropriate emergency control response
- Allow for manual initiation of shutdowns
- Alert and alarm personnel for the hazard detected in the area
- Provide incident monitoring and analysis for decision making

Appropriate detectors are installed to help ensure that adequate coverage is available for the identified gas hazards. Detector types utilised include:

- Flammable gas (located in process areas containing flammable hydrocarbons, transfer equipment, near sources of ignition, air intakes, equipment enclosures, storages tanks, etc.)
- Carbon monoxide (located in enclosed spaces where personnel may enter, including accommodation spaces)
- Flame (located in process areas, utility areas and ceiling/floor void space)

- Heat (located in equipment enclosures including turbines, engines, firewater pumps, etc.)
- Smoke (located in accommodation spaces, equipment enclosures and areas containing electrical equipment, air intakes etc.)
- Oil mist (located in turbine enclosures and other areas with significant diesel or hydraulic oils)

8.3.5.6.9 Passive Fire Protection

Passive fire protection is provided at each facility to prevent escalation of fire and explosion events, and additionally provide temporary protection while measures are taken to control the incident/accident.

Passive fire protection includes safety gaps, plated decking, fire and blast walls. Equipment and structures vulnerable to fire are provided with passive fire protection to help ensure that:

- Barriers are provided for fires to prevent escalation of inventory releases
- Essential safety equipment is protected (riser ESDVs, flare headers, etc.)
- Structural supports are protected from liquid inventory releases and fires
- Egress and evacuation routes are protected
- Personnel can remain in the temporary refuge until safe evacuation can be undertaken

If passive fire protection is intended to function following an explosion event, it is designed to withstand blast overpressure, in addition to any required fire rating. Passive fire protection is classified depending on its intended purpose as A, B, H or J rated barriers or coatings.

Specific fire and explosion ratings are determined during the Preparation phase of the project.

8.3.5.6.10 Active Fire Protection

During a fire or explosion accident event, active fire protection systems are utilised to control and extinguish fires onboard the facilities. Multiple systems are provided onboard each facility dependent on the potential fire sources and system arrangements. These systems generally include:

- Firewater distributed via isolatable ring mains provided for extinguishing and cooling
- Foam systems provided for liquid or LNG spills
- Water mist or gaseous systems for equipment enclosures
- Wet chemical systems for galley hoods

Fire water systems are supplied by redundant fire water pumps that are in different areas with separation distances to help ensure that a single event does not impair both systems. Ring mains are provided with isolatable sections and valving to help ensure the system can be isolated and remain functional with a damaged section.

Drillship

Drillship active fire protection systems are summarised in Table 8-37.

Table 8-37. Drillship Active Fire Protection Systems.

Active Fire Protection System	Protected Areas
Firewater system (including pumps, pressurized tank, ring main, deluge nozzles and fire monitors)	• Topsides process areas • Drilling derrick
Water mist system	• Engine room above the main engines
Extinguishing gaseous system (FM200)	• Mud Module Electric Room, • Derrick Module Electric Room, and • Blue/Yellow Central Control Unit (CCU)
Extinguishing gaseous system (CO_2)	• Machinery spaces (engines, aft machinery space, purifier rooms, thruster rooms, and aft electrical room)
Deck integrated fixed foam system	• Helideck
Firewater Hydrants and hoses	• Throughout the drillship
Fixed wet chemical	• Galley hoods and exhaust ducts

FPSO

FPSO active fire protection system are summarised in Table 8-38.

Table 8-38. FPSO Active Fire Protection Systems.

Active Fire Protection System	Protected Areas
Firewater supply system include deluge	• Cargo tank deck • Topsides process areas • Offloading area • Machinery spaces (non-category A equipment without combustion according – SOLAS)
Deck foam spray system	• Cargo tank deck
Foam application via concentrate and hydrant connection	• Cargo tank deck • Offloading area
Fresh water mist system	• Machinery spaces (category A equipment for internal combustion engines or oil burning equipment – SOLAS) • Gas turbine enclosure
Firewater spray firefighting systems	• Emergency generator • Paint stores
Firewater hydrants and hoses	• Machinery spaces (category A) • Machinery spaces (non-category A) • Accommodation • Stores
Fixed wet chemical	• Galley hood and exhaust duct
Deck integrated foam firefighting system	• Helideck

Near Shore Hub/Terminal

Near Shore Hub/Terminal (QU platform, trestle, FLNG, and riser platform) active fire protection systems are summarised Table 8-39.

Table 8-39. Near Shore Hub/Terminal Active Fire Protection Systems.

Active Fire Protection System	Protected Areas
Firewater supply system include deluge	• FLNG cargo tank decks • Topsides process areas • QU platform • Diesel storage • Offloading area • Machinery spaces
Firewater monitors	• Jetty trestle areas • riser platform
Deck foam spray system	• FLNG cargo tank deck • LNG containment areas
Foam application via concentrate and hydrant connection	• Cargo tank deck • Offloading area
Water mist system	• Turbine enclosures • Emergency generator • Firewater pumps
Firewater hydrants and hoses	• Machinery spaces • Accommodation • Stores
Fixed wet chemical	• Galley hood
Deck integrated foam firefighting system	• QU helideck
Foam trolleys	• QU platform where diesel and lube oil spills are possible

8.3.5.6.11 Helideck Systems

Helideck systems allow for the safe landing and take-off of aircraft within safe operating limits. Helidecks are provided at the drillship, FPSO, and QU platform. Helicopter operations at the drillship serve as the primary means of personnel transfer, while the facilities at the FPSO and QU platform serve primarily for emergency use.

The helideck is installed at the top deck of the accommodation at the bow of the drillship. For the FPSO, the helideck is located with access near the top level of the living quarters. The QU platform helideck is located at the top deck level of the facility.

All helidecks and helicopter crash rescue equipment are designed in accordance with Civil Aviation Authority (CAA) Civil Aviation Procedure (CAP) 437: Standards for Offshore Helicopter Landing Areas (CAA. 2016). The helideck and markings are installed with an aviation jet fuel resistant, non-skid surface with drain systems to contain any rainwater or fuel spills. Safety netting is provided at the perimeter edges of the helideck to prevent falls.

Equipment and facilities provided for safe helicopter operations include:

- Illuminated wind sock
- Chocks and tie-down equipment
- Helideck markings
- Non-directional beacon
- Air temperature and barometric measurement devices
- Anemometer to indicate wind strength and direction
- Foam firefighting facilities (see Active Fire Protection)

8.3.5.6.12 Emergency Power

Emergency power systems are provided at the facilities to help ensure that:

- A reliable and secure power source is available to power safety and emergency systems during an emergency or incident/accident
- An uninterruptible power supply is available in the event of a temporary power loss leading to loss of control or uncontrolled shutdown
- Safety and emergency systems are available for the required period to achieve safe muster and evacuation

The primary source for emergency power is provided by emergency generators capable of maintaining power in emergency situations for a minimum of 24 hours. Emergency generators are to start automatically upon loss of main power.

Additionally, uninterruptible power systems (UPS) are provided for emergency equipment for a period of 1 – 2 hours in the event of emergency generator failure. Navigation systems are provided with UPS supply for 96 hours.

Key users of emergency power include:

- Control and emergency shutdown (ESD) systems
- Emergency lighting
- Communication systems including public address and general alarm (PAGA)
- Fire and gas detection and control
- Temporary Refuge HVAC systems
- Equipment ventilation and cooling fans
- UPS system
- Ballast systems

8.3.5.6.13 Environmental Clean-up Systems

For control and mitigations of environmental release events, equipment and systems are available at the drillship, FPSO and Near Shore Hub/Terminal to reduce the effects of a release to the environment.

This comprises:

- Containment systems (see Bunding and Hazardous Drains)
- Shipboard Oil Pollution Emergency Plan (SOPEP) equipment for the facilities and attendant vessels

Emergency response requirement and activities in case of a major oil spill are discussed further in Section 8.3.6.7.

8.3.5.6.14 Emergency Communication Systems

In the event of a major accident, multiple forms of emergency communication are available internally on the facilities. and externally for offshore and onshore support.

Communications systems include:

- PAGA system
- Global Maritime Distress and Safety System (GMDSS) including Very High Frequency (VHF), Inmarsat C and Navigational Telex (NAVTEX) receiver
- Very Small Aperture Terminal (VSAT) radios
- Lifeboat radios
- Emergency satellite phone
- Submarine fibre optic transmission (FPSO and Near Shore Hub/Terminal)

Incident awareness and alarm systems are discussed further in Section 8.3.5.6.17.

8.3.5.6.15 Emergency Shutdown

Drillship

The drillship is equipped with an ESD system to shutdown and/or isolate equipment in a safe and controlled manner in the occurrence of a major accident event or emergency. The ESD hierarchy for the drillship provides shutdown of systems and equipment in the following tiers:

- ESD 4 – Ventilation/Oil Systems Shutdown (A - closure of quick closing valves; B - engine/thruster shutdown; C- fuel, lube and hydraulic oil transfer systems shutdown; D – machinery spaces ventilation; E-G thrusters; H – galley; I – laundry; J - heli-fuel)
- ESD 3 – Drilling VFD shutdown
- ESD 2 – Emergency Engine/Generator Shutdown (A - starboard engine/generator shutdown; B - centre engine/generator shutdown; C -port engine/generator shutdown)
- ESD 1 – Emergency Engine/Generator Shutdown
- ESD 0 – Abandon Vessel Shutdown

The ESD system can be initiated through the fire and gas system or from manual pushbuttons.

FPSO and Near Shore Hub/Terminal

The ESD system onboard the FPSO and Near Shore Hub/Terminal is provided to control process upsets by initiating isolation of production fluid releases and potential ignition sources. Shutdown valves are provided throughout the process area to reduce a potential loss of containment. The emergency shutdown system can be initiated by a process upset, input from the fire and gas system or manually. The ESD system initiates the following emergency shutdown levels:

- Unit shutdown
- Train shutdown
- Production shutdown
- Yellow shutdown
- Red shutdown

In the event of yellow and red shutdowns, hydrocarbon inventories are automatically isolated and depressurised via blowdown valves routed to the flare.

At the Near Shore Hub/Terminal, the QU platform control room interfaces with the FLNG control room to help ensure that shutdown and blowdown of the production facilities is integrated without the reliance on cascade effects.

8.3.5.6.16 Enclosure Integrity; and Heating, Ventilation and Air Conditioning

The HVAC systems and associated enclosures onboard the facilities operate to help ensure smoke and gas ingress is prevented from entering the area.

Enclosure integrity and HVAC system equipment for the temporary refuges includes:

- TR HVAC system
- Flammable gas and smoke detection on air intakes
- Fire dampers
- Internal HVAC recirculation system
- Internal and external doors

Primary air ventilation intakes for the temporary refuges are located away from gas hazards at a low elevation. Air intakes are equipped with flammable gas and smoke detection within the ducts that initiate damper closure automatically, primary HVAC shutdown and initiate the internal HVAC recirculation system. Internal recirculation systems are provided with emergency power in the event of main power loss to maintain provide positive overpressure relative to the external atmosphere.

The fire dampers carry the same fire rating equal to or better than the bulkhead where they are installed. Commonly used doors and entrances into the TR have at least two doors separating the outside atmosphere to the internal environment within the TR.

Enclosure and equipment spaces onboard the facilities are equipped with HVAC supply and extraction fans that are shutdown upon smoke or flammable gas detection via the fire and gas system.

8.3.5.6.17 Incident Awareness and Alarms

Incidents may be detected automatically by the safety system provided, or manually by personnel activating an alarm.

Automated systems are provided such as process upset, and fire and gas detection. Automated process monitoring may alert control room operators of potential issues and hazards. Fire and gas detection system will also initiate alarms on confirmed fire or gas, along with the appropriate executive action i.e., to close emergency shutdown valves and (where provided) initiate blowdown.

Fixed telephone and PAGA systems are provided on all facilities. In addition to automated systems, fixed telephone systems provide the primary means of raising an alarm. These may be supplemented by portable radios, where carried.

Detection systems are also supplemented with manual alarm call-points (MAC) located strategically throughout facilities, drilling, process and utilities areas. Their function is to allow for manual initiation of alarm, along with the appropriate executive action. Depending upon the facility, different MAC are provided for:

- Confirmed fire or gas detection
- Process shutdown
- Emergency shutdown
- Initiation of active fire protection
- Equipment emergency stop/shutdown

Alarms are initiated by fire and gas detection systems, by calling control rooms, or by activating a MAC. PAGA systems then provide the primary means for emergency announcement and alarm broadcast across all normally accessed areas. They comprise two independent sub-systems, that operate as a single unit. Field equipment and cable routings are in diverse locations to help ensure availability should any major accident occur and all cabling is fire resistant in accordance with recognised standard and good practice. In areas of high noise, audible alarms are supplemented with visual flashing strobe beacons to alert personnel of the alarm.

Table 8-40 summarises alarms on the various facilities. Different alarms have sufficiently different tones to be easily recognised.

Table 8-40. Alarms.

Drillship	FPSO	Near Shore Hub/Terminal Facilities
• PAGA audible fire and emergency alarm with flashing strobe lights in high noise areas • PAGA audible gas alarm with flashing strobe lights in high noise areas • PAGA audible prepare to abandon alarm with flashing strobe lights in high noise areas	• PAGA audible general alarm with flashing strobe lights in high noise areas • PAGA audible prepare to abandon alarm with flashing strobe lights in high noise areas	• PAGA audible general alarm with flashing strobe lights in high noise areas • PAGA audible prepare to abandon alarm with flashing strobe lights in high noise areas

8.3.5.6.18 Escape and Evacuation Routes

Escape and evacuation (egress) routes are provided at the facilities to help ensure at least two separate routes are provided from each work area. The escape and evacuation routing is established to:

- Provide protected escape and use during an accident event
- Provide designated and highly visible routes with appropriate signage
- Provide straight and direct routing for escape where possible
- Allow personnel to escape to a safe location (TR or muster area) without entering other high hazard areas during an incident/accident
- Have no routing with blind ends more than 5m long

All egress routes are provided with a durable non-slip surface to prevent slips, trips and falls.

Main egress routes are provided on the port and starboard sides of the drillship, FPSO and FLNG, running the full length of the vessels. These are connected at regular intervals with egress routes running across ships. On the drillship and FPSO, these egress routes lead to the primary safe muster area (the temporary refuge – TR, located aft of the FPSO, and at the bow of the drillship), and alternate safe muster area (at the bow of the FPSO, and aft of the drillship).

At the Near Shore Hub/Terminal, FLNG main port and starboard egress routes lead to the main means of escape from the aft of the vessel onto the trestle main egress route and QU platform, on which is located the primary safe muster area (the TR). Escape is also possible via the bow of the FLNG, via the trestle to the alternate safe muster area on the riser platform.

Escape routes on the QU and riser platforms are established on the outer boundaries of each main deck level.

8.3.5.6.19 Emergency Lighting

Emergency lighting is provided at each facility to help ensure egress route and control areas are provided adequate illumination in the event of main power loss.

Emergency light fixtures with battery back-up account for approximately 10% of the normal egress route lighting. In areas where command and control of an incident/accident is required (control rooms, switch rooms, muster areas, disembarkation stations, etc.), approximately 50% of the normal lighting is equipped with emergency power.

Battery back-ups are provided for emergency lights to help ensure adequate illumination for the duration for which they may be required.

8.3.5.6.20 Safe Muster and Temporary Refuge

The primary safe muster areas on the drillship are near the bow of the vessel, outside the accommodation unit, below the lifeboat stations, port and starboard. If personnel cannot reach the primary safe muster areas, alternate safe muster areas are provided at aft, adjacent to the aft lifeboats on each side of the funnel house. The accommodation is also the designated temporary refuge (TR). The accommodation is protected by fully plated external walls. It also relies on physical separation from the drill centre and continuous orientation of the vessel into the wind to mitigate fire and explosion risk.

The primary safe muster area for the FPSO is in the accommodation, located aft of the vessel. The accommodation is also the designated TR. Fire and blast protection criteria for the TR will be determined during the Preparation phase of the project, considering specific facility hazards and fire risk assessment. If personnel cannot reach the FPSO primary safe muster areas, an alternate safe muster area is provided at the bow.

The primary safe muster area for the Near Shore Hub/Terminal is in the accommodation located on the QU platform. The accommodation is also the designated TR. Fire and blast protection criteria for the TR will be determined during the Preparation phase of the project, considering facility specific hazards and fire risk assessment. If personnel cannot reach the primary safe muster area on the QU platform, an alternate safe muster area is provided at the riser platform on the opposite end of the hub trestle.

As designated TR's, the drillship. FPSO and QU platform accommodations include the following main functionality:

- Location of the incident control centre with facilities to raise alarm, evaluate and monitor an incident as it develops, and have control of functions to mitigate the effects of the incident
- Space to enable emergency command personnel to make effective and informed decisions regarding control of the incident, communication with and management of emergency response teams via radio, and organise a controlled evacuation
- Communications with supply bases, other installations, external emergency and rescue services
- An area for emergency response teams to assemble and don fire suits, breathing apparatus etc. as required
- Protected access to evacuation embarkation areas
- An area for basic triage and treatment of casualties
- Space for personnel to muster safely, as required
- To prevent/reduce the potential for smoke and gas ingress, TR's include the following main functionality:
- External doorways on main entrances have gas and smoke exclusion lobbies in which at least two doors separate the outside air from the internal environment
- Air intakes ducts are in non-classified areas, and located to reduce the potential for smoke or gas ingress
- Forced ventilation maintains positive pressure
- Flammable gas and smoke detection is provided in air intake ducts. On confirmed gas or smoke, intake and extract fire and gas dampers automatically close and air intake fans are shut down. The internal ventilation system continues to recirculate air
- Fire dampers are rated to a standard equal to or better than the bulkhead in which they are installed
- Fire damper open/closed status is provided to emergency control room personnel

Alternate safe muster areas are also provided with systems for communication with primary safe muster areas and the incident control.

8.3.5.6.21 Evacuation (Lifeboats, Secondary and Tertiary)

The preferred means of evacuation from the drillship is by helicopter, then support vessel. In an emergency scenario where the drillship is under immediate threat, helicopter or support vessel evacuation may not be possible. As a result, the primary means for evacuation is by davit launched lifeboat (totally enclosed motor propelled safety craft – TEMPSC). The drillship is equipped with six TEMPSC in total, four are located towards the bow, two each port and starboard and adjacent to the primary safe muster areas. Two TEMPSC are located aft, port and starboard and adjacent to the alternate safe muster areas. Each TEMPSC has a total capacity of 70 persons, giving total capacity of 280 persons at the primary safe muster areas, 140 persons at the alternate safe muster areas, or 210 persons on each of the port and starboard sides. The maximum POB for the drillship is 200.

The preferred means of evacuation from the FPSO is by crew boat. In an emergency scenario where the FPSO is under immediate threat, crew boat evacuation may not be possible. As a result, the primary means for evacuation is by TEMPSC. The FPSO is equipped with freefall type TEMPSC located aft. The numbers and specific location of the TEMPSC will be determined during the Preparation phase of the project, considering facility specific escape, TR evacuation and rescue analyses. However, TEMPSC will be located adjacent to the TR with direct access from the primary safe muster area. In addition, sufficient TEMPSC capacity will be provided for 100% of the maximum POB plus at least one spare craft.

The FPSO is also equipped with two marine escape systems, comprising an escape chute and integrated liferafts, located port and starboard at the bow with direct access from the alternate safe muster area. The capacity and specific location of the two marine escape systems will be determined during the Preparation phase of the project, considering facility specific escape, TR evacuation and rescue analysis. However, they will:

- Be in a secure and sheltered position, protected from direct damage by fire and explosion
- Enable the total number of persons for which they are designed to be transferred into inflated liferafts within a period of 10 minutes

The preferred means of evacuation from the Near Shore Hub/Terminal is by crew boat. In an emergency scenario where the Near Shore Hub/Terminal facilities are under immediate threat, crew boat evacuation may not be possible. As a result, the primary means for evacuation is by TEMPSC. Davit launched TEMPSC are located at the QU Platform. The numbers and specific location of the TEMPSC will be determined during the Preparation phase of the project, considering facility specific escape, TR evacuation and rescue analyses. However, TEMPSC will be located adjacent to the TR with direct access from the primary safe muster area. In addition, capacity will be provided to accommodate the maximum Near Shore Hub/Terminal POB (156 persons) plus one spare craft.

At the Near Shore Hub/Terminal, vessel berthing and access points are available at selected locations on the trestle jetty. Where appropriate, this provides a viable means to evacuate personnel, although no additional facilities for emergency use are provided in addition to those required for normal marine operations.

In the event of impairment of personnel escape to the TR at the QU platform, alternative evacuation facilities are provided as follows:

- Direct access to the sea from selected positions on the trestle jetty
- Liferafts and leg ladders on the riser platform

All lifeboats are of proven certified design and comply with SOLAS requirements. Each TEMPSC is also provided with external firewater spray protection, a marine band radio, an emergency position indicating radio beacon (EPIRB), and search and rescue transponder.

In addition to TEMPSC, all facilities are provided with throw-over type inflatable liferafts located at primary and alternate safe muster areas, and distributed around the facilities for use if personnel are unable to reach muster areas or use TEMPSC.

8.3.5.6.22 Lifesaving Appliances

Lifesaving appliances are available at the facilities to assist in safe escape and evacuation. These include:

- Lifebuoys
- Lifejackets
- Safety bags (including smoke hood, torch and fire-resistant gloves)

8.3.5.6.23 Search and Recovery

For rescue and recovery from the sea, field support vessels are available. In addition, shore-based support may be mobilised in the form of helicopters and additional vessels.

In the instance of a personnel overboard scenario or if rescue from sea is required, fast rescue craft (FRC) are provided at the drillship and FPSO. No FRC is provided at the Near Shore Hub/Terminal, but support vessels (i.e., tugs and crew boats) can assist, as required.

8.3.5.6.24 Medical Facilities

Medical facilities are available within each TR, including the ability to provide basic triage and treatment for injured personnel. The facilities allow stretcher access to helideck and TEMPSC embarkation areas should evacuation or medevac be required. Equipment and personnel available at the medical facilities include:

- Sick bays with beds
- Treatment areas
- Medical supplies and equipment (including medicine, bandages, defibrillators, stretchers, etc.)
- Medic supported by trained first aiders

8.3.6 Emergency Preparedness Arrangements

8.3.6.1 Introduction

In all cases where a major accident could occur, proper planning and emergency preparedness will assist in minimising consequences. Key elements of emergency preparedness described in this section of the Risk Study relate to:

1) The BP emergency response model and overall structure
2) Key roles and responsibilities
3) Unified command in a multijurisdictional emergency involving multiple parties
4) Emergency response plans
5) Training and testing
6) Key actions, equipment and facilities that respond to a major accident

8.3.6.2 Emergency Response Model and Overall Structure

The Incident Management Team (IMT), Business Support Team (BST) and the Executive Support Team (EST) form the three escalation tiers of BP's Crisis Management Response System.

The system is designed to handle all manner of incidents up to and including worst-case situations. Standard processes and well-trained people can be mobilised quickly and start managing priorities. Thereafter the response organisation can be modified to suit the particular incident.

BP entities and business units, including projects and operating assets are accountable for ensuring that plans and effective resources are in place throughout their organisation to mobilise the first two tiers of response (the IMT and BST). Since they are unlikely to have all the resources to handle a worst-case incident, they may require assistance from other parts of the organisation. Such a system helps ensure that an integrated response effort within BP is quickly and effectively implemented at the onset of an incident or crisis.

In the case of an emergency, the Project will deploy an IMT located in dual locations; in-country, with a small, core team, supported by a larger IMT based in London, UK. All IMTs base their response structure and processes on the Incident Command System (ICS).

Support to the in-country IMT may be provided via the Country Support Team (CST - also based in-country). Support may also be provided by resources beyond the region, particularly the Mutual Response Team (MRT). The MRT comprises approximately 100 experienced IMT responders, based in entities around the BP world who are trained and ready to support an incident in any region. For business continuity and other business issues there is a region BST based in London, UK, plus support from the EST in BP Head Quarters should the situation require.

The emergency response organisational structure is illustrated by Figure 8-88.

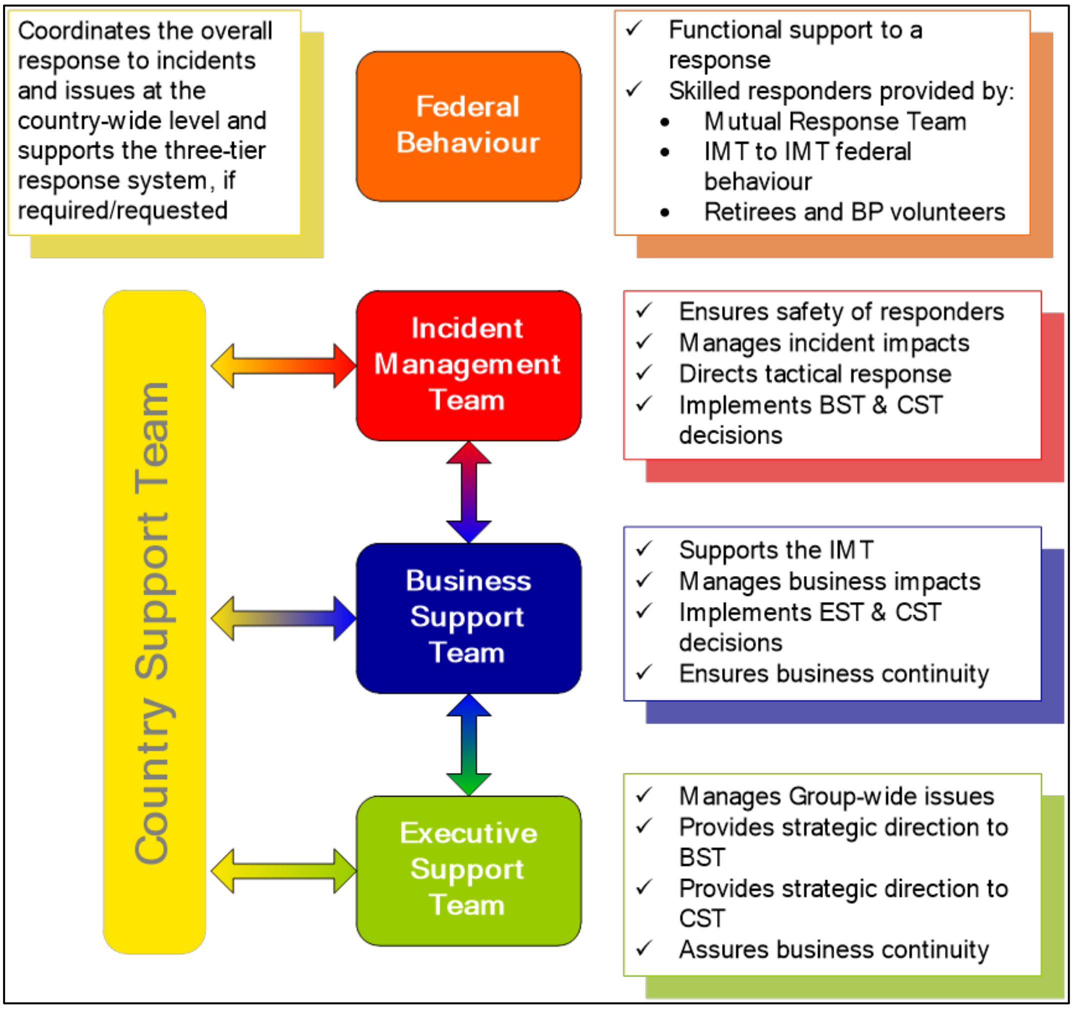


Figure 8-88. Emergency Response Organisational Structure.

The IMT organisation is dependent upon the scale of the incident and is designed to be expanded or reduced, as needed, depending on the type, complexity, and duration of the emergency. In general, any emergency will first entail the mobilisation of the command staff and then the allocation of the duties to necessary personnel, who will then gather the support units that are necessary to meet the requirements of the response.

A typical IMT organisation for a large-scale response is illustrated by Figure 8-89.

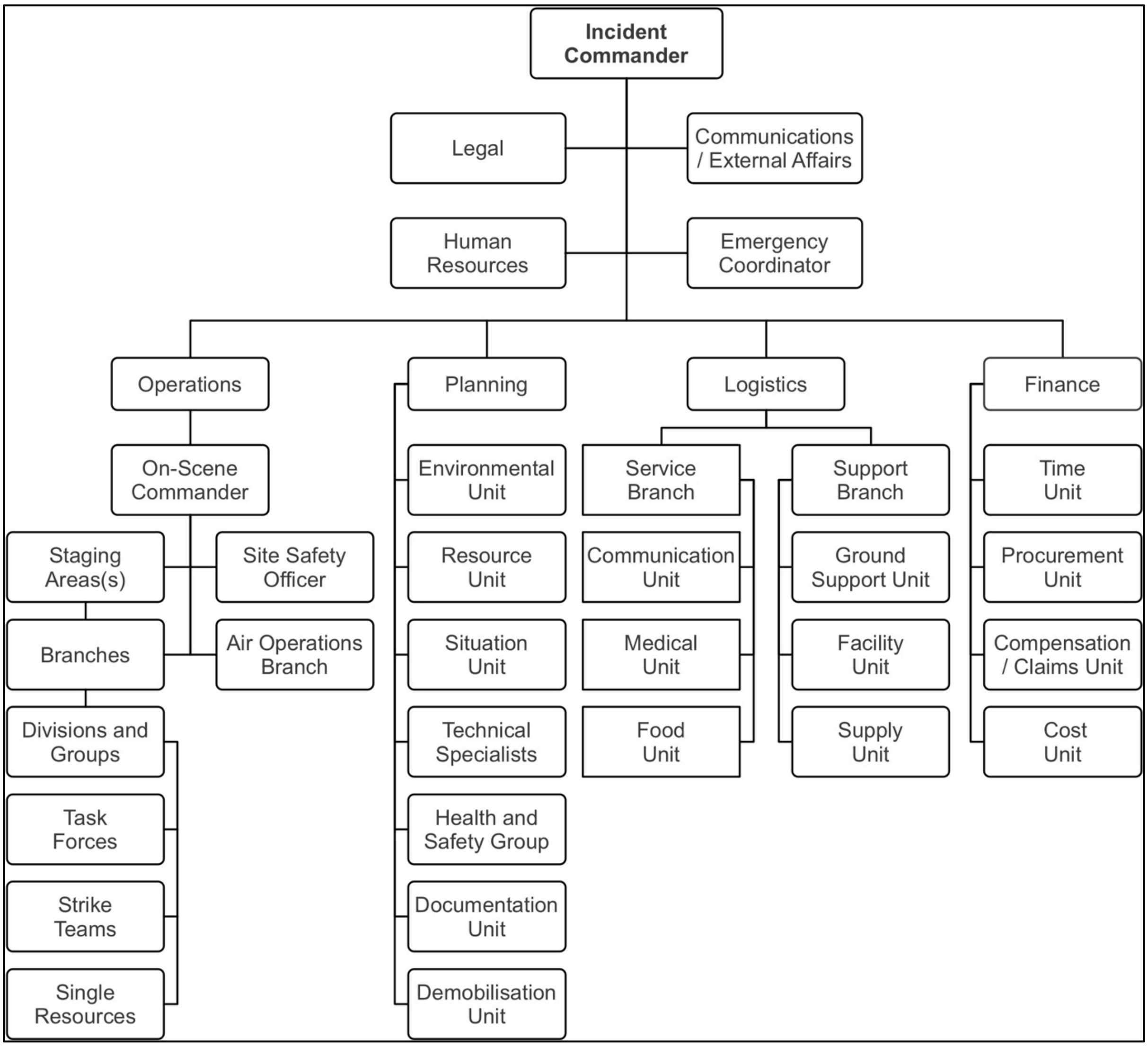


Figure 8-89. IMT Organisational Structure.

8.3.6.3 Key Roles and Responsibilities

Roles and responsibilities are defined for all personnel who perform a response function in the event of an emergency. Key roles and responsibilities are summarised for:

- The Incident Management Team (IMT)
- The Business Support Team (BST)
- The Country Support Team (CST)
- The Executive Support Team (EST)
- The Mutual Response Team (MRT)

8.3.6.3.1 The Incident Management Team

The IMT is responsible for conducting and providing direct support of the field response to resolve the incident. The actual "on-scene" response and the direct support of the Tactical Response Team (TRT), if activated, is the IMT's responsibility. Regardless of the size, its structure is defined by the ICS. An Incident Commander leads the IMT.

Off-scene, the IMT facilitates planning and supports on-scene response efforts. Roles and responsibilities include:

- Providing direction to emergency response operations.
- Supporting the on-scene IMT.
- Keeping the BST and CST informed of the status of the emergency, the deployment of equipment to the response site, and all required support.

At the location of the emergency / incident, the On-scene Coordinator is responsible for managing emergency response team actions and will liaise with the off-scene IMT. All facilities (the drillship, FPSO, Near Shore Hub/Terminal and Supply Base) have designated On-scene Coordinators. For the offshore facilities, this is typically the Offshore Installation Manager (OIM). Roles and responsibilities for the On-scene Coordinator include:

- Assembling and ensuring the orderly evacuation of personnel, making sure that all are accounted for.
- Ensuring first aid is provided to injured personnel, and preparing them for medical evacuation
- Managing the incident.
- Deploying tactical tools for controlling the emergency or bringing it to a conclusion.
- Keeping the off-scene IMT informed of the status of the emergency, the deployment of equipment to the response site, and all required support.

8.3.6.3.2 The Business Support Team

The BST has four basic responsibilities:

- Provide support to the IMT.
- Address issues that are related to the incident, but fall outside the IMT's responsibility.
- Manage business impacts, including business continuity.
- Implement decisions made by the Executive Support Team and/or Country Support Team.

Because of the nature of its work, the size of the BST is small in comparison to a typical IMT. An entity leader or designee usually performs the role of the BST Leader.

It is important to note that the BST does not give response direction to the IMT. However, it is the responsibility of the BST Leader to confirm the qualifications of the Incident Commander for leading the IMT, and if appropriate to designate a better qualified Incident Commander.

In the event of an incident impacting more than one business, it is important that one of the businesses forms the lead BST with the responsibility for supporting the IMT. The lead BST will act as a filter of and conduit for information with the IMT, other affected BSTs, and the wider BP.

A BST will normally provide notification of its activation to the BP Group Crisis and Continuity Management Team and, if appropriate to the incident, situation updates.

8.3.6.3.3 Country Support Team

The CST is responsible for coordinating the overall response to incidents and issues at the country-wide level.

The Head of Country coordinates the in-country response effort and leads the CST consisting of relevant Segment and Function representatives. The Head of Country may also activate in-country and Group resources (for example, MRTs) to assist with IMT level response, and utilise support from the appropriate BP Crisis and Continuity Management Team

An in-country response may involve one or several IMTs and BSTs addressing one or more incidents simultaneously.

Where an incident has the potential to impact several countries and which requires greater co-ordination, a Senior Executive (SE) has the option to form an EST, with representation appropriate to the incident. The Lead SE may lead the team themselves or delegate responsibility to an appropriate Segment or Function senior leader. The Lead SE may select a Head of Country (HoC) from one of the impacted countries to take the lead using the resources of their own CST.

8.3.6.3.4 The Executive Support Team

The EST has direct responsibility for managing any issues arising from the incident that could have Group-wide implications. These high-level concerns include the protection of the Group's reputation, operability, viability and earning power.

The team generally comprises the senior executive from each segment and function.

The EST does not give tactical commands to the IMT or the BST. However, strategic actions that are decided by the EST are implemented at the BST and/or CST Level.

8.3.6.3.5 The Mutual Response Team

The MRT is an IMT resource available to all businesses. Most team members are not full time emergency response personnel but they have specialist skills and experience that may benefit the responding IMT.

The resources of the MRT may be utilised to supplement an existing IMT and/or country resources. The MRT is activated by contacting the relevant Crisis and Continuity Management Team member, who will assess the response needs and, if necessary, mobilise the appropriate MRT members.

Once the MRT has been activated, it is the responsibility of the requestor to ensure that the following tasks are carried out:

- Assist in the provision of visas to MRT members (If required).
- Arrange transportation from the airport to the Incident Command Post.
- Arrange logistics for the transportation and storage of any equipment brought by MRT members.
- Arrange accommodation for MRT members.
- Brief the MRT members of the incident events prior to integration of the teams.

8.3.6.3.6 Crisis and Continuity Management Team

The role of Crisis and Continuity Management Team is to be an authority within the company with a focus on strategy, standardisation, tools, procedures and the monitoring of any risks which are material at Group level.

The Crisis and Continuity Management Team provides an independent view of crisis and continuity risk related to any incident.

Limited direct support is provided including support to the EST Team, limited support to Country Leadership, and management of the MRT. Activation of the MRT is made through contact with the relevant central Crisis and Continuity Management Team member.

The Crisis and Continuity Management Team also coordinates the Group Crisis Travel network, supporting the business in tracking and accounting for the safety of travellers.

8.3.6.4 Unified Command

Unified Command (UC) may be necessary in a multijurisdictional emergency involving multiple parties including contractors, government agencies, and/or local community leaders. Each of these entities may have different legal, geographic, and/or functional responsibilities for effective coordination, planning, and interaction to effectively manage the response. The goal of the UC is for all organisations to offer management guidelines based on a shared set of goals and strategies, along with a single incident action plan. Each participating organisation will retain its own authority and its own responsibility. Each organisation designates an individual who will assist the leader of the response team in identifying, on a joint basis, the goals, strategies, plans, resource allocations, and priorities, while working together to manage the response. These designated individuals constitute the UC, which manages the incident in accordance with a single collaborative approach that includes the following elements:

- A shared organisational structure, which may include members of different organisations assuming different roles, depending on the situation
- A single incident command centre, located as close as possible to the location of the incident, where the participating members of the UC can gather

The exact composition of the UC structure will depend on the location(s) of the incident (i.e., the geographic jurisdiction(s) and/or organisation(s) involved) and on the type of incident (e.g., the functional resources of the jurisdiction(s) and/or of the organisation(s) that are required for the response).

8.3.6.5 Crisis Management and Emergency Response Plans

BP crisis management and emergency response plans for the GTA Phase 1 Project and operations encompass all emergency responses, including supplemental emergency response plans developed by main contractors, who operate other facilities and undertake operations on behalf of BP.

Given the early stage of the project, these plans are in development. This includes an emergency response strategy that details how all emergency scenarios will be handled, including under who's primacy it will lay, and management of the various interfaces between facilities and stakeholders. The emergency response strategy is the overarching document for emergency response management, and is to be shared with all contractors and stakeholders.

BP crisis management and emergency response plans, along with main contractor supplemental plans, help ensure:

- An effective organisational structure is in place for implementing emergency plans, with good command and control structure for managing any incident
- Appropriate selection criteria are used and assessment is undertaken prior to allocating staff to roles within emergency plans
- Suitable training (and competency assessment) is provided for all those allocated roles in the emergency
- Clear and well-rehearsed plans and procedures are developed and implemented

- Appropriate staffing levels are provided to implement any emergency response during normal working hours, nights, weekends and holidays
- Interfaces between the various responders associated with all aspects of the emergency response are identified and practiced at all levels (on and off-scene), covering all expected scenarios, and using table-top exercises and drills
- Efficient means of information handling during the emergency and good critical communication arrangements are provided

BP's emergency response plans describe the entire incident command structure and BP's overarching emergency preparedness and response requirements. These plans provide a systematic, proactive, and flexible approach for responding to all emergencies.

Plans are designed to be flexible and adaptable to any situation, including local emergencies, situations that require the activation of international resources, and emergencies that require a combined response by BP, its partners, contractors, government agencies, and third-party responders.

Minor incidents and accidents will be managed locally, using local personnel and the resources of the IMT in-country. For more serious incidents, a larger response organisation may be required.

Each facility under the command of a Person In Charge (PIC) has its own emergency response plan. This includes all vessels involved in offshore construction and installation. These plans address occupational health and safety incidents as well as major accidents. Further, they address potential interfaces and interactions with different development facilities and stakeholders.

The assessment of hazards and risks, undertaken as an integral part of the design process for the GTA Phase 1 Project, including this Risk Study and Occupational Risk Assessment, provides input into emergency scenarios and their responses.

BP emergency response plans include:

- Overall development emergency response strategy
- FPSO emergency response plan, including interface with the condensate offtake tanker
- FPSO SOPEP
- Near Shore Hub/Terminal and associated facilities emergency response plan, including interface with the FLNG and LNGC
- FLNG emergency response plan
- FLNG SOPEP
- Onshore and offshore medical emergency plans
- Blowout cap and containment response plans, including a Source Control Emergency Response Plan (SCERP)
- Oil spill contingency plan (OSCP)
- Epidemic/pandemic emergency plan

BP emergency response plans will interface with third party contractor plans wherever relevant, to help ensure that all emergencies, including those on third party facilities, or which result in inter-facility impacts, are appropriately managed. Third party contractor emergency plans include:

- Offshore construction and installation emergency response plans
- LNGC emergency response plan

- LNGC SOPEP
- Condensate offtake tanker emergency response plan
- Condensate offtake tanker SOPEP
- Drillship emergency response plan
- Drillship SOPEP
- Support vessel and crew boat emergency response plans
- Support vessel and crew boat SOPEPs
- Aviation (helicopter) emergency response plans

Security plans will also be developed to assist the BP and facilities security officers, the PIC, and the crew to help ensure the safety and security of the facilities and their cargos. The plans provide guidelines and procedures to prevent and manage security incidents including:

- Unauthorized access to facilities and restricted access areas
- Piracy, in port or at sea
- Introduction of unauthorized weapons or other dangerous devices
- Use of a vessel as a weapon or a means to cause damage or destruction
- Introduction of illegal drugs or other contraband

Additional emergency response plans will be developed, as needed, to meet Mauritania and Senegal regulatory requirements.

8.3.6.6 Training and Testing

Suitable arrangements will be developed and implemented for training individuals on emergency response and ensuring their emergency preparedness. The type of training required depends upon the role of the individual in the event of an emergency but cover personnel with a management response role, as well as other personnel, contractors and visitors.

Training is kept up to date, with suitable refresher training provided. Records are maintained of all training and testing. Participation in the testing of emergency plans is not solely a training exercise and all personnel involved will have had previous training to introduce them to their role in an emergency. The level and objectives of training will differ depending upon the individual, but is specific to their role and responsibilities in responding to the emergency.

In addition to training, emergency preparedness is evaluated and practiced though testing. Objectives of testing are to help ensure:

a) Completeness, consistency and accuracy of emergency plans and other documentation used to respond to an emergency

b) Adequacy of the equipment and facilities, and their operability, especially under emergency conditions

c) Competence of personnel to carry out the duties identified for them in the relevant plans, and their use of the equipment and facilities

d) The overall testing regime includes the following aspects of emergency response:

e) Activating emergency plans and notifying participants, including sounding alarms and mobilising facility personnel with a role to play in the event of an emergency

f) Establishing the on-site emergency control centre (ECC) from where the on-scene response to the emergency is directed and coordinated within a suitable time. This may include considering the ability to establish an alternative on-scene ECC in some tests, to demonstrate the ability to operate when the designated on-scene ECC is untenable

g) Information from involved parties is supplied promptly and accurately, so that those at the centre have access to an up-to-date picture of the emergency and the response to it, and from which they can base their decision-making

h) The ability of involved parties to work together, using the available information, to develop the response to the emergency

i) Information on the emergency, and the response to it, is passed to all participating organisations and as appropriate, to the media

j) Equipment identified as having a role in the response to an emergency is operational, and that involved parties are competent and able to use it.

Testing is based on facility specific accident scenarios identified in hazard identification and risk assessment. Tests generally address the response during the initial emergency phase, which is usually the first few hours after the incident occurs. Periodic testing also combines on-site and off-site emergency plans (or parts of plans) at the same time to verify they work effectively together.

Testing is also evaluated for ‘lessons learned’. This is used to determine whether modifications are required to improve emergency response plans and overall preparedness.

The different exercises used to test on-scene and off-scene emergency plans and response are summarised in Table 8-41.

Table 8-41. Emergency Response Exercises.

Type	Description	Typical Frequency
Drills	Involves testing a specific and relatively simple aspect of the emergency plan in isolation. Examples are: fire drills; alarm testing; evacuation; roll call and searching; cascade telephone calls; spillage control and recovery. These drills undertaken on the facilities at intervals typically ranging from weekly to monthly	Weekly to monthly
Seminar exercises	Involves training staff and developing emergency plans. They facilitate discussion about the different organisations’ responses during an emergency	Initial plan development then annually
Walk-through exercises	Involves training staff or developing emergency plans. The emergency response is ‘walked through’, including visiting appropriate facilities such as emergency command	Initial plan development then annually
Table-top exercises	Involves allowing information exchange and dissemination between organisations, together with decision making, to be tested. They are carried out in relation to a model, plans or photographs to depict the establishment. They could involve using information technology or virtual reality systems	Prior to start up then annually

8.3.6.7 Response to a Major Spill

Spill risks have been identified and are included in the design requirements for all facilities, and for verification of all vessels operating in the field. GTA Phase 1 Project well fluids are primarily gas with associated condensate. Major spill risks are identified as a blowout during drilling operations, large condensate release from the FPSO, or large diesel release at the Near Shore Hub/Terminal.

The following emergency response plans deal with major spills:

- The BP blowout cap and containment response plans (BP. 2016b) under which a regional plan will be developed, including a SCERP
- Oil spill contingency plans

To control the source of a blowout, BP will utilise:

1) The Containment Response System (CRS) response team. The CRS is an internal BP organisation who can supply equipment and services, including capping stacks, ROV survey and tooling, and debris removal equipment

2) Oil Spill Response Limited (OSRL). BP is an associate member of OSRL which is a globally recognized organisation for intervention in the event of oil spills. OSRL can supply equipment and services including capping and containment equipment, ROV survey, debris removal equipment, and dispersant equipment including underwater application

To respond to an oil spill, BP also has an OSCP. This plan complies with the requirements of the 1992 International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC).

The OSCP consists of three levels of intervention in the event of accidental offshore spills. It includes the necessary resources and measures that are required for the management of Tier 1, 2, and 3 spills, as well as for the management of all environmental impacts, including potential effects on the Mauritanian and Senegalese coasts, and neighboring coasts.

The various tiers of intervention are described in Figure 8-90.

TIER 1	TIER 2	TIER 3
• Site response necessary • Small spill affecting a limited area • Spill remains visible in the immediate vicinity of the site • Low environmental impact • Spill easily handled with the resources available on site • Spill source controlled and secured • Little media attention	• Regional and national response necessary • Spill extends beyond the immediate vicinity of the site • Tier 1 response means exhausted such that other regional and national response means required • Potential impact on sensitive areas or local communities • Local and national media attention	• National and international response necessary • Blowout or loss of well control • Spill has cross offshore boarders • Tier 1 and 2 response means exhausted such that other national and international response means required • Significant impact on sensitive areas or local communities • International media attention

Figure 8-90. Oil Spill Response Tiers.

A Tier 1 response involves monitoring the spill and performing one or more localized interventions, using spill kits (as required by Shipboard Oil Pollution Emergency Plans SOPEP) as well as a set of intervention equipment for use in case of a spill. The dispersants and the dispersant-spraying devices will be located onboard support vessels. Additional intervention equipment will be stored in a warehouse at the supply base(s), or if necessary, at various strategic locations.

All vessel and facilities are subject to strict spill prevention measures, as described in the vessel SOPEP documents. The SOPEP documents and the BP OSCP will be tested and exercised prior to the start of operations. Any, and all incidents involving spills of oil into the water will be reported to BP and to Mauritanian and Senegalese authorities as required.

With the consent of the Mauritanian and Senegalese authorities, BP will establish a Tier 1 capacity to cover scenarios involving offshore, in-port, and coastal spills. This would include dispersant, the use of which would require the consent of the national authorities prior to its application.

BP also has a set of logistical resources for a Tier 2 response. Any Tier 2 response will take place with the consent of, and with coordination by, the Mauritanian and Senegalese authorities in charge of marine pollution response plans: the Merchant Navy Directorat (*Direction de la Marine Marchande*) in Mauritania and the High Authority for the Coordination of Maritime Safety and the Protection of the Marine Environment (*Haute Autorité Chargée de la Coordination de la Sécurité Maritime et de la Protection de l'Environnement Marin*) (HASSMAR) in Senegal.

In the highly unlikely event of a scenario that requires a Tier 3 response, international resources will be activated. OSRL (and CRS response team for well control related incidents/accidents) will assist in the event of a major spill, providing Tier 3 response equipment and expert consultation. OSRL may also provide aerial surveillance aircraft and aerial chemical treatment by means of dispersants, while also offering a broad inventory of intervention equipment for combating oil spills. OSRL also has access to additional support provided by companies that are members of the global response network.

BP has access to OSRL and CRS Tier 3 inventory, to its technical consultation, and to the response team, 24 hours a day and 7 days a week. This includes aerial operations for spraying Tier 3 dispersant, and additional offshore and onshore equipment, all of which can be mobilised in a matter of days.

Any Tier 3 responses will take place in coordination with, and subject to the consent of, the Mauritanian and Senegalese authorities.

8.3.6.8 Response to Other Major Accidents

Other major accidents typically involve fires, explosions and/or major damage to facilities. General philosophy and actions in response to these major accidents involves:

- Incident awareness i.e., initiating and responding to an alarm
- Escaping from the immediate work area
- Mustering in a place of safe temporary refuge
- Assessing the situation and deciding on the appropriate emergency response actions
- Where necessary, evacuating the facility

While the specifics of each major accident may be very different, the general philosophy and actions are consistent and summarised further in Table 8-42. For these actions to be undertaken effectively, incident awareness, escape, temporary refuge and evacuation facilities are provided on all facilities, along with rescue and recovery support for personnel in the sea, as described in Section 8.3.5.6.

Table 8-42. General Actions and Response.

Phase	Description
Incident Awareness	The initial warning of an incident will be given. Alarms and announcements will usually direct personnel to go to their primary safe muster area.
Escape	Once personnel are alerted to the emergency, they make their workplace safe and make their way to their primary safe muster area, via designated escape (egress) routes. In the event personnel cannot muster to their primary safe muster area, they will make their way to an alternate safe muster area.
Safe Muster	Once personnel arrive at their primary or alternate safe muster area, a roll call is carried out to help ensure all personnel are accounted for.
Assess	From the initial alarm, the On-Scene Commander (PIC), along with the on-scene IMT leaders, assimilate all information on the extent and severity of the event. The PIC is then responsible for making decisions as to what course of action to take. If safe to do so, emergency response teams may be required to don appropriate protective clothing including breathing apparatus, locate and recover missing/injured persons. Emergency response firefighting teams may also be deployed. However, this is only the case if the fire is clearly controllable, and it is safe to do so. If the event is brought under control, then no further emergency response action may be necessary. If the event cannot be brought under control, the PIC will make the decision to evacuate the facility. The order to evacuate will only be taken after due consideration of all the facts. Evacuation itself has inherent risks and the PIC will take time to help ensure they understand the scale of the event before making the decision to evacuate. Primary safe muster areas are designed to withstand the effects of anticipated major accident events for sufficient time for the PIC to make the decision to evacuate and for evacuation to be undertaken in a safe and controlled manner.
Evacuate	For the drillship, Helicopter is the preferred evacuation method. If helicopter is not available, then a support vessel is utilised. For the FPSO and Near Shore Hub/Terminal, crew boat is the preferred evacuation method. However, during an emergency evacuation, helicopter, supply vessels or crew boats may not be available in time, or may be prevented by the event from being an evacuation method. In such cases, the primary means of evacuation is by lifeboat (total enclosed motor propelled safety craft –TEMPSC).

8.4 Occupational Risk Assessment

8.4.1 Introduction

Section 8.4 of the Risk Study and Occupational Risk Assessment details the assessment of occupational hazards and risks (i.e., the Occupational Risk Assessment). Occupational hazards comprise:

- Personal safety hazards
- Materials and substances potentially hazardous to the person that are used and handled, but that do not have the potential to result in a major accident event
- Hazards with the potential for injury, illness and/or limited localised fatality
- Workplaces and work activities addressed as part of the Occupational Risk Assessment comprise:
- The drillship; the FPSO; the Near Shore Hub/Terminal and associated facilities; support vessels; the supply bases; and offshore construction and installation vessels and other facilities
- Normal drilling and production operations, including all support and ancillary activities; inspection, testing and maintenance; and Offshore construction and installation, including diving

The assessment of occupational hazards and risks comprises three main parts:

1) Identification of occupational hazards
2) Occupational risk analysis
3) Review of the measures taken to manage occupational hazards and risks, including response in the event of illness or injury

8.4.2 Identification of Occupational Hazards

A thorough and systematic approach to hazard identification forms the basis for the assessment of GTA Phase 1 Project occupational hazards and risks. The hazard identification section of the Occupational Risk Assessment addresses the process by which hazards are identified and associated accident events defined. It comprised the following key aspects:

1) Review and summary of occupational hazards based on:
    - Facilities environment, design and operational aspects
    - The Ensco DS-12 HSE Case (Atwood Oceanics. 2016)
    - Hazards identified during project specific hazard identification workshops. These workshops comprised multidiscipline teams of personnel familiar with the facilities design and operation workshops (BP, KBR. 2017a), (BP, KBR. 2017b), (KBR. 2016).
    - Hazards from other similar facilities
2) Occupational related hazard categories and checklists adopted from ISO 17776: Major Accident Hazard Management During the Design of New Offshore Installations (ISO. 2016), with the development of a Hazard Register (Goddard. 2018b) and documentation of occupational hazards.

8.4.2.1 Review and Summary of Occupational Hazards

Review of GTA Phase 1 Project facilities, their operating environment, and specific production and support operations was undertaken to understand and document relevant occupational hazards. Relevant hazards were documented with consideration to the surrounding environment, the facilities and their operations, as summarised in Table 8-43.

Table 8-43. Occupational Hazards: Relevant Environment, Facilities and Operations.

Hazards Relating to		Occupational Hazard	Major Hazard
The Environment and Surrounding Conditions (Section 8.4.2.1.1)	Ocean Currents		(See Sect. 8.3)
	Waves and Swells	X	(See Sect. 8.3)
	Winds and Severe Weather	X	(See Sect. 8.3)
	Lightning	X	(See Sect. 8.3)
	Rainfall or Fog	X	(See Sect. 8.3)
	Earthquakes		(See Sect. 8.3)
	Air Traffic Activity (Excluding Facility Helicopter Operations		(See Sect. 8.3)
	Marine Traffic Activity		(See Sect. 8.3)
	Security		(See Sect. 8.3)
Offshore Oil and Gas Production (General) (Section 8.4.2.1.2)	Process Hydrocarbons		(See Sect. 8.3)
	Support Vessels	X	(See Sect. 8.3)
	Stability		(See Sect. 8.3)
	Structural Integrity		(See Sect. 8.3)
	Crew Transportation	X	(See Sect. 8.3)
	Materials Handling and Lifting	X	(See Sect. 8.3)
	Accommodation Spaces	X	(See Sect. 8.3)
	Diesel Fuel Transfer and Storage		(See Sect. 8.3)
	Engine Rooms, Machinery Spaces and Utilities Areas	X	(See Sect. 8.3)
	Chemical Injection		(See Sect. 8.3)
	Compressed Gases	X	
	Hydrogen Sulphide (and Hydrogen Sulphide	X	(See Sect. 8.3)
	Inspection, Testing and Maintenance	X	(See Sect. 8.3)
	Offshore Construction and Installation	X	
Drillship Drilling Operations (Section 8.4.2.1.3)	Use of Explosives		(See Sect. 8.3)
	Well Control		(See Sect. 8.3)
	Mud Returns and Processing		(See Sect. 8.3)
	Well Testing or Clean-up		(See Sect. 8.3)
	Operational Baskets	X	
	Helicopter Refuelling		(See Sect. 8.3)
	Drilling Equipment Handling and Lifting	X	
	Simultaneous Operations		(See Sect. 8.3)
FPSO Hydrocarbon Processing	Subsea Production Facilities, Risers and Pipeline		(See Sect. 8.3)
	Processing		(See Sect. 8.3)
	Condensate Storage		(See Sect. 8.3)
	Condensate Offloading		(See Sect. 8.3)

<table>
<tr><th colspan="2">Hazards Relating to</th><th>Occupational Hazard</th><th>Major Hazard</th></tr>
<tr><td rowspan="4">Near Shore Hub/Terminal LNG Processing
(Section 8.4.2.1.4)</td><td>Feed Gas Pipeline and Riser</td><td></td><td>(See Sect. 8.3)</td></tr>
<tr><td>LNG Processing</td><td rowspan="3">X</td><td>(See Sect. 8.3)</td></tr>
<tr><td>LNG Storage</td><td>(See Sect. 8.3)</td></tr>
<tr><td>LNG Offloading</td><td>(See Sect. 8.3)</td></tr>
<tr><td colspan="2">The Supply Bases (Section 8.4.2.1.5)</td><td>X</td><td></td></tr>
<tr><td colspan="2">Product Used, Stored or Produced (Section 8.4.2.1.6)</td><td>X</td><td>(See Sect. 8.3)</td></tr>
<tr><td colspan="4">Note: ‘X’ denotes an occupational hazard present for the category</td></tr>
</table>

8.4.2.1.1 Hazards Relating to the Environment and Surrounding Conditions

8.4.2.1.1.1 Waves and Swells

Waves and swells (the peak swell period is December-April) may present a hazard for marine activities, with excessive waves and swells also having the potential to result in an increased risk associated with other operations or hazards. These include:

- Lifting and materials handling operations
- Crew boat transfer operations
- Support vessel operations
- Slips, trips and falls
- Sea sickness

The Near Shore Hub/Terminal breakwater is designed to help ensure wave, and swell conditions have minimal impact on hub related operations. Weather is continually monitored and where safe operating limits may be exceeded, at risk work is halted.

8.4.2.1.1.2 Winds and Severe Weather

Maritime trade winds, trade winds (or harmattan), winds of the Intertropical Convergence Zone (ITCZ) and/or cyclones of nontropical origin may bring wind and severe weather. Winds and severe weather can cause waves and swells as discussed in the previous section. At risk work has clearly defined safe operating limits for winds and severe weather. Lightning and rainfall/fog are discussed below.

8.4.2.1.1.3 Lightning

Lightning presents several risks. In terms of occupational health and safety, it may strike persons outside and exposed.

Risks associated with lightning strikes are managed through clearly defined safe operating limits for severe weather. Weather is continually monitored and where lightning may be expected, at risk work are halted.

8.4.2.1.1.4 Rainfall or Fog

Heavy rainfall or fog may result in a reduction in visibility, with an increased risk associated with other operations and hazards, including:

- Lifting and materials handling operations
- Crew boat transfer operations

- Support vessel operations
- Slips, trips and falls
- Working at heights or over water

Risks associated with poor visibility are managed through clearly defined safe operating limits. Weather is continually monitored and where safe operating limits may be exceeded, at risk work is halted.

8.4.2.1.2 Hazards Relating to Offshore Oil and Gas Production

8.4.2.1.2.1 Support Vessels

Several vessels assist with, and attend to the offshore operations. These include supply vessels, guard vessels, mooring line vessels, and tugs to assist with LNGC berthing and fast crew boats. Support vessel operations may contain several occupational health and safety related hazards. These include:

- Man overboard
- Falls/crushing during transfer
- Hazards relating to accommodation spaces
- Hazards relating to engine rooms and machinery spaces

Hazards associated with the above are discussed in subsequent sections.

In addition, tugs and tow lines are used to assist the LNGC with berthing. A parted tow line has the potential to impact a person on deck resulting in fatality.

Support vessel risks are managed through various safeguards and controls including inspections and maintenance to help ensure seaworthiness of vessels; crew training and competence assurance; navigation aids and weather forecasting; and safe operating procedures including LNGC berthing, clearly defined environmental limits, and use of appropriate lifesaving facilities and appliances.

8.4.2.1.2.2 Crew Transportation

Fast crew boats are used to transfer personnel from the supply base to the FPSO and Near Shore Hub/Terminal. Boats have capacity to carry up to 25 passengers and four crew.

Crew boat accidents may occur during transit between facilities or during transfer (embarkation/disembarkation). Occupational accidents include man overboard, or fall/slip during transfer with the potential for crushing between the vessel and its berth. Personnel may also experience sea sickness.

Crew boat transportation risks are managed through various safeguards and controls including inspection, and maintenance to help ensure seaworthiness of vessels; compliance with recognised marine standards and codes of practice; crew and passenger training and competency; navigation aids and weather forecasting; and safe operating procedures including environmental limits and use of appropriate lifesaving appliances. Main boat landing areas are also provided with articulated gangways and non-slip coatings to facilitate safe transfer.

8.4.2.1.2.3 Materials Handling and Lifting

Numerous materials handling and lifting operations take place offshore. Hazards relevant to all facilities involve use of main cranes for loading and unloading supplies and equipment, and moving deck loads. Cranes are located on the drillship, FPSO, FLNG and QU Platform. With significant lifting activity, there is the potential for dropped objects, and fatality due to direct impact to personnel.

Material handling and lifting risks are managed through various safeguards and controls including inspection and testing of lifting equipment; dedicated lifting and laydown areas; training and competency of crew; cargo manifest verification; and safe operating procedures including environmental limits.

8.4.2.1.2.4 Accommodation Spaces

Accommodation units contain various materials that present a fire risk including cellulose-based materials (e.g. paper, fabrics, etc.), plastics, cooking fats and oils, laundry and electrical equipment. Certain types of fire in accommodations (e.g. small fires involving from paper, fabrics, plastics, and galley cooking oils) may present a risk of burns, or respiratory issues due to smoke inhalation.

Accommodation fires are typically very localized, quickly detected with accommodation smoke and fire detection systems, and easily controlled using hand held extinguishers. Hose reels and firewater are also provided in the accommodation spaces.

8.4.2.1.2.5 Engine Rooms, Machinery Spaces and Utilities Areas

Engine room, machinery spaces and utility areas may contain several occupational health and safety related hazards. These include:

- Exhaust fumes from engines
- Excessive heat and humidity
- Hot surfaces such as engines and exhausts
- High noise
- Dust and debris

Occupational health and safety risks associated with engine room, machinery spaces and utility areas are managed through various safeguards and controls including ventilation and air conditioning of spaces; lagging and guarding of hot surfaces; crew training and competence; and use of appropriate personal protective equipment including hearing and eye protection.

8.4.2.1.2.6 Compressed Gases

This section covers specifically the physical hazards related to the high pressure accumulated in compressed gas systems. The other hazards related to the chemical nature of the gas (flammable, toxic, corrosive, asphyxiant, etc.) are discussed in Section 8.4.2.1.6.

Compressed gases are present in storage gas cylinders and distribution lines. In addition, the drillship, FLNG and FPSO are equipped with compressed air systems comprising compressors, filters/dryers, air receivers/storage tanks and distribution piping. Compressed air systems provide air for instrument control (e.g. control and emergency shutdown valves) and utility services (e.g. starting air, pneumatic pumps, pneumatic hand tool).

At high pressure, a jet of compressed gas (even compressed air or nitrogen) can result in serious injury upon direct impact on any part of the body. Compressed gas cylinders may also present a projectile hazard if an unsecured cylinder is knocked over and the cylinder valve breaks.

Risk associated with compressed gases are managed though safe storage and handling procedures, including protective caps, and use of stands specifically designed to avoid any risk of the cylinders' being dropped; inspection, testing and maintenance of gas cylinders; and use of appropriate personal protective equipment, including safety glasses.

8.4.2.1.2.7 Confined Space Entry

Entry into confined spaces present a risk of asphyxiation (low oxygen) or poisoning from toxic gas.

H_2S is highly toxic and can result in fatality at a very low concentration. A single breath that is contaminated by 1,000 parts per million (ppm) can induce a coma. Continued exposure to this concentration, or to an even weaker concentration (on the order of 200 ppm) quickly leads to death.

H_2S may form in stagnant pools of water in confined spaces such as bilges or tanks, where sulphate-reducing bacteria (SRB) obtain energy by oxidizing organic compounds or molecular hydrogen, while reducing sulphate to H_2S.

Risks associated with confined space entry are managed through the safe entry procedures including gas testing and purging; use appropriate personnel protective equipment such as breathing apparatus and gas monitors; and crew training and competence.

8.4.2.1.2.8 Construction, Installation and Decommissioning

There are a significant number of occupational health and safety related hazards associated with offshore construction and installation. Main hazards, along with offshore construction and installation activities are summarised in Table 8-44.

Table 8-44. Summary of Offshore Construction and installation Main Activities and Hazards.

Facility	Main Activity	Main Hazards
Subsea	FPSO mooring system installation	Lifting, including heavy lifts; welding, cutting, grinding etc.; working at heights; work over the side
	Production manifold with pile installation	
	PLEM installation	
	Other subsea infrastructure installation including distribution units, flexible jumpers, umbilicals, fibre optic cables; flexible risers	
	18” production pipeline installation	
	30” export gas pipeline installation	
	6” MEG pipeline installation	
	MEG distribution manifold installation	
Near Shore Hub/Terminal	Rock dumping	Lifting, including heavy lifts; welding, cutting, grinding etc.; working at heights; work over the side; diving
	Armour placement	
	Jetty trestle construction	
	Trestle topsides installation	
	QU platform jacket installation	
	QU platform deck installation	
	QU platform bridge installation	
	Hook-up and commissioning	Purging and leak testing
FPSO and FLNG	Tow	Tow line failure, collision
	Mooring hook-up	Anchor/mooring line failure; welding, cutting, grinding etc.; work over the side
	Hook up and commissioning	Welding, cutting, hot work, work at heights, work using ladders for access, diving (Near Shore Hub/Terminal); pressure testing; electrical work; purging and leak testing

These hazards may potential result in various incidents and accidents including:

- Impacts from dropped objects
- Pressure testing leaks

- Electrocution
- Falls from heights
- Personnel injuries associated with burns, welding fumes, asphyxiation etc.
- Personnel injuries from hand tools

Hazards associated with decommissioning are generally the same to those associated with offshore construction and installation.

Risks associated with offshore construction and installation are managed through a wide range of safeguards and controls, including HSSE planning; control of work procedures; installation and construction specific activities hazard identification and risk assessment; and development and implementation of safe work practices and procedures.

8.4.2.1.2.9 Inspection, Testing and Maintenance

There are a significant number of occupational health and safety related hazards associated with inspection, testing and maintenance. This may include new or uncommon hazards, arising due to the infrequent nature of the activity.

Main inspection, testing and maintenance activities and hazards that could lead to personnel injury and/or fatality are summarized in Table 8-45.

Table 8-45. Summary of Inspection, Testing and Maintenance Main Activities and Hazards.

Inspection, Testing and Maintenance Activity	Main Hazards
Hot Work	Welding, cutting, grinding
Pressurised Equipment	Pressure testing, pipeline pigging, purging and leak testing
Equipment Under Tension/Compression	Spring loaded devices, relief valves and actuations, hydraulically operated systems, vessel moorings or tie-offs
Use of Chemicals/Hazardous Materials	Toxic fluids and solids, paint, corrosives
Working at Height	Elevated work platforms, temporary platforms including scaffolding, ladder use, work over water
Diving Operations	Lack of oxygen; lifting with diving ongoing; vessel movements with divers in the water
Lifting	Lifting of tools and equipment; manual material handling and use of lifts/elevators, man-riding equipment
Confined Space Entry	Tank or vessel entry, asphyxiation, gaseous firefighting system flooding, working at height in large tanks
Electricity	Inappropriate isolation, lack of grounding, electrical faults

Due to the non-routine nature of some inspection, testing and maintenance activities, along with the locations where the work is carried out, as part of control of work procedures, each activity is reviewed and risk assessed prior to commencing the work to help ensure that required safeguards are implemented as necessary. Other safeguards and controls include the control of work procedures, including the permit to work system; use of appropriate personal protective equipment; and crew training and competence.

8.4.2.1.3 Hazards Relating to Drillship Operations

8.4.2.1.3.1 Operational Baskets

Personnel baskets are used onboard the drillship and include work baskets, hydraulic access baskets and transfer baskets (e.g. Billy Pugh). Transfer baskets may be used as a means of transferring personnel in emergencies only.

Catastrophic equipment failure during lifting could result in fatality. Personnel could be dropped, or could fall, onto the rig, into the water or onto a boat – with associated risk of impact injuries and/or drowning.

Risks associated with personnel basket transfer are managed through various safeguards and controls including regular inspection, testing and maintenance of equipment including visual examinations prior to use. Personnel are trained and competent in the safe use of the equipment and appropriate personal protective equipment (PPE) is worn. Communication are also maintained during transfers to alert operators immediately in case of potential problems and issues. Operations are restricted during adverse weather or poor sea states as defined by safe operating limits.

8.4.2.1.3.2 Drilling Equipment Handling and Lifting

Heavy "tubulars" (tubular-shape materials), required for drilling and well construction, are stored in dedicated racks on the drillship, from where they are hoisted into the derrick, as and when required, for assembly and lowering down-hole. Handling and lifting operations include:

- Lifting the BOP, marine riser, and LMRP
- Tubular handling with an elevated Catwalk Shuttle System (CWS)
- Drill pipe, casing and tubing stand-building and racking (stand-building involves pre-assembling a "stand" or "length" of 2 to 3 tubulars that will be stored and manipulated later as a single tubular item)

As with other heavy equipment, dropped and swung tubulars have the potential to result in significant damage to equipment and fatality. Collisions of hydraulic rig floor equipment can also lead to heavy dropped objects within the derrick with the potential for severe injury or fatality.

For collision prevention, the drillship is equipped with an automated and remotely operated system for tubular handling, the CWS. This incorporates an anti-collision system with emergency stop buttons provided at easily accessible locations. Additionally, risks associated with dropped objects are managed through various other safeguards and controls including dedicated crane for BOP and marine riser handling; crew training and competence assurance; inspection and maintenance of equipment; and safe lifting plans and procedures.

8.4.2.1.4 Hazards Relating to Near Shore Hub/Terminal LNG Processing

LNG processing involves cooling methane to a cryogenic liquid state (-160ºC) using a refrigerant comprising mainly of methane, ethylene, and propane. Occupational hazards associated with these cryogenic liquids relate to cold burns and asphyxiation.

Cryogenic liquids and their associated cold vapours can produce effects on the skin like a thermal burn, and prolonged exposure can cause frostbite and fatality. Unprotected skin can also stick to materials that are cooled by cryogenic liquids, and breathing of extremely cold air may damage the lungs.

When cryogenic liquids form a gas, this gas is heavier than air and may accumulate near the floor, displacing air. This may result in asphyxiation and fatality.

Risks associated with cryogenic and cold gas release are primarily managed through process system safeguards to prevent loss of containment, including appropriate design; and inspection, testing and maintenance. In addition, containment systems are provided in areas where leaks are considered most likely (e.g. loading arms) to limit the spread of any LNG spill, and associated gas evaporation rates. Cold surfaces associated with cryogenic processing/piping are also insulated.

8.4.2.1.5 Hazards Relating to the Supply Bases

To support offshore operations, supply bases are provided in Dakar and/or Nouakchott within existing port facilities. The main purpose of the supply bases is to:

- Provide short-term transit and cross-over facilities for personnel working at the FPSO and Near Shore Hub/Terminal.
- Store equipment and materials.
- Provide operations and maintenance.

A summary of the supply bases' activities and occupational hazards is provided in Table 8-46.

Table 8-46. Summary of Supply Bases Activities and Hazards.

Activity	Main Hazards
Personnel Transfer – Automobile	Driving to and from the supply bases with facility personnel in transit
Personnel Transfer – Crew Boat	Embarkation/disembarkation (slips, trips and falls), caught between during transfer, man overboard
Storage of Hazardous Materials	Compressed gas cylinders, hazardous chemicals
Lifting	Forklift transfers, dropped object risks during supply boat lifts, manual handling

Risks associated with supply bases' hazards are managed through various safeguards and controls, including control of work procedures; and crew training and competence. In addition, the site is securely fenced, monitored by CCTV, with access/entry control.

8.4.2.1.6 Hazards Relating to Product Handled, Used or Stored

Oil and gas development and production operations involve various hazardous substances and chemical products, in addition to the hydrocarbons produced and exported. Hazards related to the handling, use or storage of products that have the potential to result in a major accident are discussed in Section 8.3. For the purposes of the Occupational Risk Assessment, hazardous materials and substances potentially hazardous to the natural, human, or physical environment that are used and handled, but that do not have the potential to result in a major accident event are considered.

A register of such materials, and substances, along with their specific hazards, is given in Appendix O-1. Table 8-47 presents a summary of the types of hazardous materials used and handled.

Table 8-47. Summary of the Types of Hazardous Materials Used, Stored or Produced.

Icon	Hazard	Description
	Oxidising	Capable of causing an intense fire; strong oxidizer (e.g. welding oxygen)
	Corrosive	Corrosive to metals and can cause severe skin burns and eye damage (e.g. hydrochloric acid, biocide, etc.)
	Explosive	Unstable explosive leading to mass explosion hazard, fire, blast, or projectile hazard (e.g. perforation charges)
	Environmental	Material can cause air/water pollution to the surrounding environment and is toxic to aquatic life (e.g. defoamer, condensate, aerosols, etc.)
	Flammable	Material is easily capable of ignition leading to fire or explosion (e.g. solvents, paints, etc.)
	Compressed Gas	Gas under pressure could lead to high pressure release (e.g. bottled gas, instrument air systems, etc.)
	Health	Material may be fatal if swallowed or enters airway, cause damage to organs or fertility/genetic defects (e.g. sodium hydroxide, drilling fluid additives, mineral based oil, etc.)
	Toxic	Material can be toxic or fatal if contacted with skin, inhaled, or swallowed (e.g. biocide, methanol, etc.)
	Harmful	Material can be an irritant, cause dizziness or cause harm to bodily organs if inhaled or ingested (e.g. detergents, cleaners, etc.)

Risks associated with the above hazards are managed through various safeguards and controls, in particular through safe storage and handling practices and procedures.

Compressed gases are also used as an extinguishing medium for fires in certain enclosed spaces. These may present an asphyxiation hazard for personnel in the space protected should the gas be released. Total flooding CO_2 fire extinguishing system are provided onboard the drillship in the paint store, machinery spaces, engine rooms, thruster rooms, and emergency generator room. For the FPSO and Near Shore Hub/Terminal, water mist systems are provided to protect spaces in place of gaseous extinguishing systems.

Risks associated with release of CO_2 and asphyxiation are managed through various safeguards and controls including double action to discharge (prime and discharge), manual discharge, audible and visual alarms in all protected spaces to alert anyone inside that the fire suppression system has been activated, along with a delay in discharge following activation.

8.4.2.2 Occupational Hazard Categorisation and Listing

All occupational hazards and associated accident events were documented in a Hazard Register (Goddard. 2018a). Organisation and documentation of hazards in the register is based around the categories of offshore oil and gas related hazards given in ISO 17776 (ISO. 2016).

These categories, along with associated accident hazard guidewords, provide an extensive hazard checklist for GTA Phase 1 Project occupational hazards. This checklist was used as a final review to capture and organise relevant occupational hazards (including those discussed in the previous sections), and to help ensure the identification process was robust and comprehensive.

Although differences exist between GTA Phase 1 Project facilities, a significant proportion of the occupational hazards are common across the various workplaces and work activities. As a result, and where relevant, they are presented and assessed in the occupational risk analysis (Appendix O-4) as a consolidated listing.

For each ISO hazard category, a list of potential occupational hazards relevant to the GTA Phase 1 Project facilities and operations is developed. A mark is then added where relevant, in the five columns related to a facility of the project: Drillship; Subsea & FPSO; Near Shore Hub/Terminal & FLNG; Support Vessels; and supply bases. A mark "O" means that the occupational hazard is relevant during the Operations Phase. A mark "C" means it is relevant during the (offshore) Construction phase. A mark "D" means it is relevant during the Decommissioning Phase. Note that drilling operations are ongoing during the Construction Phase (including engineering design).

Table 8-48 presents a listing of identified occupational hazards for GTA Phase 1 Project facilities and operations.

Table 8-48. Identified Occupational Hazards.

Hazard Ref #	Hazard Category	Occupational Hazards	Drillship	Subsea and FPSO	Shore Hub and FLNG	Support Vessels	Supply Bases
H-01	Hydrocarbons	Major Hazard, not occupational. Cryogenic/cold effects addressed under Hazard Category H-13					
H-02	Refined hydrocarbons	Addressed under Hazard Categories H-20 to H-23					
H-03	Other flammables	Accommodation galley cooking oils	C	O, D	C, O, D	O	
		Miscellaneous accommodation materials including paper, fabrics, and plastics	C	O	O	O	O
		Paints and miscellaneous flammable used and stored in small quantities	C	C, O, D	C, O, D	O	O
H-04	Explosives	Major Hazard, not occupational					
H-05	Pressure	Compressed gas cylinders under pressure (e.g. welding bottles)	C	C, O, D	C, O, D		
		Instrument air systems and compressor tanks (for instrument control)	C	O	O		
		Nitrogen, purging and leak testing systems	C	C, O, D	C, O, D		
		Pressure tests (during commissioning or maintenance)	C	C, O, D	C, O, D		
		Air compressors and tanks used during air diving operations			C, D		
		Gaseous firefighting systems (e.g. engine rooms, turbine enclosures)	C	O	O		
		Pipeline pigging (during commissioning or maintenance)		C, O, D	C, O, D		
H-06	Height difference	Working at height (from permanent or temporarily installed platforms including scaffolding)	C	C, O, D	C, O, D		
		Use of ladders (access during installation)		C, D	C, D		
		Working over water (during installation, inspection and maintenance)	C	C, O, D	C, O, D		
		Slippery or congested walkways	C	C, O, D	C, O, D	O	O
		Air diving with installation activities ongoing above			C, D		

Hazard Ref #	Hazard Category	Occupational Hazards	Drillship	Subsea and FPSO	Shore Hub and FLNG	Support Vessels	Supply Bases
H-07	Induced stress	Maintenance on devices such as spring-loaded relief valves and actuators, hydraulically operated devices	C	C, O, D	C, O, D		
		Vessel tie-offs/moorings		C, O, D	C, O, D	O	
H-08	Dynamic situations	Driving/parking at the supply bases					O
		Forklift operations	C	O			O
		Maintenance involving moving or rotating equipment	C	O	O		
		Use of hand tools	C	C, O, D	C, O, D	O	O
		Use of knives in galley/kitchens	C	C, O, D	C, O, D	O	
		Routine lifting (e.g. main cranes, supplies, containers etc.)		O	O	O	
		Routine lifting or skidding of drilling equipment (e.g. in derrick, drill pipe, BOP, marine riser etc.)	C				
		Heavy construction lifts (piles, decking, subsea equipment, piping)		C, D	C, D		
		Use of lifts/elevators	C				O
		Use of man riding equipment	C				
		Direct transfers from vessels, including crew boats (excludes baskets)		C, O, D	C, O, D		
		Use of baskets for personnel transfers	C	C, D	C, D		
H-09	Natural environment	Sea state/sea sickness	C	C, O, D	C, O, D	O	
		Excessive temperatures/heat	C	C, O, D	C, O, D	O	O
		Winds	C	C, O, D	C, O, D	O	O
		Low visibility/night operations	C	C, O, D	C, O, D	O	
		Lightning	C	C, O, D	C, O, D	O	O

Hazard Ref #	Hazard Category	Occupational Hazards	Drillship	Subsea and FPSO	Shore Hub and FLNG	Support Vessels	Supply Bases
H-10	Hot surfaces	Hot process piping and equipment	C	O	O		
		Exhausts (e.g. engines and turbines)	C	O	O	O	
		Steam piping including waste heat recovery units			O		
		Galley cooking equipment	C	C, O, D	C, O, D	O	
H-11	Hot fluids	Hot glycol (regeneration)		O			
		Galley cooking oils	C	C, O, D	C, O, D	O	
H-12	Cold surfaces	Cryogenic pipework and equipment			O		
		Equipment associated with low temperature gas processing			O		
H-13	Cold fluids	Cryogenic liquids (LNG refrigerant) in liquefaction and storage process streams			O		
		Cold gases (methane) in fractionation process streams			O		
H-14	Open flame	Hot work, cutting and welding	C	C, O, D	C, O, D	O	O
H-15	Electricity	Commissioning and maintenance of electrical equipment (high and low voltage equipment, power distribution and switchgear)	C	C, O, D	C, O, D	O	O
H-16	Electromagnetic radiation	Thermal radiation from flare		O	O		
		Thermal radiation well test burners	C				
		Welding (heat and light)	C	C, O, D	C, O, D	O	O
H-17	Ionizing radiation open source	Inspection and maintenance of process vessels with build up of naturally occurring radioactive materials (NORM)			O		
H-18	Ionizing radiation closed source	Use of radioactive sources used during well logging	C				

Hazard Ref #	Hazard Category	Occupational Hazards	Drillship	Subsea and FPSO	Shore Hub and FLNG	Support Vessels	Supply Bases
H-19	Asphyxiates	Entry into confined spaces such as tanks and vessels	C	O	O	O	
		Areas with gaseous fire extinguishing systems (e.g. CO_2) such as electrical switchgear room, engine rooms, machinery spaces	C				
		Nitrogen systems		C, O, D	C, O, D		
		Lack of oxygen during air diving operations			I, D		
		Gas from cryogenic liquid spills (LNG and its refrigerant)			O		
H-20	Toxic gas	Welding (exhaust fumes)	C	C, O, D	C, O, D	O	O
		Turbines, engines, diesel driven pumps, generators (exhaust fumes)	C	C, O, D	C, O, D	O	
		Hydrogen sulphide (H_2S) due to bacterial activity in stagnant water and confined spaces	C	C, O, D	C, O, D	O	
H-21	Toxic liquid	Toxic fluid hazards as listed in Appendix O	C	C, O, D	C, O, D	O	O
H-22	Toxic solids	Toxic solid hazards as listed in Appendix O	C	C, O, D	C, O, D	O	O
H-23	Corrosives	Corrosives as listed in Appendix O	C	C, O, D	C, O, D	O	O
H-24	Biological	Communicable diseases such as Diphtheria, Hepatitis A, Tetanus, Typhoid, Malaria, and Yellow Fever	C	C, O, D	C, O, D	O	O
		Contaminated food	C	C, O, D	C, O, D	O	O
		Contaminated water	C	C, O, D	C, O, D	O	O
H-25	Human factors	Manual materials handling	C	C, O, D	C, O, D	O	O
		Vibration	C	C, O, D	C, O, D	O	
		Poor lighting	C	C, O, D	C, O, D	O	O
		Poorly positioned/laid out controls	C	C, O, D	C, O, D	O	
		Awkward location of workplaces and machinery areas	C	C, O, D	C, O, D	O	O
		Poor organisation and job design	C	C, O, D	C, O, D	O	O
		Heat stress	C	C, O, D	C, O, D	O	O

Hazard Ref #	Hazard Category	Occupational Hazards	Drillship	Subsea and FPSO	Shore Hub and FLNG	Support Vessels	Supply Bases
H-26	Psychological	Stress (causes, living on the job/away from family, working and living on a hazardous plant, post-traumatic stress following serious incidents, injuries to self)	C	C, O, D	C, O, D	O	
		Fatigue from shift work	C	C, O, D	C, O, D	O	
H-27	Security	Major Hazard, not occupational					
H-28	Natural resources	N/A					
H-29	Medical	Medical unfitness	C	C, O, D	C, O, D	O	O
		Sea sickness – Addressed under Hazard Category H-09					
H-30	Noise	High noise levels in machinery and process workplaces	C	C, O, D	C, O, D	O	
		Intrusive noise in sleeping areas, offices and recreational areas	C	C, O, D	C, O, D	O	
Note: Ref # is taken directly from ISO 17776 hazard categories (ISO, 2016); C - (Offshore) Construction Phase; O – Operations Phase; D – Decommissioning Phase							

8.4.3 Occupational Risk Analysis

The occupational risk analysis worksheets are given in Appendix O-4. These worksheets contain the assessment of all occupational hazards and risks, as identified in Table 8-48.

Occupational risk is the combination of the likelihood of the occurrence of a work-related event that is hazardous to a person or group of persons' health or safety, and the severity of such an event. The risk analysis process involved ranking each hazardous event by considering the likelihood of occurrence and the severity of the potential harm.

Risks were assessed using the risk matrix given in Figure 8-91 (Caisse Régionale d'Assurance Maladie des Pays de la Loire, les Services de Santé au Travail du Maine-et-Loire. 2002). This matrix is different from that used for the preliminary risk analysis of major hazards. Consequence levels are more aligned to the less significant effects associated with occupational type incidents and accidents (mainly injury and sometime fatality in an area limited to the immediate surrounding of the hazard).

As with the preliminary risk analysis of major hazards, an initial risk ranking was first assigned by considering the hazard without any safeguards. Safeguards 'in place' or planned were then identified and a residual risk assessed. This process helped identify whether existing safeguards were sufficient, or whether further safeguards were required.

		Likelihood (L)			
		1 Highly Unlikely	2 Unlikely	3 Likely	4 Very Likely
Severity (S)	4 Very serious	S	S	U	U
	3 Serious	A	S	U	U
	2 Average	A	S	S	S
	1 Slight	A	A	A	A

U (RED)	**Unacceptable high risk**. The establishment must take immediate reductive measures in putting into place means of prevention and protection. Priority 1.
S (YELLOW)	**Significant risk**. The establishment must propose a reductive plan to be put into place over the short, medium and long term. Priority 2.
A (GREEN)	**Acceptable risk**. No additional action is required. Priority 3.

#	Likelihood (L)	Severity (S)
1	**Highly Unlikely**	**Slight**: Accident or illness that does not entail a work stoppage
2	**Unlikely**	**Average**: Accident or illness that does entail a work stoppage
3	**Likely**	**Serious**: Accident or illness with partial permanent disability
4	**Very Likely**	**Very Serious**: Fatal accident or illness

Figure 8-91. Occupational Risk Matrix.

From this, occupational hazards and associated accident events as detailed in Appendix O-4, those events where residual risk may result in fatality are summarised in Table 8-49.

Table 8-49. Fatality Occupational Hazards and Risks.

Hazard Category	Accident Event	Residual Risk		
		L	S	R
Pressure	Failure of system under Nitrogen, purging or leak testing	1	4	S
	Failure of system under pressure tests (during commissioning or maintenance)	1	4	S
	Accidental release or failure during pigging operations (during commissioning or maintenance)	1	4	S
Height Difference	Fall when working at height (from permanent or temporarily installed platforms including scaffolding)	1	4	S
	Fall from ladders (access during installation)	1	4	S
	Fall when working over water (during installation, inspection and maintenance)	1	4	S
	Object falls onto diver from installation operations overhead	1	4	S
Induced Stress	Spring loaded device equipment failure during maintenance	1	4	S
	Rupture of a mooring line or tie-off parts	1	4	S
Dynamic Situation	Injury during maintenance of moving or rotating equipment	1	4	S
	Dropped object during routine lifting (e.g., main cranes, supplies, containers etc.)	1	4	S
	Dropped object during routine lifting or skidding of drilling equipment (e.g., in derrick, drill pipe, BOP, marine riser etc.)	1	4	S
	Dropped object or crane failure during heavy construction lifts (piles, decking, subsea equipment, piping)	1	4	S
	Accident involving personnel lifts/elevators	1	4	S
	Accident involving man riding equipment	1	4	S
	Dropped personnel basket	1	4	S
Cold Fluids	Cryogenic release of LNG process refrigerant	1	4	S
Electricity	Electrical shock from un-isolated power cables/equipment during commissioning and maintenance	1	4	S
Asphyxiates	Asphyxiation during confined space entry	1	4	S
	Accidental release of CO_2 in confined spaces or machinery areas covered by gaseous fire extinguishing systems	1	4	S
	Accidental release of N_2 during commissioning or maintenance	1	4	S
	Lack of oxygen during diving operations	1	4	S
	Inadvertent release of cryogenic liquid fluid with large vaporisation	1	4	S
Toxic Gas	H_2S exposure during confined space entry	1	4	S
Note: Abbreviations in table denoted by 'L' – Likelihood, 'S' – Severity, 'R' – Risk Ranking				

8.4.4 Measures Taken to Manage Occupational Hazards and Risk

Occupational hazards and risks are managed through the development of a strong safety culture, and the implementation of robust control of work arrangements. These arrangements are based on a comprehensive understanding of facilities specific hazards and risks. For the GTA Phase 1 Project, management activities start at the early stages of the project and continue through the Preparation phase into decommissioning.

All BP facilities and operations are managed through the implementation of an overarching Operating Management System (OMS) (BP. 2016c). The OMS framework incorporates BP's standards, processes and practices under a single management system. Within the GTA Phase 1 project operational boundary, where contractors undertake activities on behalf of BP using their own operational management system arrangements (for example, the drillship and FLNG), these arrangements will meet BP's contractual and OMS framework requirements.

OMS encompasses all the elements of a strong and thorough risk management system, including leadership commitment; hazard identification and risk analysis, and management for ongoing risk reduction; training of both management and site personnel; management system audits; and the use of leading and lagging key performance indicators (KPIs) to track progress and guide change.

The BP OMS is described in further detail in Section 8.3.5. Measures taken to manage occupational hazards and risks are then discussed in the following sections, based on the following:

1) Activities undertaken as part of the GTA Phase 1 Project design process to manage occupational hazards and risks during operations
2) Management of occupational hazards and risks during operations
3) Management of occupational hazards and risks during (offshore) construction
4) Management of occupational hazards and risks during decommissioning
5) Medical treatment and response

8.4.4.1 Management as Part of the Design Process

The BP Healthmap process (BP. 2015) forms the basis for managing occupational hazards and risk during the Preparation phase of the project. Healthmap exercises and health hazard assessments are undertaken throughout the Preparation phase of the project. The purpose of these assessments is to manage occupational hazards and risks, in so far as is practicable, through basic design; rather than placing reliance on procedural controls, and crew training and competence.

Healthmap exercises include hazard identification workshops, design reviews, ergonomic assessments, and specific health hazard and risk assessments. Exercises are attended by a representative cross-section of key Project stakeholders (e.g. operations, maintenance, engineering and HSSE) familiar with relevant health and safety related aspects of design. Common 'healthy design' input areas and typical considerations are given in Table 8-50.

Table 8-50. Common Healthy Design Input Areas and Considerations.

Design Input	Typical Considerations
Chemical Selection	Consider health risk during the selection of insulation, coating materials, additives, water treatment chemicals, drilling muds.
Chemical Handling and Storage	Engineer and design storage space based on anticipated need versus purchasing aftermarket retrofits like plastic chemical storage cabinets.
Product Containment	Process sampling, pigging, draining, venting designs reduce potential personal exposures.
Noise	Anticipate and eliminate areas where equipment noise levels may cause employee noise exposures to exceed applicable limits or impact an employee’s ability to hear an alarm or cause a nuisance inside nearby accommodation areas.
Lighting	Consider if general illumination levels are sufficient for the environment and type of work. Consider stroboscopic effects on rotating machines, flicker (fatigue, epileptic seizure), optical radiation (some lamp designs produce significant emissions), and glare.
Non-ionizing Radiation	Consider potential sources including electrical power lines, electrical appliances, computers, radar, induction heaters, and laser sources.
Ergonomics	Consider ergonomic equipment and task design to prevent manual handling injuries (e.g. by provision of good valve positioning, design for adequate access, egress, implementation of lifting aids, and work flow design aimed at minimizing the need for manual handling tasks altogether).
Ventilation (General)	Consider HVAC location of intake and exhaust, sized to provide adequate air supply for living quarters, laundries, galleys, offices, medical room etc. without risk of inappropriate mixing or backflow.
Ventilation (Local)	Provide adequate capture velocity for effective local extraction of contaminant (e.g. laboratories, fabrication workshops, drilling mud handling plant).
Vibration	Consider vibration health risks to whole body (e.g. when the body is supported on a surface that is vibrating) and hand-arm (e.g. when vibration passes to hand from hand held vibrating portable tools and equipment).
Thermal Environment	Consider related human accommodation needs where temperature extremes (hot and/or cold) exist (e.g. provision of weather refuges/shelters).
Potable Water Systems	Prevent contamination or infection by sound design of storage, distribution and outlets. Consider materials of construction that do not support microbial growth or provide a source of toxic substances, colour or odour changes to the water. Designs that allow water to remain standing for considerable periods (e.g. dead legs) should be avoided.
Waste Water	Prevent contamination or infection by sound design of storage, distribution and outlets.
Biohazards	Consider and design for correct disposal of sharps, infected waste, and soiled waste (with body fluids) in health care facilities and female changing rooms.
Vector-borne Infections	Consider and design for prevention of vector-borne infections like Malaria and Yellow Fever.
Food and Water-borne Infections	Consider prevention of infections such as cholera, shigellosis, typhoid, paratyphoid, and Escherichia coli infection in food process production and catering facility design.
Legionnaires’ Disease	Consider prevention of Legionella pneumophila formation in air conditioning units, cooling towers, and shower design.

Design Input	Typical Considerations
Accommodation and Worker Welfare Facilities	Solicit technical input from BP Group Health and 'accommodation and worker welfare' facility design specialist. Realistically estimate POB that consider requirements through the full Project life cycle. Position camp(s) and accommodation outside potential endemic or public health hazardous areas. Consider and design for space, lighting, noise and vibration abatement, clean air source for ventilation intake, properly controlled temperature and humidity, hygiene, workforce size, volume/size of bedrooms, washrooms, toilets (e.g. easily cleanable), change rooms where work involves excessive dirt, heat, fumes, etc. laundry, smoking area, and refuge.
Kitchen and Galley	Solicit technical input from BP Group Health and 'food and safety' facility design specialist.
Health Care Facility and Sick Bay	Solicit technical input from BP Group Health and a 'health care facility and sick bay' facility design specialist.
Insects and Rodents	Design for the prevention of entry and harbourage of insects, rodents, animals, birds and other vermin, as well as environmental contaminants, such as smoke and dust.

8.4.4.2 Management during Operations

The BP OMS, along with key supporting standards such as the GDP Control of Work (BP. 2016a) set expectations and define requirements for control of work and managing occupational hazards and risks. These are supported by development and implementation of comprehensive occupational health and safety management system arrangements, key aspects of which are described below.

Roles and Responsibilities

The drillship, FPSO, and Near Shore Hub/Terminal (including the LNGC, offtake tanker, support vessels, and offshore construction and installation vessels) have clearly defined organisations with roles and responsibilities defined, communicated and understood. Each facility has a designated PIC, supporting by a management/supervisory team. They are responsible for ensuring:

- Hazards within their area of responsibility are identified, documented and controlled
- HSSE management system arrangement relevant to their area of operations are implemented effectively
- Any incidents, accident or hazards are reported, investigated and any subsequent recommendations put in place
- Personnel have the appropriate skills to carry out their job functions safely

Overall responsibilities for the PIC include:

- Overall daily charge of the facility, including command and control during an emergency
- Promoting a positive HSSE culture and 'setting an example' for behaviour based safety programs
- Making decisions with respect to health, safety and pollution prevention

Training and Competence

Personnel are trained and competent in the tasks they are performing. This includes meeting clearly defined competency requirements for their assigned roles. Competences are documented and used to establish detailed training requirements and competence testing. Documented and up to date training programs are in place to support the competence assurance process. This includes:

- Training needs analysis
- Training requirement matrices
- Training records
- Initial training, refresher training, recertification, and remedial training for employees who are recognized as operating below established standards

Planning and Scheduling

Planning and scheduling of work follows a documented process that clearly identified the scope of work, the individual task steps, and any Interactions between the scope and other tasks (e.g. simultaneous operations – SIMOPs).

Where relevant, Subject Matter Experts (SMEs) are included in the planning stages, as required by the complexity of the task. The planning process also allows time for the necessary actions required for the safe execution of the work including hazard identification and risk assessment; the identification of employees, equipment, parts and materials required for the completion of work; the development of risk assessed and approved plans/procedures for the overall work method; and the safe isolation and re-instatement of the plant or equipment.

Task-Based Risk Assessment

All tasks will not proceed without some form of risk assessment. This involves:

- Inspection of the worksite prior to work being performed
- Task-based risk assessment (TRA) to identify potential hazards associated with the work, along with all required safeguards
- At least one person directly involved in the work activity being part of the TRA team

Permit to Work

A permit is required before conducting work that involves:

- Confined space entry
- Work on energy systems (i.e., a system that can accidentally release energy like electricity, heat, pressure, mechanical etc.)
- Lifting activity
- Ground disturbance
- Hot work
- Other potentially hazardous tasks

The permit to work system is a critical process for control of workplace (and major) hazards and risks. Work permit documentation defines the scope of work; identifies and reviews potential hazards, and identifies control measures required to undertake the work safely. The work permit also links the work to other associated work permits or SIMOPS, and helps prevent safeguards that may be common to more than one permit being removed (e.g. isolations).

Upon the completion of work controlled by a permit, the permit is formally closed with verification that the worksite has been left in clean, tidy and in a safe condition, including the removal and proper disposal of residual liquids and contaminants. Where relevant, this also includes whether the process plant and equipment are ready for integrity testing, and can safely be brought back to service.

While the work permit is not a control for an individual work task, it is a means of providing the basis for the controls. In addition, the work permit process communicates key hazard and risk management information to all personnel involved in the work.

Authorisation and Communication

To help ensure the safe execution, prior to work commencing:

- SIMOPs are identified and the appropriate safe management arrangements made
- Work permits are reviewed and agreed by key stakeholders
- Personnel involved in the work are made aware of identified hazards, safeguards in place to manage risks; and emergency actions, plans and facilities.
- The workplace is inspected to confirm the workplace condition, and safeguards are in place, as recorded in the permit documentation
- Required PPE is checked by a competent person
- Any other personnel that may be affected by the work are informed of, and understand the impact and status of the work

Lessons Learned

Lessons learned from past workplace accidents and incidents are documented, used to modify safe work procedures as necessary, and shared with the workforce.

Stop Unsafe Work

Personnel are made aware and understand that they have the obligation and authority to stop any unsafe work. This includes reporting any unsafe work to supervisors. Instances of work being stopped are recorded and investigated.

Safe Work Practices and Procedures

Safe work practices and procedures are defined for all potentially hazardous work activities. This includes:

- Safe isolation and de-isolation of plant and equipment including risk assessment with isolations locked and tagged
- Confined space entry
- Working at heights, including work over the side
- Pressure testing
- Use of PPE
- Safe storage and handling of hazardous materials, including use and review of MSDSs
- Hot work, including any work that involves potential ignition sources
- Lifting operations
- Effective communications of HSSE management information including shift change, safety meetings and dissemination of lessons learned
- Employee representation and participation (e.g., to safety workshops such as HAZID, HAZOP, etc.)
- Housekeeping procedures

- Permit to work system
- Safety risk assessments
- Weather and operational restrictions

Behavioral Based Safety Program

BP implements a Behavioral Based Safety (BBS) program for all personnel, including Safety Observation Conversation (SOC) program for all managers and supervisors.

The BBS program promotes interventions that are people-focused and incorporate observations of employees performing routine work tasks and giving timely feedback on safety-related behaviour. The program encourages individuals and their work groups to consider the potential for accidents, and to continually assess their own behaviour as safe or unsafe.

BBS observations are made by employees carrying out all work tasks. These observations are recorded on pre-formatted cards that are reviewed and consolidated to identify workplace safety related insights and trends. Necessary action is taken to mitigate identified hazards and risks.

The SOC program applies behavioural safety principles designed to address both personal and process safety. SOC involves managers and supervisors observing work sites and activities; communicating with involved workers to discuss/highlight safe and any unsafe work practices; and implement agreed actions, as required, to manage and reduce risk.

Storage and Handling of Hazardous Materials and Substances

Hazardous materials and substances are handled and stored in a safe and controlled manner to manage risks associated with exposure to personnel and the environment. This includes:

- Safe storage and handling procedures, with all personnel involved in using hazardous materials and substances trained and deemed competent to do so.
- Use of the appropriate personal protective equipment when handling hazardous material.
- Proper identification and labelling of hazardous materials and substances, with all materials and substances used solely for their intended purpose.
- Review of labelling and MSDSs prior to handling to identify properties and hazards, and to help ensure the appropriate safeguards are implemented.
- Proper storage including use of sealed containers, separation of incompatible substances, with storage in well ventilated and dry areas.
- Provision of, and training in the use of emergency procedures and equipment. This include how to deal with fires and spills; and what to do in a medical emergency, including use of equipment such as eye wash stations.

8.4.4.3 Management during Offshore Construction

Occupational health and safety management requirements during offshore construction and installation are an integral part of BP’s OMS and general control of work requirements, as described previously.

As part of this, the project has developed an overarching HSSE Management Plan (BP. 2017b) specifying occupational health and safety management goals, objectives and requirements during the Preparation phase of the project.

The GTA Phase 1 Project has an Injury Free Goal.

In terms of personal safety, this means being injury free wherever we work or travel on company business. This Injury Free Goal is based on the premises that:

1) Good safety performance is at the core of a successful project and business. Everything we do relies upon the safety of our workforce and the communities around us;

2) With the right action and attitude all work related injuries are avoidable; and

3) No one wants to come to work and be injured.

Achieving our Injury Free Goal is as much about our “Hearts and Minds” and personal discipline, as well as effective processes and practices. We all need to be safety leaders to look after ourselves, our colleagues and contribute to a positive safety culture where we are intolerant of anything less than our Injury Free Goal (BP. 2017b).

The Plan defines how GTA Phase 1 Project aims to meet this goal, in accordance with applicable BP requirements, and covers all managed activities undertaken by the Project.

Due to the size and complexity of the GTA Phase 1 Project, delivery of specific HSSE Management Plans will be developed to cover discrete activities such as FPSO hookup and commissioning, and breakwater construction etc. Contractors involved in such activities must also have their own HSSE Management Plans and systems in place, with the appropriate controls.

The GTA Phase 1 Project also considers any activity associated with subsea, FPSO or Near Shore Hub/Terminal installation and construction to be a Potentially High Consequence Activity (PHCA). PHCA contracts have additional requirements and controls for contractors to help ensure risks are managed. For all PHCA contracts, the contractor is required to have the following in place before work commences:

- BP-contractor HSSE management system bridging document
- Contractor HSSE Plan which includes the self-verification plan

To align major contractors and their subcontractors with the GTA Phase 1 Project Injury Free Goals, prior to work commencing, Project Sponsor Forums and joint workshops are held. The objectives of these forums and workshops is to verify that safety expectations, along with roles and responsibilities are clear; the work is understood; and teams are aligned on BP HSSE expectations.

In addition to the requirements detailed in Section 8.4.4.2, key occupational health and safety management requirements for offshore construction and installation include:

- Roles, responsibilities and accountabilities are clearly defined with a Single Point Accountable person for safety on the project. They own OMS conformance and carry out systematic self-verification. The Vice President (VP) Mauritania and Senegal (M&S) Projects is supported by BP Site Safety Leaders, and the GTA Phase 1 Project HSSE Manager.

BP Site Safety Leaders are responsible for safety on their site. They have a critical role implementing the HSSE management system requirements within their site, connecting the workforce to the Project leadership, and managing personal safety.

The GTA Phase 1 Project HSSE manager has two key roles: line support and verifying conformance to BP HSSE requirements. The HSSE manager provides HSSE-related expertise and links to other support groups within BP, support the project team in implementing HSSE procedures to manage project specific risks, develop and implement HSSE self-verification and contractor oversight programs, and help ensure adequate resource are provided to implement HSSE management requirements.

- Pre-mobilisation verification of contractors will be undertaken to help ensure that their HSSE Plans and management systems have been properly developed and implemented, are effective and meet BP GTA Phase 1 Project overarching HSSE management requirements.

- As part of the development of safe offshore construction and installation practices and procedures, detailed hazard identification and risk assessment workshops will be conducted for all construction and commissioning activities. These workshops will be undertaken once offshore construction and installation plans and activities are sufficiently detailed.
- During design, constructability and installation aspects are considered as part of the design process. This helps ensure that, in so far as is practicable, equipment and facilities are designed to reduce risks associated with offshore construction and installation activities.

8.4.4.4 Management during Decommissioning

If no field life extensions are planned, the facilities will be decommissioned out of service at the end of the field life.

Detailed plans and procedures will be developed for the decommissioning phase, and activities will be managed with similar processes, systems and requirements as described for the offshore construction and installation, and the operations phases.

8.4.4.5 Medical Treatment and Response

A detailed description of emergency preparedness arrangements and response plans is given in Section 8.3.6.

Facilities specific emergency response plans address the range of occupational type accidents (illnesses and injuries), as well as major hazards. These plans are supported by detailed medical protocols and requirements, as documented in medical procedures.

All facilities (the drillship, FPSO and Near Shore Hub/Terminal) have a full-time Medic onsite to manage injuries, illnesses and general health of personnel. The drillship, FPSO and QU platform are equipped with dedicated sick bays with patient beds, medical equipment and medications. Main offshore construction and installation vessels are also equipped with appropriate medical facilities and trained medical support.

Medical equipment and medications are selected based on BP requirements, site specific occupational health and safety hazards and risks, vessel Flag State medicine chest guidance, and World Health Organisation (WHO) (2007) guidelines.

In addition to the trained Medic, certain crew members are also trained in First Aid and can provide first responder assistance to the Medic if necessary. The Medic is responsible for dispensing, securing, and monitoring the use of controlled and therapeutic drugs. Additional shore based medical support is provided by a Company Medical Advisor, to advise and direct healthcare and emergency situations offshore.

Depending upon the type and severity of the incident onboard the facility, the sick or injured person may require medical evacuation (medivac). Medivac will primarily be undertaken by helicopter. Depending upon the type and severity of the incident, shore-based treatment may be provided locally, or out of country. A third party medical services provider (such as International SOS) is available for additional shore side support as required.

8.5 Conclusions and Recommendations

8.5.1 Overall Conclusion

The overall conclusion from the Risk Study and Occupational Risk Assessment is that GTA Phase 1 Project specific hazards and risks have been identified, analysed and assessed in a robust and rigorous manner, commensurate with available design information and definition. Risks are below relevant established risk tolerability criteria, with comprehensive GTA Phase 1 Project requirements and processes in place to ensure accident hazards and risks continue to be identified, where possible eliminated, assessed and managed to ALARP through all stages of the project.

In addition to the Risk Study and Occupational Risk Assessment (and supporting analyses), further detailed assessment of facilities accident hazards and risks is ongoing as part of the GTA Phase 1 Project design process. These assessments include:

- Fire, explosion and cold spill (cryogenic release) hazard analyses. This analysis takes place when design is sufficiently progressed and can utilize 3D CFD consequence models. It then feeds into design requirements for fire, explosion, and cold spill prevention, control and mitigation.
- Emergency systems studies. These studies assess and verify the performance of emergency systems for the major accident events for which they are required to function, and provide input into design requirements for fire, explosion, and cold spill prevention, control and mitigation.
- Emergency preparedness and response studies. These studies assess and verify the performance of escape, TR, evacuation and field rescue facilities, and provide input into design to help ensure personnel can reach a place of safety during any major accident event.
- Hazard identification and risk assessment workshops. These workshops will help ensure hazards and risks associated with installation, commissioning and operation activities are appropriately managed and will feed into the development of safe work plans, procedures and practices.
- Ongoing Healthmap exercises and health hazard assessments. These exercises are focused on managing occupational hazards and risk through the basic design, rather than placing reliance on procedural controls, and crew training and competence.

Other analyses will also be undertaken to evaluate facilities, activity and location specific risks, such as offshore construction and installation SIMOPS, dropped object and vessel collision, as required. Specific consequence and risks analyses may also be conducted to evaluate options and assist in decision making.

All these assessments, along with the development of an overarching GTA Phase 1 Project HSSE Case will provide input and justification for design safety requirements, and accident event prevention, control and mitigation.

As part of this, risk reduction measures are continually identified and assessed. Measures focus (in order of priority) on avoidance, prevention, control and mitigation. As part of ongoing efforts to reduce risks to ALARP, risk reduction measures have and will continue to be considered, taking account of risk reduction, and the level of ‘effort’ required (e.g. cost and schedule impact) to implement them. Risk reduction measures are only ruled out if ‘effort’ is grossly disproportionate to the benefit gained.

GTA Phase 1 Project facilities are being designed, and will be operated, in accordance with recognized good industry practice; and industry rules, regulatory requirements, codes and standards. This includes significant emphasis on inherent safety with focus on avoidance and prevention to manage hazards and risks, in priority to control and mitigation.

As part of the Risk Study and Occupational Risk Assessment, SECE have been identified. These elements will be further defined during the GTA Phase 1 Project design process with specific arrangements put in place to manage them. This includes documentation of performance requirements (performance standards) with associated assurance and verification schemes for design and operations.

A project HSSE Plan has been developed that defines overall HSSE management requirements and activities for the GTA Phase 1 Project, including relevant requirements from BP’s OMS. Effective HSSE management systems have, and will continue to be implemented, in accordance with BP’s corporate HSSE policies and overarching OMS requirements. In addition, assessment of major hazards and risks will provide input into development of specific operational HSSE management system arrangements.

In the unlikely event a major accident were to occur; comprehensive and robust arrangements are being made for emergency preparedness and response. Given the early stage of the project, these arrangements are in development. However, they will address the full range of accident events and possible emergency scenarios, including major fires and explosion, oil spills and occupational accidents/incidents.

8.5.2 Risk Study Conclusion

The Risk Study undertaken for the GTA Phase 1 Project included preliminary risk assessment that identified 46 major accident events. Initial risk ranking was assigned by considering the hazard and potential consequences without any safeguards. Safeguards were then identified and a residual risk assessed. Following implementation of relevant safeguards, and using the Republic of Senegal (2005) Risk Study Guide risk matrix, no events were ranked with 'Unacceptable' residual risk (RED), with all events ranked 'Significant' residual risk (YELLOW). For residual risks ranked 'Significant', plans have and will continue to be implemented to reduce risk.

For all hydrocarbon related major accident events, detailed consequence modelling has been undertaken, according to two scenarios: one considered as "credible" and the other considered as "worst-case". This modelling assessed a range of consequence effects, specifically:

- Oil spill
- Cryogenic spill, including far field flammable gas dispersion
- Explosion
- Fire – jet fire, pool fire, and fireball

Modelling of cryogenic spill, explosion and fire effects for the Drillship, FPSO and FLNG shows that, despite the risk of fatality for personnel directly exposed to the immediate effects of the event, escape routes, temporary refuges and safe muster areas, and evacuation facilities (e.g. evacuation routes, and lifeboats) should remain available and unimpaired for all but the most extreme of major accident events. This is reflective of good separation of TR's and safe muster areas from hazardous process/drilling areas, and diverse escape and evacuation facilities.

In general, hazard ranges and consequence effects are limited and contained well within facilities safety zones (designated a minimum of 500 m from the facilities themselves). The main purpose of these safety zones is to protect facilities and associated operations from external hazards such passing vessels, fishing activity and possible security threats, however, they also provide a buffer zone in case accidental hydrocarbon release, followed by explosions/fires. For certain extreme hydrocarbon events, hazard ranges were determined to extend past the limit of the safety zone i.e.:

- Large explosion on the FPSO or FLNG
- Large LNG release from the FLNG or LNGC

For large explosions, while overpressures decay exponentially with distance, overpressure effects may be experienced a significant distance from the blast centre. For the FPSO and FLNG, worst case explosions were determined to have overpressures ranging from just under 0.05 bar at the safety zone limit, and 0.02 bar extending over 1,150 m from the blast center (and some 400-600 m past the safety zone limit). At 0.02 – 0.05 bar overpressure levels, minor damage may be expected, such as windows breaking. Assessment of explosion in the Risk Study is conservative and these extreme cases are not considered representative of design events (i.e. blast scenarios that it would be reasonably practicable to design for/against).

In case of a large release from an LNGC or FLNG storage tank, flammable gas may also disperse significant distances downwind (extending up to 500 m past the safety zone limit). However, the likelihood of such an event is extremely low (<1E-05 per year, or 1 in 100,000 per year) and requires a damaging LNGC collision with the berth/FLNG. Historically, no such event has ever occurred and collision risks are managed through comprehensive safe berthing arrangements and procedures, including the use of multiple tugs to help control and maneuver the LNGC.

Collated furthest effects are summarised by consequence event type for the FPSO and Near Shore Hub/Terminal in Figure 8-92 and Figure 8-93.

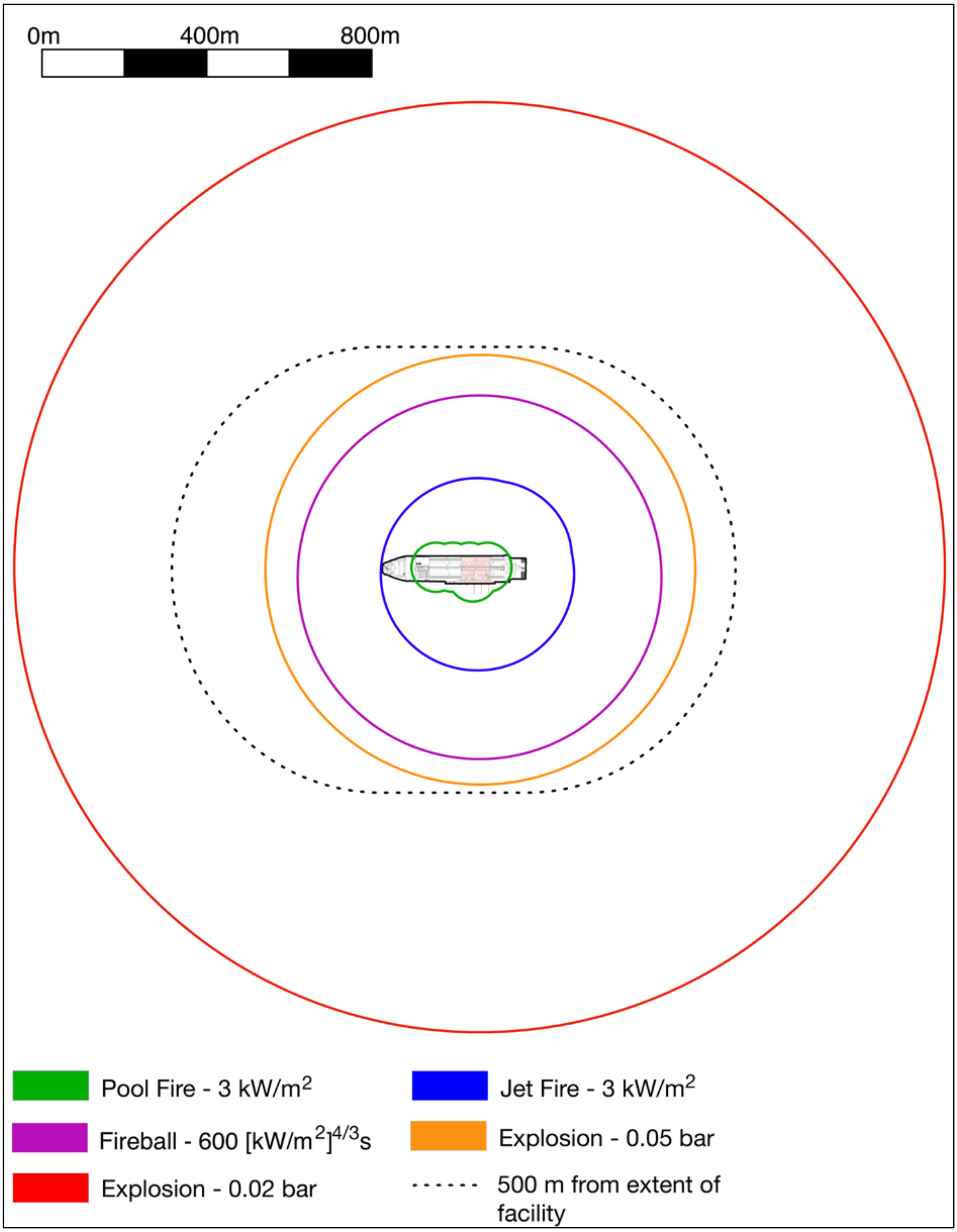


Figure 8-92. FPSO Furthest Consequence Effects by Event Type.

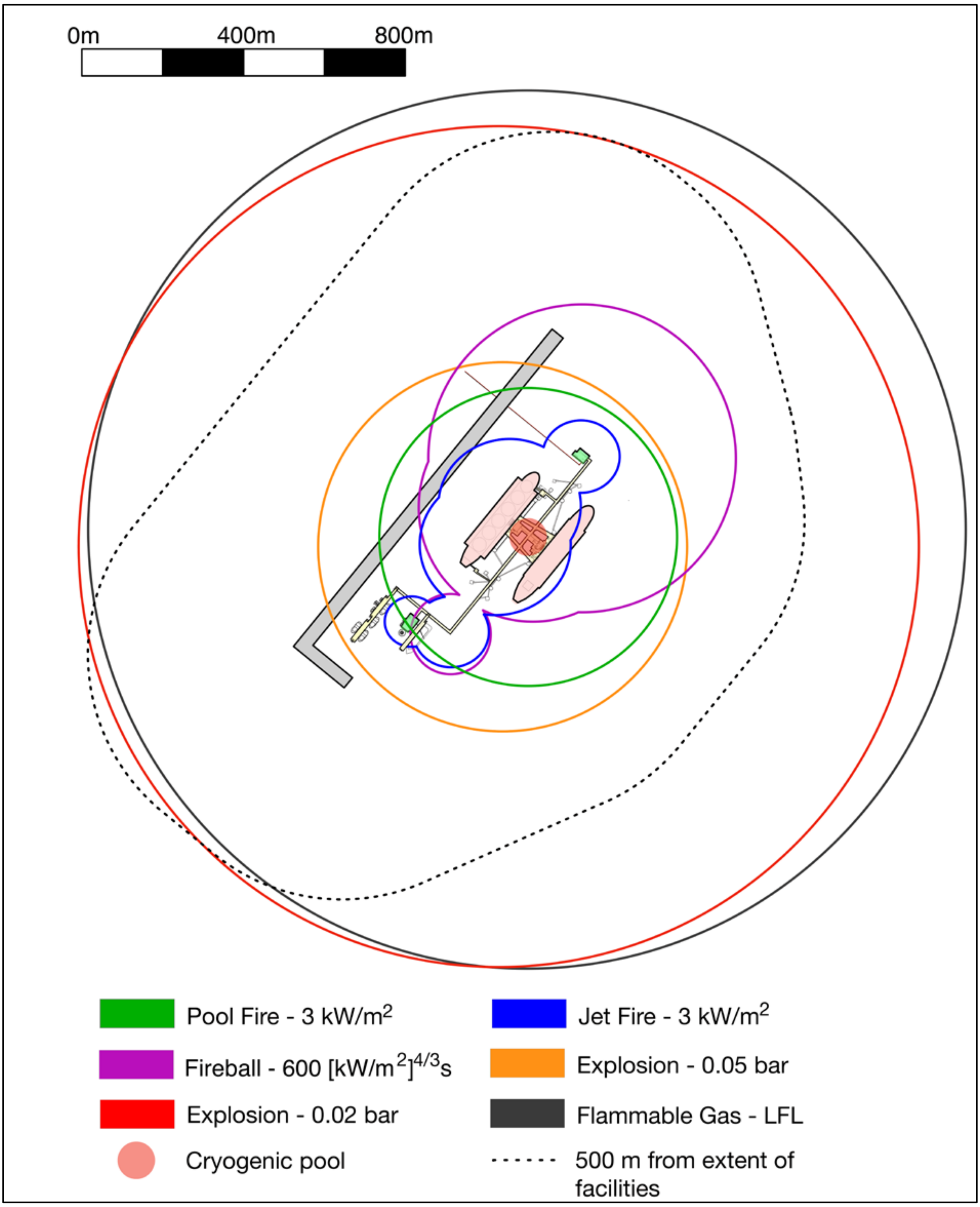


Figure 8-93. Near Shore Hub/Terminal Furthest Consequence Effects by Event Type.

Two major oil spill major accidents were modelled, blowout and release of condensate (and diesel) from the FPSO storage tanks.

For blowout, modelling of marine pollution showed that the territorial water of Mauritania and Senegal could be impacted within a matter of hours. If the blowout was not quickly controlled, the shorelines of Mauritania and Senegal could be impacted after approximately 4 days with light to moderate oiling possible. Depending upon the scenario (boreal summer or boreal winter, and specific environmental conditions) territorial waters of Cape Verde, Guinea, Guinea-Bissau, Sierra Leone, The Gambia, and Western Sahara could also be impacted, but not shorelines. The thickness of the condensate spill is limited to mostly sheen and rainbow sheen that will more readily disperse. A small amount of metallic sheen (>5 μm) could be found in the local area around the well (~25 km).

For major condensate (and diesel) spill after a major leak from the FPSO storage tanks, modelling of marine pollution showed that the shorelines of Mauritania and Senegal could be impacted within 2 days with moderate to heavy oiling possible. Depending upon the scenario (boreal summer or boreal winter, and specific environmental conditions) waters of Cape Verde, Guinea-Bissau and The Gambia, could also be impacted, but not shorelines. The waters of Mauritania and Senegal could experience a spill with a surface thickness more than 5 μm making them candidates for containment and recovery techniques. The waters of other neighbouring countries could experience oil sheen on the surface waters but not at a thickness that is likely to be effective for containment and recovery.

Following modelling of major accident event consequences, Bowtie analysis was undertaken for all major accident events. For the purposes of this analysis, major accident events were grouped with 24 individual Bowties (and Central Feared Events) developed. Bowtie analysis was used to verify that suitable and sufficient barriers were in place for the prevention, control and mitigation of all major accident events.

Following Bowtie analysis, risks were quantified in terms of event frequency and associated fatality risk. Fatality risk is considered for all facilities workers, and for far field effects at the Near Shore Hub.

PLL (the total number of worker fatalities in year) can be used as a simple measure of societal risk and is useful to understand major contributors the overall risk. Considering all GTA Phase 1 facilities workers, the estimated major accident fatality rate is 0.09 per year. This can also be expressed as a long-term average of approximately one fatality per 11 years of operation. It is important to note however, that this figure is based on major accidents that may potentially result in multiple fatality and that happen much less frequently. Approximately 28% of the estimated fatality risk is attributed to the Near Shore Hub, 37% to the FPSO and 35% to the Drillship, as broken down in Table 8-51.

Table 8-51. Fatality Risk Contribution.

Bowtie ID	Bowtie (and Central Feared Event)	Fatality Risk Contribution
3	Drillship Transportation (Helicopter) Accident	22%
12.02	FLNG Hydrocarbon Process Release	15%
4.02	FPSO Vessel Collision (Passing Vessel)	13%
2.02	FPSO Loss of Vessel Stability/Capsize	10%
2.01	Drillship Loss of Vessel Stability/Capsize	10%
12.01	FPSO Hydrocarbon Process Release	7%
5.01	FPSO Hydrocarbon Riser Release	5%
8.02	FLNG LNG Release during LNGC Loading	5%
9	QU Platform Structural Failure/Damage	4%
1	Drillship Blowout or Well Release	3%
7	FLNG Refrigerant Release	3%
6.02	FPSO Condensate Storage Tank Fire	1%
14.01	FPSO/NSH Transportation Accident (Crew Boat Founders)	1%
14.02	FPSO Transportation Accident (Dropped FROG)	<1%
15	FPSO Vessel Collision (Condensate Offtake Tanker)	<1%
4.01	Drillship Vessel Collision (Passing Vessel)	<1%
5.02	Riser Platform Hydrocarbon Riser Release	<1%
13	FPSO Chemical Injection Release	<1%
16	QU Platform Fuel Gas Release	<1%
11	Drillship Well Testing or Clean-up Hydrocarbon Release	<1%
8.01	FLNG/ LNGC LNG Release from Storage Tank	<1%
10	NSH Vessel Collision (LNGC with Berth)	<1%
6.01	FPSO Condensate Storage Tank Release	N/A
17	Security Incident	N/A

IRPA (the probability a worker will be fatality injured at work in a year, taking account of the time they spend on a facility exposed to its specific hazards) is useful to understand risk levels for individual workers. IRPA is calculated for all GTA Phase 1 facilities workers. Maximum worker IRPA are 2.4E-04 per year for the Drillship (a maximum probability of fatality from a major accident event of 1 in 4,167 per year), 2.1E-04 per year for the Near Shore Hub/Terminal (a maximum probability of fatality from a major accident event of 1 in 4,762 per year) and 2.0E-04 per year for the FPSO (a maximum probability of fatality from a major accident event of 1 in 5,000 per year).

LSIR (the probability of fatality for a hypothetical individual who is permanently present at a specific location) is useful for showing the spatial distribution of risk. LSIR is calculated for the Near Shore Hub/Terminal only, given the different facilities present and relative proximity to shore. Contours show that the probability of fatality of 1E-06 per year (1 in a million per year) for the Near Shore Hub/Terminal lies well within the limits of the facilities 500-600 m safety zone, as shown in Figure 8-94.

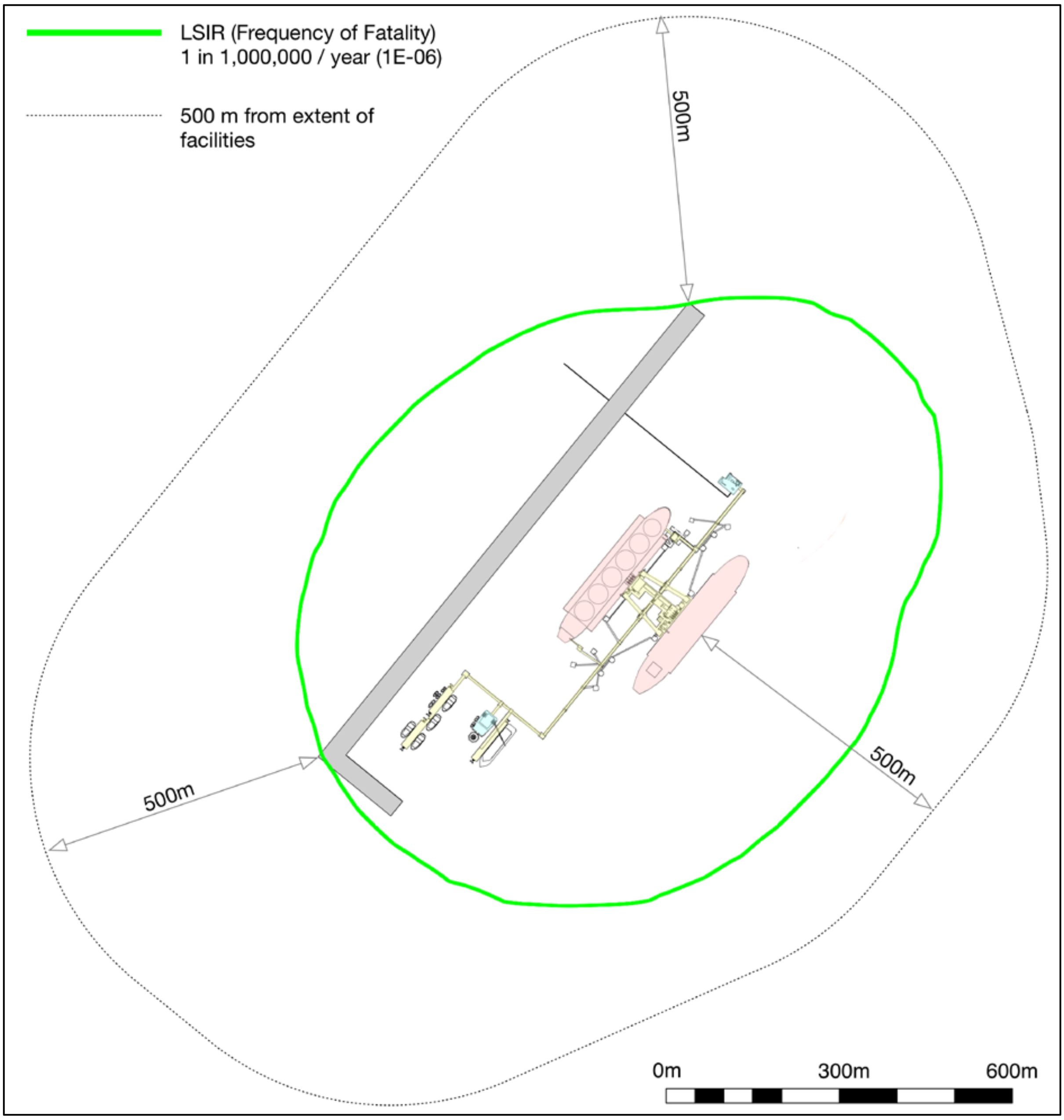


Figure 8-94. Near Shore Hub/Terminal LSIR at 1 in 1,000,000 per Year.

Relevant established risk tolerable criteria for offshore workers (IRPA) (UK HSE. 2001) is of the order of 1E-03 per year (1 in 1,000 per year). GTA Phase 1 Project worker individual risks are below this, calculated to be a maximum of 2.4E-04 per year (1 in 4,167 per year).

Relevant established risk tolerability criteria for members of the public (LSIR) is of the order of 1E-06 per year (1 in a million per year) (European Maritime Safety Agency. 2013). The 1E-06 per year risk contour for the GTA Phase 1 Project Near Shore Hub/Terminal facilities lies well within the 500-600 m safety zone.

The closest neighbouring communities of N'Diago in Mauritania, and Saint-Louis in Senegal, are located 16 km and 13 km respectively from the Near Shore Hub/Terminal. These communities are a significant distance away from any hazard or risk zone resulting from the GTA Phase 1 Project facilities with maximum effect distances (0.02 bar explosion overpressure and flammable gas dispersion) extending just over a km from Near Shore Hub/Terminal LNG production and export facilities.

Comprehensive management plans and processes are in place during the Preparation phase of the project to help ensure major hazards are appropriately assessed and managed; and residual risk reduced. This includes continued efforts to reduce residual risks in line with ISD and ALARP principles; along with the development of robust risk and safety management system arrangements.

8.5.3 Occupational Risk Assessment Conclusion

Assessment of occupational risks identified a total of 78 occupational accident events. Initial risk ranking was assigned by considering the hazard and potential consequences without any safeguards. Safeguards were then identified and a residual risk assessed.

Following implementation of relevant safeguards, and using the risk matrix given in Figure 8-92 (Caisse Régionale d'Assurance Maladie des Pays de la Loire, les Services de Santé au Travail du Maine-et-Loire. 2002), no events were ranked 'Unacceptable' residual risk (RED), with 55 events ranked 'Significant' residual risk (YELLOW) and 23 events ranked 'Acceptable' residual risk (GREEN). For residual risks ranked 'Significant', plans have and will continue to be implemented to reduce risk.

Of the 78 occupational accident events, 24 could result in fatality. These events were related to the following hazards/activities:

- Use of explosives on the drillship
- High pressure systems and activities such as nitrogen purging, pressure tests and pigging
- Working at heights
- Diving during offshore construction and installation
- Induces stress from mooring lines and equipment failures
- Dynamic situations including rotating equipment, dropped objects, and use of lifts; elevators; manriding equipment and personnel baskets
- Exposure to cryogenic liquids (also a major accident event)
- Electrical equipment

Comprehensive management plans and processes are in place during the Preparation phase of the project to help ensure occupational hazards are appropriately assessed and managed, and residual risks reduced. This includes include hazard identification workshops, design reviews, ergonomic assessments, specific health hazard and risk assessments; along with the development of robust occupational health and safety management system arrangements for (offshore) construction, operation and decommissioning.

8.5.4 Recommendations

As part of the Risk Study and Occupational Risk Assessment, a number of recommendations have been made. Recommendations made are as follows:

1) **CFD Consequence Modelling:** The Risk Study utilised empirical modelling for release, cold spill, fire and explosion for the FPSO and Near Shore Hub/Terminal. While this provides a conservative assessment of hazards and risks, it has limitations for determining DAL for SECE. As design progresses and detailed 3D design information becomes available, CFD models could be utilised to model accidental release consequences and effects. These models take account of the detailed

geometry surrounding the release and should be used as a key input into design of release, cold spill, fire and explosion control and mitigation measures.

2) **Vapour Cloud Explosion and Detonation:** The FLNG refrigerant system contains ethylene. Ethylene is a highly flammable and reactive chemical and a dangerous fire and explosion hazard. With accidental ethylene releases, there is the potential for explosive DDT with significant overpressure effects. DDT could be evaluated as part of the design CFD explosion modelling, for example, by considering the likelihood of DDT in terms of spatial pressure gradients across the flame front.

3) **Assessment of Escalation Impact:** A detailed analysis of escalation potential could be completed using CFD consequence modelling results to determine the likelihood for impairment of equipment and structures leading to significant escalation of an initial event – e.g. a cargo tank fire, ethylene explosion, or rupture of a riser. Such scenarios may threaten the integrity of the TR or the FPSO/FLNG and require evacuation. Escalation may be caused by overpressure impact, fire engulfment for a sustained period or embrittlement of structures due to cryogenic impact. Escalation analysis could also be used to determine the benefit of fire, explosion and cryogenic spill protection for key structures.

4) **Refrigerant Storage Vessels:** Sustained engulfment by fire of refrigerant storage vessels may result in a BLEVE – generating significant overpressure and a large fireball. Consideration could be given to refrigerant storage so that potential for BLEVE and escalation impact is minimised (e.g. position, inventory, fire protection).

CHAPTER 9: ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

9.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

This chapter presents the Environmental and Social Management Plan (ESMP) developed for the GTA gas production project.

9.1 Objective of the ESMP

The objective of the ESMP is to:

- Summarize the project design and operational controls (D&OC) measures and the mitigation measures proposed to avoid or reduce significant[169] negative impacts;
- Define a system for the implementation, the compliance monitoring and the performance evaluation of these measures; and
- Identify reporting mechanisms.

During the course of the project, the actions listed in the ESMP will be reviewed periodically to determine that its provisions are being implemented and to confirm that the planned measures effectively mitigate the predicted impacts. Findings will be reported to the relevant project or operation management teams, and the actions listed in the ESMP may be amended as necessary or in pursuit of continual improvement.

9.2 ESMP Operational Tools

The mitigation measures proposed to avoid or reduce the impacts of the GTA project are summarized in Tables 9-1 and 9-4 along with the primary roles for implementation and the monitoring of implementation as between BP and its contractors. Tables 9-1 to 9-3 list the mitigation measures for the impacts associated with routine activities of the project during the Construction Phase (Table 9-1), the Operations Phase (Table 9-2) and the Decommissioning Phase (Table 9-3). Table 9-4 is dedicated to the mitigation measures for the impacts associated with potential accidental events.

These four tables are operational tools for the implementation of the ESMP and for monitoring its implementation. They provide the following information for each component of the biophysical or the social environment that could be impacted:

- Listing of potential impacts;
- Country in which the impact could occur;
- Design and operational controls inherent to the project to mitigate the impacts;
- Specific mitigation measures to further avoid or reduce negative impacts with a significance rating over 1-Negligible;
- Rating of the residual impact;
- Objectively verifiable indicators of the implementation of the measures;
- Suggested source for verification of implementation;
- Recommended frequency of verification of implementation;
- Primary role in implementation of the measure;
- Primary role in monitoring implementation; and
- Cost of the implementation of the measure.

[169] All impacts with a rating higher than 1 – Negligible are included as potentially significant.

Because of their complexity and length, these tables are grouped at the end of this section.

The actions included in the ESMP may be refined at a later stage to reflect specific requirements or conditions arising from the detailed design. A case in point is the use of vessels of different sizes. Some of the regulations under MARPOL are applicable only to ships of 400 gross tonnage and above while other regulations are applicable to all ships. The intent of the measures related to MARPOL in the ESMP is to provide assurance that steps will be taken to reduce the potential for environmental and social impacts. The extent to which these measures apply to different vessels will differ with size. Smaller vessels will fall under facility-wide management plans (e.g. Contractor Environmental Management Plans). A vessel assurance process will be put in place that will check that vessels used meet specified standards and requirements.

It is important to note that most of the monitoring activities to be conducted by GTA Phase 1 project are through equipments/instruments/meters installed on the FPSO and FLNG. The cost associated with those are included in CAPEX and the use/maintenance of the equipment will be captured in project OPEX. The details of the OPEX costs for use and maintenance of meters are not available.

Another type of monitoring activities to be conducted by the project are those that are generally combined with other GTA Phase 1 maintenance/integrity inspection activities, e.g. seabed surveys. This approach is often adopted by the oil and gas industry to optimize vessels utilization time. Therefore, the cost of those campaigns will not be only associated to environmental activities. They will be captured in the OPEX cost.

The production sharing contracts/Joint Operating Agreements define the mechanism by which these OPEX costs are approved annually by all GTA's partners.

In Tables 9-1 to 9-4, some project Design & Operation Controls measures as well as some proposed mitigation measures recommend the preparation of further studies and plans. Table 9-5 gathers the list of these additional studies and plans announced in the measures as well as the approximate schedule expected for the preparation of these documents. Preliminary versions or outlines of some of these plans are included in this ESIA. For example, Appendix S provides a preliminary waste management plan, Appendix T provides a preliminary decommissioning plan and Section 9.5 provides an outline of the capacity building plan. Detailed versions of these plans will be prepared by BP.

Additional studies and plans relating to routine activities will be provided to the DCE and the Technical Committee upon request. Plans associated to accidental events prepared by BP will be discussed and forwarded to national authorities including the Ministry of Fisheries and Maritime Economy/Mauritanian Coast Guard and HASSMAR in Senegal. The relevant national authorities will be invited to the relevant exercises conducted by the project to test the applicable contingency plans. The sharing and presentation format such as thematic sessions will be determined with the relevant authorities depending on the nature of the plan.

9.3 ESMP Implementation

9.3.1 Framework

As indicated in Section 2.15, BP, as project operator, will implement operational procedures outlined in its project-specific Health, Safety, Security and Environment (HSSE) management plan for the GTA project. The purpose of the GTA project HSSE Management Plan is to define how the project-specific HSSE impacts and risks will be managed in conformance with applicable BP Group-wide HSSE requirements. Due to the size and complexity of the GTA project, delivery-specific HSSE plans may be developed to cover discrete construction activities (e.g., FPSO, breakwater construction, etc.). Compliance with the GTA project HSSE Management Plan will enable BP and its contractors to conduct project activities in a safe and environmentally sound manner.

The ESMP records the management measures that will be taken by the project in response to the impacts that have been identified. Design and operational control measures and mitigation actions will be incorporated and tracked through to completion in action tracking tools.

The project management team will regularly review the ESMP implementation to verify continuing suitability, adequacy, and effectiveness. Corrective actions will be identified and executed should:

- gaps be identified in the ESMP, and/or
- changing circumstances be encountered.

During the proposed project, BP and its contractors will establish and maintain communication between various levels of each organization. BP will be responsible for responding to requests from Mauritanian and Senegalese authorities regarding environmental performance.

A system of verification and oversight will be put in place to evaluate implementation and follow-up of the ESMP with the intent that actions and responsibilities identified are carried out, and amended as necessary to improve performance.

9.3.2 Roles and Responsibilities

The successful implementation of an ESMP is driven by the clarity of the roles and responsibilities given to contractors to undertake the actions presented in the ESMP. This requires the project management team to recognize the necessary resources required to implement and manage the ESMP for the project.

BP's contractors will be made aware of the ESMP and associated requirements and responsibilities during contract discussions and from the initial kickoff meetings to demobilization.

It is expected that BP and/or its contractors will have HSSE representatives aboard the drillship, the FPSO, at the nearshore hub/terminal and at the onshore supply bases. These HSSE representatives will be responsible for ensuring that the ESMP is implemented as planned, and/or for identifying and reporting changing circumstances if any.

Roles for each mitigation measure have been identified in Tables 9-1 to 9-4. During the Construction Phase, and possibly the Decommissioning Phase, contractors will carry out day-to-day operational delivery of the ESMP while BP will conduct oversight of the activities to help ensure the contractors' compliance with the ESMP. BP will also be responsible for engaging with relevant national authorities responsible for following up on the ESMP throughout the project.

Additionally, Mauritanian and Senegalese authorities may carry out external monitoring of the implementation of the ESMP according to their own national procedures and requirements.

Where contractors are conducting operational activities, they will have the direct responsibility to manage HSSE issues associated with those activities. The contractors will undertake regular HSSE inspections and ongoing review of compliance to the ESMP.

BP will review contractors' compliance with the ESMP and HSSE commitments in line with contract conditions, including bridging documentation, during the project. A specific BP HSSE manager will be appointed for the GTA project to oversee the implementation of the ESMP. The appointed BP GTA project HSSE manager will be responsible for internal reporting of environmental performance for review and as a basis for improving the actions identified in the ESMP.

The appropriate Mauritanian and Senegalese authorities, notably the DCE in Mauritania and the DEEC in Senegal, have oversight responsibility for reviewing documentation and the project compliance with the approved ESMP.

9.3.3 Conformance Monitoring and Performance Evaluation

BP will put in place systems to monitor ESMP results versus expectations, conformance with applicable HSSE policies, standards, and procedures, and compliance with regulatory requirements.

Non-conformance reporting and recording of HSSE events will be implemented as per regulatory requirements. All potentially serious events will be investigated and analyzed, and lessons learned from these investigations will be communicated internally, with corrective actions implemented as necessary. A common information system will be used for recording incidents including the following:

- Fuel and/or other hydrocarbon uncontrolled release into the environment;
- Collision with marine fauna;
- Unauthorized disposal of waste or other materials; and
- Incidents with other sea users.

Systematic assessments and/or inspections will be conducted in project locations to confirm conformance with defined HSSE policies, standards, and procedures, and compliance with current ESMP and regulatory requirements. The premise of such assessments or inspections is that they provide an acceptable means of verifying conformance to project standards, and compliance with regulations.

A continuous improvement program will be developed and implemented at project locations and will actively involve BP employees and the contractor workforce. The HSSE function will support BP management in assessing and analyzing problems and developing improvement plans or corrective actions.

As a result of continuous improvement, or during the course of the project lifetime, new practices, procedures or technologies may be proposed and adopted that require a revision of a currently identified action or source and frequency of verification in the ESMP. The intent of the original action will be taken into consideration in the decision of implementing such new practice, procedure or technology. An example of this is the potential use of drone technology in surveillance, environmental monitoring or in improving maritime safety.

9.3.4 Records and Reporting

Procedures will be developed in order to collect, analyze critical information and monitor improvements. Records will be maintained concerning conformance with the current ESMP and HSSE policies, standards, and procedures.

During the project, there will be operations and activities that may cause environmental impacts if not carried out correctly. Relevant activities will be reviewed prior to commencement to verify that appropriate protocols are in place for their execution. Records will be kept to provide a log of ESMP compliance during the project. A system will be put in place to manage these records and be accessible to BP throughout the project. These records will consist of, at a minimum, the following components:

- Permits, licenses, consents, certificates, registrations, and other authorizations;
- HSSE policy and emergency response documentation;
- Audit and inspection documentation;
- Training documentation (where appropriate); and
- Non-conformance reporting and recording of all HSSE events.

A number of additional reporting requirements are listed in the ESMP tables that follow.

Reviews of the ESMP will be conducted during the project to verify the implementation and effectiveness of the mitigation measures proposed in this ESIA:

- **ESMP Compliance Reviews** – Adherence to the ESMP and associated requirements will be evaluated by means of both the contractors and BP, and if necessary, audits. The frequency of these reviews will be determined for each of the three project phases. Managers will record and report the results of compliance reviews and any other self-verification/oversight processes to relevant parties.
- **HSSE Management Strategies Reviews** – Periodic senior management reviews of the HSSE management strategies will be conducted to assess the effectiveness of the system and to identify and implement system improvements.

On a periodical basis, BP will prepare ESMP Compliance Reports. The reports will provide a statement of compliance with the mitigation measures identified in Tables 9-1 to 9-4, with supporting notes. The ESMP Compliance Reports will be provided to Mauritanian and Senegalese authorities by BP.

9.4 Monitoring of the ESMP by the National Authorities

The implementation of the ESMP will be monitored by the Mauritanian and Senegalese authorities. A monitoring plan has been developed for this purpose. It is provided in Appendix U of this report. The purpose of this plan is to provide a monitoring tool to the authorities, detachable from the rest of the ESIA if needed. The plan covers both the monitoring of the implementation of the ESMP, presented in Chapter 9 of this report, and the monitoring of the implementation of the surveillance and monitoring plan (SMP), presented in Chapter 10.

The monitoring plan includes five tables that constitute operational tools for the authorities:

- Table U-1: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Construction Phase;
- Table U-2: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Operations Phase;
- Table U-3: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Decommissioning Phase;
- Table U-4: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Accidental events; and
- Table U-5: SMP Monitoring by the Mauritanian and Senegalese Authorities.

The following information are specified in the first four tables used for the monitoring of the ESMP:

- Potential impacts, by biophysical and social resource;
- Country where the impact could occur;
- Project Design & Operation Controls measures to mitigate impacts;
- Mitigation measures to avoid or reduce non-negligible negative impacts;
- Residual impact assessment;
- Operator monitoring elements (as a reminder);
- Authorities monitoring indicator;
- Monitoring activity to be carried out by the authorities;

- Authorities monitoring schedule;
- Potential institution responsible for monitoring in Mauritania;
- Potential institution responsible for monitoring in Senegal; and
- Cost of the monitoring activity by the authorities.

In Table U-5 for monitoring the SMP, the following information is provided:

- Potential impacts, by biophysical and social resource;
- Operator monitoring measures;
- Operator monitoring elements (as a reminder);
- Authorities monitoring indicator;
- Monitoring activity to be carried out by the authorities;
- Authorities monitoring schedule;
- Potential institution responsible for monitoring in Mauritania;
- Potential institution responsible for monitoring in Senegal; and
- Cost of the monitoring activity by the authorities.

In Mauritania, potential monitoring authorities may be identified by the DCE. In Senegal, potential monitoring authorities include the Technical Committee, including ANAM, DEEC, HASSMAR and the Ministry of Fisheries and Maritime Economy.

The monitoring activities to be carried out by the authorities include reading of monitoring reports and management plans provided by the GTA Phase 1 project as well as other project documents, and project facilities inspections and visits[170]. There are no monitoring costs associated with document reading. For inspections and visits, the GTA Phase 1 project plans for the transportation by boat or helicopter as used by the project personnel to reach the project facility and accommodation at the facility depending on the duration of the inspection/visit. The cost of this transportation and accommodation will be covered by the GTA Phase 1 project.

9.5 Capacity Building Plan

As expressed by the DCE in Mauritania, and the Technical Committee and the DEEC in Senegal, these public institutions need to build up capacities to monitor offshore oil and gas activities which are new to Senegal and recent to Mauritania.

Indeed, the countries lack environmental regulations applicable to offshore oil and gas activities. Existing onshore environmental regulations are not always appropriate to offshore projects, and therefore may need to be adapted. Additionally, the DCE and the Technical Committee currently lack mechanisms, and sufficient resources and capability to monitor the environmental performance of offshore oil and gas activities. Effective monitoring of projects on shore is an integral part of their day-to-day operations, and the DCE and the Technical Committee need to be able to extend this monitoring capacity to the offshore environment. Finally, the DCE, the Technical Committee and the DEEC which provides the secretariat for the Technical Committee, operate with limited resources with regards to the scope of their responsibilities and their day-to-day workload.

[170] A set of visits are planned in the monitoring plan. Inspections will be ad hoc visits by the authorities to verify information provided in the documents produced by the GTA Phase 1 project after review of these documents.

It is in this context that the ESIA Terms of Reference approved by DCE and DEEC in October 2016 require the ESIA to recommend measures for institutional capacity building relevant to the implementation of the ESMP and include the associated budget.

The current section of the ESIA provides an outline of the capacity building plan for the Mauritanian and Senegalese authorities for the monitoring of the ESMP and SMP. A detailed capacity building plan will be prepared by BP in 2019 in collaboration with the relevant authorities. The budget associated with the capacity building plan for the national authorities involved in the implementation of the ESMP is also included in the current ESIA.

The capacity building training program will aim at strengthening the capacity of the DCE and relevant authorities in Mauritania as well as of ANAM, HASSMAR and DEEC in Senegal to monitor environmental aspects of offshore oil and gas projects in general, and to monitor the implementation of the GTA Phase 1 project ESMP and SMP in particular. It could cover the following aspects:

- **Oil & gas awareness** going through the fundamental principles of hydrocarbons reservoir, drilling and evaluation of an exploration well, design, construction, and commissioning of facilities and production engineering & surface processing of produced fluids.
- **Environmental and Social Impact Assessment** covering the principles, methodologies and tools used to assess impacts from Oil & Gas activities and best practices.
- **Environmental Management Systems** (EMS) covering the various elements of an ISO 14001 type environmental management system, the environmental aspects and impacts of Oil and Gas operations, how to review and interpret an EMS and assess and monitor the impacts of the operations on the environment.
- **Oil spill preparedness and response** covering planning, responding and managing an oil spill.
- **Safety training** to be able to access offshore O&G facilities

In addition to the training program, the capacity building includes a technical support program for the DCE and the Technical Committee to support them in their monitoring of the ESMP and SMP. This technical support, which should be mutually agreed, could take the form, for example, of coaching from an expert or a consulting firm. The terms of reference and the selection process of the expert or the consulting firm will be determined based on agreed terms between the relevant authorities and the GTA Phase 1 project.

The budget associated with the capacity building plan in the ESIA is presented in Table 9-6. It amounts to US $ 900,000:

- US $ 450,000 for Mauritania; and
- US $ 450,000 for Senegal.

The budget includes two components: a training component totaling US $ 250,000 per country and a technical assistance program totaling US $ 200,000 per country. BP will strive to implement the capacity building plan as effectively as possible.

It should be noted that the capacity building plan mentioned in this section as well as its associated budget are conditional to a positive final investment decision by the GTA Phase 1 project.

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles.

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Multiple Components of the Biophysical and Social Environment - Design and Operational Control Measures							
D01	Contractors will be expected to comply with the contract terms that have been established, including HSSE standards and performance requirements.	Bridging document between BP HSSE and contractors HSE/HSSE requirements	Bridging document	Once, at contract execution	Contractors	BP	Included in project costs
D02	Compliance with applicable national and international regulations (MARPOL 73/78 Annex VI) and guidelines regarding emissions of nitrogen oxides (NOx) and sulphur oxides (SOx) from main project vessels.	Valid International Air Pollution Prevention Certificate (IAPPC) confirming compliance with both the equipment and operational requirements of Annex VI	Main vessels documentation	Once, before mobilization to site	Contractors	BP	Included in project costs
D03	An efficient flare burner head equipped with an appropriate combustion enhancement system will be selected with the intent of minimizing incomplete combustion, black smoke, and hydrocarbon fallout to the sea.	Flare burner head equipped with combustion enhancement system	Flare burner head/combustion enhancement system specifications documentation	Once, before start-up	Contractors	BP	Included in project costs
D04	Volumes of hydrocarbons flared will be recorded.	Emissions monitoring system installed	Drilling: Emissions monitoring system specifications	Drilling: Once, before execution of well flowback	Contractors	BP	Included in project costs
		Flare metering system installed	Flare metering system specifications described in the Basis of Design for the FLNG	FLNG: Once, before start-up	Contractors	BP	Included in project costs
		See Chapter 10: Surveillance and Monitoring Plan					

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D05	Compliance with applicable national and international regulations (MARPOL 73/78, Annex IV and V) for waste and wastewater discharges from offshore project vessels.	Valid International Sewage Pollution Prevention Certificate	Offshore project vessel documentation	Once each for offshore project vessels before mobilization	Contractor	BP	Included in project costs
		Waste management plan and waste record book	Offshore project vessel documentation	Once each for offshore project vessels before mobilization	Contractor	BP	Included in project costs
		Certificates for type approval of oil pollution prevention equipment, such as oily-water separating equipment, oil filtering equipment, process units and oil content meters	Offshore project vessel documentation	Once each for offshore project vessels before mobilization	Contractor	BP	Included in project costs
D06	A waste management plan will be developed and implemented to avoid unauthorized waste discharges and transfers, with written procedures for collection, segregation, storage, processing and disposal of waste, including use of equipment and record keeping.	Waste Management Plan (WMP) in place for both onshore and offshore facilities/vessels	WMP documentation	Before commencement of project construction	Contractor	BP	Included in project costs
D07	Waste not permitted to be discharged at sea (such as waste chemicals, cooking oils or lubricating oils, biomedical waste) will be transported onshore for transfer to an approved disposal facility[171] (in-country or an international provider).	Waste management plan with approved disposal route and management practices for each waste stream	WMP documentation	Before commencement of project construction	Contractor	BP	Included in project costs

[171] In this document, a treatment center can mean either a center for waste treatment or for final disposal.

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D08	Ballast water will be discharged according to IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM), where applicable.	Project vessels ballast water management procedures, and use of a record book, as appropriate (vessels >400 GT)	Project vessels documentation	Once each for offshore project vessels	Contractor	BP	Included in project costs
D09	Discharges of SBDF[172] mud and cuttings will be managed. SBDF cuttings will only be discharged once the performance targets of 6.9 g/100 g retained "synthetic on cuttings" on wet solids averaged over the whole well discharge can be satisfied. The concentration of SBDF on cuttings will be monitored on the drillship. No excess or spent SBDF will be discharged to the sea. Spent or excess SBDF that cannot be re-used during drilling operations will be brought back to shore for disposal. If mineral oil base drilling fluid (OPDF[173]) were to be selected, cuttings contaminated with mineral oil base drilling fluid at a concentration greater than 1% by weight mineral oil on dry cuttings will not be discharged. No OPDF will be discharged as whole fluid.	Drilling: Waste management plan describing equipment in place, specifications, and procedures for drill cuttings, muds and fluids management.	Drilling: Waste management plan.	Before drillship mobilization	Contractor/BP	BP	Included in project costs

[172] SBM: Synthetic Based Muds; SBDF: Synthetic Based Drilling Fluids.
[173] OPDF: Organic-Phase Drilling Fluids.

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D10	Selection of drilling chemicals will be in accordance with the BP chemical selection and waste management standards to reduce potential for environmental effect. Where feasible, lower toxicity drilling muds and biodegradable and environmentally friendly additives within muds, cements and completion fluids will be preferentially used. If barite is used as weighting agent, it will not contain more than: – Hg: max 1 mg/kg dry weight in stock barite and – Cd: max 3 mg/kg dry weight in stock barite.	Drilling chemicals chemical composition specifications included in Drilling and Completion Fluids Basis of Design	Drilling and Completion Fluids Basis of Design	Once for similar wells, or following a change of vendor or system	Contractor	BP	Included in project costs
D11	Completion and well workover fluids to be discharged overboard will be tested to confirm the fluids are suitable for discharge as required by applicable national and international regulations. Fluids that do not meet the specification would either be treated offshore or transported onshore for transfer to an approved disposal[174] facility (in-country or an international provider).	Specifications included in Drilling and Completion Fluids Basis of Design or Well Workover Plan	Drilling and Completion Fluids Basis of Design or Well Workover Plan	Once for similar wells, or following a change of vendor or system	Contractor	BP	Included in project costs

[174] In this document, a treatment center can mean either a center for waste treatment or for final disposal.

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D12	A pipeline and FLNG hydrotesting plan will be developed and implemented, detailing hydrotesting requirements, and demonstrating, based on an environmental risk assessment approach, the chemical additives to be selected as well as likely concentrations, volumes and frequencies of discharges. The plan will include a strategy to minimize environmental impact.	Subsea: Pre-commissioning execution plan includes environmental-risk based chemical selection and management.	Subsea: Pre-commissioning execution plan	Prior to operations phase (commissioning)	Contractor	BP	Included in project costs
		FPSO: Chemical selection specifications in Basis of Design	FPSO: Chemical Selection Plan	Prior to operations phase (commissioning)	Contractor	BP	Included in project costs
		FLNG: Chemical selection specifications in Basis of Design	FLNG: Basis of Design	Prior to operations phase (commissioning)	Contractor	BP	Included in project costs
		See Chapter 10: Surveillance and Monitoring Plan					

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D13	A dredging management plan will be developed for large dredging works (breakwater, disposal areas, potential sand borrow areas offshore) and implemented that defines the dredging methodology, identifies and assesses dredged materials disposal options and sites, characterizes the composition and behavior of the sediment to be dredged, and defines the area of influence and the potential mitigation and monitoring measures. In addition, pre- and post-dredged survey will be performed.	Dredging management plan	Dredging management plan	Once prior to each large dredging operation	Contractor	BP	Included in project costs
D14	Commitment to building Hub at approximately 10 to 11 km from shore with an intended benefit of limiting impact on the seagrass beds.	Final engineering documentation	Final engineering documentation	Once prior to initiation of Hub construction	Contractor	BP	Included in project costs
D15	The FLNG and FPSO will be designed, constructed, and operated to avoid routine flaring[175].	Flaring and Blowdown Philosophy for FPSO	Flaring and Blowdown Philosophy for FPSO	Once prior to initiation FPSO construction	Contractor	BP	Included in project costs
		Fuel Gas and flaring Philosophy for FLNG	Fuel Gas and flaring Philosophy for FLNG	Once prior to FLNG mobilization	Contractor	Contractor, BP	Included in project costs
D16	Lighting will be reduced to the extent that worker safety and safe & secure operations is not compromised. Reduction of light may include avoiding use of unnecessary lighting, shading, and downward lighting where possible.	Final engineering documentation	Final engineering documentation	Once prior to initiation of hub, FLNG and FPSO construction	Contractor	Contractor, BP	Included in project costs

[175] Routine flaring is defined in Section 7.3.1.

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D17	Development and implementation of a wildlife handling and rescue protocol for the FLNG and FPSO vessels and project patrol boats.	Wildlife handling and rescue protocol available on FLNG and FPSO and project patrol boats	Vessel documentation	Once prior to initiation of FLNG, FPSO and patrol boats mobilization	Contractor/BP	Contractor, BP	Included in project costs
		Induction program of vessel masters covers wildlife handling and rescue protocol	BP-provided training materials / vessel contractors' training logs	Once prior to initiation of, FPSO and patrol boats mobilization	Contractor/BP	Contractor, BP	Included in project costs
D18	The seabed in the project areas has been mapped as part of an extensive geophysical and geotechnical survey carried out by the project. The survey has confirmed that the project seabed infrastructure does not pose a risk to the submarine telecommunication cables.	Results of the geophysical and geotechnical survey	Geophysical and geotechnical survey reports	Once, before the Construction Phase starts	BP	BP	Included in project costs
D19	The relevant maritime, port or shipping authorities will be notified of all permanent offshore facilities as safety zones and routine shipping routes to be used by project-related vessels. Permanent facility locations will be demarcated on nautical charts.	Relevant maritime, port or shipping authorities notified of all permanent offshore facilities, as well as safety zones and routine shipping routes to be used by project-related vessels	Notification sent by the project to relevant maritime, port or shipping authorities	Once, before the Construction Phase starts and following changes in zoning	BP	BP	Included in project costs
D20	Project vessels will follow the Convention on International Regulations for Preventing Collisions at Sea (COLREGs) adopted by the IMO.	Project vessels procedures indicating that they follow COLREG	Project vessel documentation	Once, before the Construction Phase starts	Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D21	Main project vessels will be equipped with Universal Shipborne Automatic Identification System (AIS), a system of transponders installed on vessels which transmit over two dedicated digital marine VHF channels.	Main project vessels with AIS equipment	Project vessel documentation	Once, before the Construction Phase starts	Contractor	BP	Included in project costs
D22	Where there is a risk of vessel interaction, standard communication procedures will be used in international maritime traffic and shipping, aided by project patrol boats or standby vessels near the drilling, pipelay and Nearshore Hub/Terminal Area to prevent collision with larger vessels.	Communication procedures used by project vessels	Project vessel documentation	Once, before the Construction Phase starts	Contractor	BP	Included in project costs
		Proper demarcation of the exclusion safety zones	Documentary evidence of the demarcation of the exclusion safety zones	Once, before the Construction Phase starts and quarterly	Contractor, BP	BP	Included in project costs
D23	Information will be provided to the national industrial fishing fleet of both Mauritania and Senegal to communicate and record the exclusion safety zones and applicable navigational charts.	Information provided to national industrial fishing fleets on permanent exclusion safety zones and applicable navigational charts	Notification sent by the project to authorities in charge of or organizations representing national industrial fishing	Once, before the Construction Phase starts and following permanent changes in zoning	BP	BP	Included in project costs
D24	Exclusion safety zones will be demarcated on applicable navigational charts, and a communication procedure will be developed to communicate the location of the exclusion safety zones to the local fishing communities. This is intended to allow pirogues avoid the exclusion safety zones.	Location of exclusion safety zones communicated to local fishing communities	Records of information provided by the project to local fishing communities	Once, before the Construction Phase starts and Quarterly or as adjusted based on monitoring of exclusion zone breaches	BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D25	The seabed has been mapped as part of an extensive geophysical and geotechnical survey carried out by the project. The survey has not identified any shipwrecks or other maritime heritage on the seabed. Further seabed surveys are foreseen prior to dredging taking place.	Results of the geophysical and geotechnical surveys	Geophysical and geotechnical survey reports	Once, before the Construction Phase starts	Contractor/BP	BP	Included in project costs
		Dredging management plan specifying pre-dredge survey	Dredging management plan	Once, before the dredging takes place	Contractor/BP	BP	Included in project costs
D26	A site security plan will be developed that considers the security arrangements for each of the facilities including the modalities of support provided by government.	Owing to the sensitive nature, BP will not be in a position to share any details.					
D27	Expat workers and national workers will undergo a briefing to raise awareness on health risks, prevention and available treatment and their responsibilities. There will be an active screening and medical treatment program for workers.	Briefing of workers on health risks, prevention, treatment and responsibilities and medical screening and treatment program for workers	Workers health program documentation	Once, before and/or at the start of the Construction Phase starts	Contractor/BP	BP	Included in project costs
D28	The nature of the drilling, pipelay, FPSO and FLNG Construction Phase activities will reduce the need for onshore stay-overs of personnel.	Offshore workers accommodation arrangements for drilling and pipelay activities and construction of FPSO and FLNG minimize any onshore stay-overs in Saint-Louis and N'Diago	Workers accommodation arrangements in contractors' documentation	Once, before the Construction Phase starts	Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D29	Develop and implement a flaring protocol with the intention to meet defined operational combustion performance.	Drilling: Provisions for flaring specified in Completion and Well Flowback Basis of Design	Drilling: Completion and Well Flowback Basis of Design document	Once, before initial flaring is initiated	Contractor/BP	BP	Included in project costs
		Specifications in Flaring and Blowdown Philosophy for FPSO	Specifications in Flaring and Blowdown Philosophy for FPSO	Once, before initial flaring is initiated	Contractor/BP	BP	Included in project costs
		Specifications in Flaring and Blowdown Philosophy for FLNG	Specifications in Flaring and Blowdown Philosophy for FLNG	Once, before initial flaring is initiated	Contractor/BP	Contractor, BP	Included in project costs
Air Quality and Greenhouse Gases							
Impact: IMP01: Reduction in ambient air quality (NO_x and SO_x only) (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M01	Maintaining routine maintenance procedures to help ensure that engines are operating at defined operational performance and specified emissions levels.	Maintenance Program for project vessels	Maintenance record books or system	Regular checks for offshore project vessels as per maintenance program	Contractor	BP	Included in project costs
M02	Monitoring fuel consumption as a proxy for measuring performance and emissions. When practical, or as required by applicable regulations, vessel operators will be expected to utilize low-sulfur fuels to limit SOx production.	Contractor Environmental Management Plan to include monitoring of fuel consumption by fuel type	Emissions reporting system	Quarterly checks for offshore project vessels	Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Sediment Quality							
Impact: IMP06: Changes in bottom contours, grain size, and some chemical parameters from dredging activities and discharge of drilling muds and cuttings discharges (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M03	Dredged material and drill cuttings will not be disposed on or near carbonate mounds and away from coastal areas. The proposed pipeline route will avoid sensitive carbonate mounds.	Pre- and post-dredging survey reports	Survey report results	Once following completion of the post-dredging survey when the survey report becomes available	Contractor/BP	BP	Included in project costs
		Results of the geophysical and geotechnical surveys	Survey report results	Once before construction / drilling	BP	BP	Included in project costs
Benthic Communities							
Impacts: IMP08: Disturbance to benthic communities from resuspension and deposition of sediments in close proximity to dredging activities (Residual impact: 1 - Negligible) IMP09: Introduction of aquatic invasive species (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M03	Dredged material and drill cuttings will not be disposed on or near carbonate mounds and away from coastal areas. The proposed pipeline route will avoid sensitive carbonate mounds.	Pre- and post-dredging survey reports	Survey report results	Once following completion of the post-dredging survey when the survey report becomes available	Contractor/BP	BP	Included in project costs
		Results of the geophysical and geotechnical surveys	Survey report results	Once before construction / drilling	BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Birds							
Impact: IMP11: Incineration of individual birds from well stem test flaring at the drillship (Residual impact: 2 – Low)					**Country:** Mauritania and Senegal		
None	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Marine Mammals							
Impacts: IMP15: Auditory impairment due to sound from construction activities, particularly pile driving and VSP survey (Residual impact: 1 – Negligible) IMP16: Potential vessel strike resulting in marine mammal injury or mortality (Residual impact: 1 – Negligible)					**Countries:** Mauritania and Senegal		
M04	Seismic survey mitigation measures to be implemented during VSP survey(s) with the aim of minimizing the acoustic exposures to marine mammals (e.g. gradually increasing seismic source elements over a period of approximately 30 minutes until the operating level is achieved before any VSP activity begins).	Data Acquisition Plan will include procedures around soft start and marine mammal / turtle observations if required	Data Acquisition Plan	Once before each VSP survey	Contractor	BP	Included in project costs
M05	Sound mitigation measures will be implemented during pile driving (e.g. soft-starting [gradually increasing hammer power]).	Procedure for sound mitigation for pile driving	Construction Noise Management Plan	Once before pile driving activities	Contractor	BP	Included in project costs
M06	Vessel operators will implement vessel strike avoidance protocols to reduce the potential for vessel strike with marine mammals and sea turtles (including injured/dead protected species reporting).	Induction program of vessel masters covers vessel strike avoidance protocol	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M07	Collection and analysis of acoustic data from the area to determine background sound levels and marine mammal presence/absence, and underwater sound modeling to determine distances to various thresholds.	Underwater sound modeling report	Underwater sound modeling report	Once, following completion of the underwater sound modeling report	BP	BP	Included in project costs
Sea Turtles							
Impacts: IMP18: Avoidance or displacement from areas under construction for some species; attraction to other species as a foraging strategy; Noise disturbances from construction activities, particularly pile driving and VSP surveys; loss of foraging habitats from proposed construction (Residual impact: 1 – Negligible) IMP19: Potential vessel strike resulting in sea turtle injury or mortality (Residual impact: 1 – Negligible)					**Countries:** Mauritania and Senegal		
M04	Seismic survey mitigation measures to be implemented during VSP survey(s) with the aim of minimizing the acoustic exposures to marine mammals (e.g. gradually increasing seismic source elements over a period of approximately 30 minutes until the operating level is achieved before any VSP activity begins).	Data Acquisition Plan will include procedures around soft start and marine mammal / turtle observations if required	Data Acquisition Plan	Once before each VSP survey	Contractor	BP	Included in project costs
M05	Sound mitigation measures will be implemented during pile driving (e.g. soft-starting [gradually increasing hammer power]).	Procedure for sound mitigation for pile driving	Construction Noise Management Plan	Once before pile driving activities	Contractor	BP	Included in project costs
M06	Vessel operators will implement vessel strike avoidance protocols to reduce the potential for vessel strike with marine mammals and sea turtles (including injured/dead protected species reporting).	Induction program of vessel masters covers vessel strike avoidance protocol	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M07	Collection and analysis of acoustic data from the area to determine background sound levels and marine mammal presence/absence, and underwater sound modeling to determine distances to various thresholds.	Underwater sound modeling report	Underwater sound modeling report	Once, following completion of the underwater sound modeling report	BP	BP	Included in project costs
Threatened Species and Protected Areas							
Impacts: IMP22: Physical injuries and disturbances to threatened species (Residual impact: 2 – Low) IMP23: Disturbance, possible auditory injury, vessel strike to threatened species from vessels, operations (Residual impact: 2 – Low) IMP24: Introduction of non-native or invasive species (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M04	Seismic survey mitigation measures to be implemented during VSP survey(s) with the aim of minimizing the acoustic exposures to marine mammals (e.g. gradually increasing seismic source elements over a period of approximately 30 minutes until the operating level is achieved before any VSP activity begins).	Data Acquisition Plan will include procedures around soft start and marine mammal / turtle observations if required	Data Acquisition Plan	Once before each VSP survey	Contractor	BP	Included in project costs
M05	Sound mitigation measures will be implemented during pile driving (e.g. soft-starting [gradually increasing hammer power]).	Procedure for sound mitigation for pile driving	Construction Noise Management Plan	Once before pile driving activities	Contractor	BP	Included in project costs
M06	Vessel operators will implement vessel strike avoidance protocols to reduce the potential for vessel strike with marine mammals and sea turtles (including injured/dead protected species reporting).	Induction program of vessel masters covers vessel strike avoidance protocol	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M07	Collection and analysis of acoustic data from the area to determine background sound levels and marine mammal presence/absence, and underwater sound modeling to determine distances to various thresholds.	Underwater sound modeling report	Underwater sound modeling report	Once, following completion of the underwater sound modeling report	BP	BP	Included in project costs
Biodiversity							
See Mitigation Measures listed to mitigate impacts on Marine Mammals, Sea Turtles, Threatened Species and Protected Areas: M04, M05, M06 and M07							
Maritime Navigation							
Impact: IMP28: Risk of collision between project vessels and pirogues due to project vessels movements (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Construction Phase starts and Semi-annually thereafter	BP	BP	Included in project costs
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Construction Phase starts and Quarterly thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M10	Equip the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with radar or infrared systems that can detect small fishing vessels during poor visibility/night time.	Project vessels equipped with radar or infrared systems	Project vessels equipment listing	Once for offshore project vessels before mobilization	Contractor, BP	BP	Included in project costs
M11	Provide adequate lighting aboard the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with the intent of maintaining high visibility during poor visibility/night time. These vessels will also feature searchlights that can be used to shine on or signal approaching pirogues and foghorns for audible signaling.	Vessels well-lit during poor visibility or at night and equipped with searchlights	Project vessels equipment listing	Once, before offshore project vessel mobilization	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-agreed training materials / vessel contractors' training logs	Once, before offshore project vessel mobilization	Contractor, BP	BP	Included in project costs
M12	Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the exclusion safety zones.	Project patrol boat in place	Project vessels logs	Once, before the Construction Phase starts and Semi-annually	Contractor, BP	BP	Included in project costs
M13	Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.	FLOs in place aboard the project patrol boats, if and when necessary.	Project patrol boats Person on Board records	Once, at the beginning of the Construction Phase and Quarterly	Contractor, BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M14	Equipping the support vessels and the project patrol boat with lifesaving appliances approved by the Convention for Safety of Life at Sea (SOLAS) and IMO, which can be used to assist in rescuing fishermen in the water in line with international maritime protocols or in the event of an accident involving a pirogue with a project vessel. Assist with the rescue of any fishermen involved in a collision with a project vessel or following the capsizing of their vessel due to ship wake associated with project vessels.	Lifesaving appliances in place in project vessels and assistance to fishermen provided in the event of an accident with a project vessel	Project vessels equipment listings	Once, before the Construction Phase starts	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	Contractor, BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessels HSSE incident reports	After a reported incident	Contractor, BP	BP	Included in project costs
M15	In case of a collision, BP will inform as soon as possible the relevant national authorities: the Mauritanian Coast Guard (Garde Côte Mauritanienne) in Mauritania and HASSMAR in Senegal.	National authorities informed in case of a collision	Records of information provided by the project to national authorities	After a reported collision	BP	BP	Included in project costs
M16	Ensuring that each project vessel keeps records of maritime safety incidents with pirogues and other vessels, including near misses, and that these are subsequently shared with the project. BP will monitor maritime safety incidents and adjust, if required, project specific maritime safety rules, security and search & rescue arrangements in place.	Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessel HSSE incident reports	Quarterly	Contractor, BP	BP	Included in project costs
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Construction Phase starts and Quarterly	BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Construction Phase starts and Quarterly	BP/Contractor	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Construction Phase starts and Annually	BP	BP	Included in project costs
Artisanal Fisheries and Related Activities							
Impact: IMP29: Potential loss of artisanal fishing gears (nets and buoys) due to project vessels movements in artisanal fishing areas (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Construction Phase starts and Quarterly thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs
M12	Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the exclusion safety zones.	Project patrol boat in place	Project vessels logs	Once, before the Construction Phase starts and Semi-annually	Contractor, BP	BP	Included in project costs
M13	Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.	FLOs in place aboard the project patrol boats, if and when necessary	Project patrol boats Person on Board records	Once, at the beginning of the Construction Phase and Quarterly	Contractor, BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Construction Phase starts and Quarterly	BP	BP	Included in project costs
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Construction Phase starts and Quarterly	BP/Contractor	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Construction Phase starts and Annually	BP	BP	Included in project costs
M20	Develop and implement a framework for interaction with artisanal fisheries, with provisions covering engagement with local communities on access to fishing grounds, grievance and recourse mechanism for damage to fishing gear, environmental awareness building, livelihood enhancement and the role of community liaison officers.	Framework for interaction with artisanal fisheries developed and implemented	Framework documentation	Once, before the Construction Phase starts	BP	BP	Included in project costs
			Evidence of follow-up activities in conformance with Framework documentation	Annually	BP	BP	Included in project costs
M21	Project vessels to record incidents with fishing gears and report them to the project.	Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	BP	BP	Included in project costs
		Records of maritime incidents with other sea users kept by contractors	Contractor records of incidents with other sea users'	Quarterly	Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M22	To the extent feasible, establish a maritime corridor or speed restrictions for project vessels within artisanal fishing areas.	Induction program of vessel masters covers speed restrictions in areas of artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts and Semi-annually if needed	Contractors, BP	BP	Included in project costs
M23	Implement an environmental awareness building program in association with local schools and community groups.	Environmental awareness program implemented in local schools and community groups	Environmental awareness program records	Once, during or after the program is implemented	BP	BP	Included in project costs
M24	Provide technical assistance to mutually agreed marine resource research programs notably the national oceanographic research centers of both countries (CRODT and IMROP).	Technical assistance provided to marine resource research program with CRODT and IMROP	BP technical assistance records	Once, during or after the technical assistance is provided	BP	BP	Included in project costs
M27	Developing a social investment program to enhance project benefits for the directly affected N'Diago and Saint-Louis communities, including livelihood enhancement activities.	Social investment program to enhance project benefits for the communities of N'Diago and Saint-Louis developed	Social investment program documentation	Once, before the Construction Phase starts and Annually	BP	BP	Included in project costs
Community Health, Safety and Security							
Impact: IMP30: Risk of conflicts between artisanal fishermen and public security forces if some fishermen need to be escorted out of the exclusion safety zones (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Construction Phase starts and annually thereafter	BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Construction Phase starts and Quarterly	BP	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Construction Phase starts and Annually	BP	BP	Included in project costs
M25	The project will seek to work with the public security forces to establish an appropriate response and security framework which may include resource, equipment, training and response protocols.	Owing to the sensitive nature, BP will not be in a position to share any details.					
M26	Include in the security stakeholder engagement plan, provisions around response, management and interface with Public security forces for security incidents scenario such as act of terrorism and unlawful entry in the exclusion safety zones.	Owing to the sensitive nature, BP will not be in a position to share any details.					

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Public Infrastructure and Services							
Impact: IMP32: Placing additional demands on the public security forces limited resources since they will be required to be available 24/7 to handle a safety incident with artisanal fishermen or a search and rescue operation if needed (Residual impact: 1 – Negligible)					**Countries:** Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Construction Phase starts and annually thereafter	BP	BP	Included in project costs
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Construction Phase starts and Quarterly thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs
M10	Equip the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with radar or infrared systems that can detect small fishing vessels during poor visibility/night time.	Project vessels equipped with radar or infrared systems	Project vessels equipment listing	Once for offshore project vessels before mobilization	Contractor, BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M11	Provide adequate lighting aboard the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with the intent of maintaining high visibility during poor visibility/night time. These vessels will also feature searchlights that can be used to shine on or signal approaching pirogues and foghorns for audible signaling.	Vessels well-lit during poor visibility or at night and equipped with searchlights	Project vessels equipment listing	Once, before offshore project vessel mobilization	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-agreed training materials / vessel contractors' training logs	Once, before offshore project vessel mobilization	Contractor, BP	BP	Included in project costs
M12	Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the exclusion safety zones.	Project patrol boat in place	Project vessels logs	Once, before the Construction Phase starts and Semi-annually	Contractor, BP	BP	Included in project costs
M13	Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.	FLOs in place aboard the project patrol boats, if and when necessary	Project patrol boats Person on Board records	Once, at the beginning of the Construction Phase and Quarterly	Contractor, BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M14	Equipping the support vessels and the project patrol boat with lifesaving appliances approved by the Convention for Safety of Life at Sea (SOLAS) and IMO, which can be used to assist in rescuing fishermen in the water in line with international maritime protocols or in the event of an accident involving a pirogue with a project vessel. Assist with the rescue of any fishermen involved in a collision with a project vessel or following the capsizing of their vessel due to ship wake.	Lifesaving appliances in place in project vessels and assistance to fishermen provided in the event of an accident with a project vessel	Project vessels equipment listings	Once, before the Construction Phase starts	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	Contractor, BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessels HSSE incident reports	After a reported incident	Contractor, BP	BP	Included in project costs
M16	Ensuring that each project vessel keeps records of maritime safety incidents with pirogues and other vessels, including near misses, and that these are subsequently shared with the project. BP will monitor maritime safety incidents and adjust, if required, project specific maritime safety rules, security and search & rescue arrangements in place.	Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Construction Phase starts	BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessel HSSE incident reports	Quarterly	Contractor, BP	BP	Included in project costs
M25	The project will seek to work with the public security forces to establish an appropriate response and security framework which may include resource, equipment, training and response protocols.	Owing to the sensitive nature, BP will not be in a position to share any details.					

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M26	Include in the security stakeholder engagement plan, provisions around response, management and interface with Public security forces for security incidents scenario such as act of terrorism and unlawful entry in the exclusion safety zones.	Owing to the sensitive nature, BP will not be in a position to share any details.					
Social Climate							
Impact: IMP34: Social discontent in N'Diago and Saint-Louis due to the potential perception of loss of fishing grounds and fishing catches combined with the limited employment opportunities, the perception of unsatisfied grievances and/or compensation claims (e.g. for lost gear), and elevated safety risk for fishermen at sea due to presence of project vessels (Residual impact: 2 – Low)					**Countries:** Mauritania and Senegal		
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Construction Phase starts and Quarterly thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Construction Phase starts and Quarterly	BP	BP	Included in project costs
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Construction Phase starts and Quarterly	BP/Contractor	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Construction Phase starts and Annually	BP	BP	Included in project costs
M20	Develop and implement a framework for interaction with artisanal fisheries, with provisions covering engagement with local communities on access to fishing grounds, grievance and recourse mechanism for damage to fishing gear, environmental awareness building, livelihood enhancement and the role of community liaison officers.	Framework for interaction with artisanal fisheries developed and implemented	Framework documentation	Once, before the Construction Phase starts	BP	BP	Included in project costs
			Evidence of follow-up activities in conformance with Framework documentation	Annually	BP	BP	Included in project costs
M23	Implement an environmental awareness building program in association with local schools and community groups.	Environmental awareness program implemented in local schools and community groups	Environmental awareness program records	Once, during or after the program is implemented	BP	BP	Included in project costs
M24	Provide technical assistance to mutually agreed marine resource research programs notably the national oceanographic research centers of both countries (CRODT and IMROP).	Technical assistance provided to marine resource research program with CRODT and IMROP	BP technical assistance records	Once, during or after the technical assistance is provided	BP	BP	Included in project costs
M27	Developing a social investment program to enhance project benefits for the directly affected N'Diago and Saint-Louis communities, including livelihood enhancement activities.	Social investment program to enhance project benefits for the communities of N'Diago and Saint-Louis developed	Social investment program documentation	Once, before the Construction Phase starts and Annually	BP	BP	Included in project costs

Table 9-1. ESMP-Construction Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M28	Engaging in an on-going dialogue with national, regional and local authorities to monitor the social climate in the local communities in order to help identify and support, if needed, ad hoc measures to prevent social discontent linked to project activities and its escalation into conflicts.	Periodic meetings between project representatives and national, regional and local authorities to monitor the social climate and, if needed, identification of support to ad hoc measures to prevent social discontent linked to project activities	Project meeting records	Once, before the Construction Phase starts and semi-annually	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles.

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Multiple Components of the Biophysical and Social Environment - Design and Operational Control Measures							
D01	Contractors will be expected to comply with the contract terms that have been established, including HSSE standards and performance requirements.	Bridging document between BP HSSE and contractors HSE/HSSE requirements	Bridging document	Once, at contract execution	Contractors	BP team	Included in project costs
D02	Compliance with applicable national and international regulations (MARPOL 73/78 Annex VI) and guidelines regarding emissions of nitrogen oxides (NOx) and sulphur oxides (SOx) from main project vessels.	Valid International Air Pollution Prevention Certificate (IAPPC) confirming compliance with both the equipment and operational requirements of Annex VI	Main vessels documentation	Once, before mobilization to site	Contractors, BP	BP team	Included in project costs
D04	Volumes of hydrocarbons flared will be recorded.	See Chapter 10: Surveillance and Monitoring Plan					
D05	Compliance with applicable national and international regulations (MARPOL 73/78, Annex IV and V) for waste and wastewater discharges from offshore project vessels.	Valid International Sewage Pollution Prevention Certificate	Offshore project vessel documentation	Once each for offshore project vessels before mobilization	Contractors, BP	BP	Included in project costs
		Waste management plan and waste record book	Offshore project vessel documentation	Once each for offshore project vessels before mobilization	Contractors, BP	BP	Included in project costs
		Certificates for type approval of oil pollution prevention equipment, such as oily-water separating equipment, oil filtering equipment, process units and oil content meters	Offshore project vessel documentation	Once each for offshore project vessels before mobilization	Contractors, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D06	A waste management plan will be developed and implemented to avoid unauthorized waste discharges and transfers, with written procedures for collection, segregation, storage, processing and disposal of waste, including use of equipment and record keeping.	Waste Management Plan (WMP) in place for both onshore and offshore facilities/vessels	WMP documentation	Before commencement of project operations followed by regular Duty of Care audits as required by law or based on monitoring performance	Contractors, BP	BP	Included in project costs
D07	Waste not permitted to be discharged at sea (such as waste chemicals, cooking oils or lubricating oils, biomedical waste) will be transported onshore for transfer to an approved disposal facility[176] (in-country or an international provider).	Waste management plan with approved disposal route and management practices for each waste stream	WMP documentation	Before commencement of project operations followed by regular Duty of Care audits as required by law or based on monitoring performance	Contractors, BP	BP	Included in project costs

[176] In this document, a treatment center can mean either a center for waste treatment or for final disposal.

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D11	Completion and well workover fluids to be discharged overboard will be tested to confirm the fluids are suitable for discharge as required by applicable national and international regulations. Fluids that do not meet the specification would either be treated offshore or transported onshore for transfer to an approved disposal[177] facility (in-country or an international provider).	Specifications included in Drilling and Completion Fluids Basis of Design or Well Workover Plan	Drilling and Completion Fluids Basis of Design or Well Workover Plan	Once for similar wells, or following a change of vendor or system	Contractor	BP	Included in project costs
D15	The FLNG and FPSO will be designed, constructed, and operated to avoid routine flaring[178].	Flaring and Blowdown Philosophy for FPSO	Flaring and Blowdown Philosophy for FPSO	Once prior to initiation FPSO construction	Contractor	BP	Included in project costs
		Fuel Gas and flaring Philosophy for FLNG	Fuel Gas and flaring Philosophy for FLNG	Once prior to FLNG mobilization	Contractor	Contractor, BP	Included in project costs
D16	Lighting will be reduced to the extent that worker safety and safe & secure operations is not compromised. Reduction of light may include avoiding use of unnecessary lighting, shading, and downward lighting where possible.	Vessel operational procedures restrict unnecessary lighting	Project Vessel operational procedures	Once prior to initiation of FLNG and FPSO operations	BP	BP	Included in project costs
D17	Development and implementation of a wildlife handling and rescue protocol for the FLNG and FPSO vessels and project patrol boats.	Wildlife handling and rescue protocol available on FLNG and FPSO and project patrol boats	Project Vessel documentation	Once prior to initiation of FLNG, FPSO and patrol boat operations	BP	BP	Included in project costs

177 In this document, a treatment center can mean either a center for waste treatment or for final disposal.
178 Routine flaring is defined in Section 7.3.1

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D19	The relevant maritime, port or shipping authorities will be notified of all permanent offshore facilities as safety zones and routine shipping routes to be used by project-related vessels. Permanent facility locations will be demarcated on nautical charts.	Relevant maritime, port or shipping authorities notified of all permanent offshore facilities, as well as safety zones and routine shipping routes to be used by project-related vessels	Notification sent by the project to relevant maritime, port or shipping authorities	Once, before the Operations Phase starts and following changes in zoning	BP	BP	Included in project costs
D20	Project vessels will follow the Convention on International Regulations for Preventing Collisions at Sea (COLREGs) adopted by the IMO.	Project vessels procedures indicating that they follow COLREG	Project vessel documentation	Once, before the Operations Phase starts and before mobilization of new vessels	Contractors, BP	BP	Included in project costs
D21	Main project vessels will be equipped with Universal Shipborne Automatic Identification System (AIS), a system of transponders installed on vessels which transmit over two dedicated digital marine VHF channels.	Main project vessels with AIS equipment	Project vessel documentation	Once, before the Operations Phase starts and before mobilization of new vessels	Contractors, BP	BP	Included in project costs
D22	Standard communication procedures will be used in international maritime traffic and shipping, aided by project patrol boats or standby vessels near the drilling, pipelay and Nearshore Hub/Terminal Area to prevent collision with larger vessels.	Communication procedures used by project vessels	Project vessel documentation	Once, before the Operations Phase starts and before mobilization of new vessels	Contractors, BP	BP	Included in project costs
		Proper demarcation of the exclusion safety zones	Visual recognition of the demarcation of the exclusion safety zones	Once, before the Operations Phase starts and Annually	Contractors, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D23	Information will be provided to the national industrial fishing fleet of both Mauritania and Senegal to communicate and record the exclusion safety zones and applicable navigational charts.	Information provided to national industrial fishing fleets on permanent exclusion safety zones and applicable navigational charts	Notification sent by the project to authorities in charge of or organizations representing national industrial fishing	Once, before the Operations Phase starts and following permanent changes in zoning	BP	BP	Included in project costs
D24	Exclusion safety zones will be demarcated on applicable navigational charts, and a communication procedure will be developed to communicate the location of the exclusion safety zones to the local fishing communities. This is intended to allow pirogues to avoid the exclusion safety zones.	Location of exclusion safety zones communicated to local fishing communities	Records of information provided by the project to local fishing communities	Once, before the Operations Phase starts and Annually or as adjusted based on monitoring of exclusion zone breaches	BP	BP	Included in project costs
D25	The seabed has been mapped as part of an extensive geophysical and geotechnical survey carried out by the project. The survey has not identified any shipwrecks or other maritime heritage on the seabed. Further seabed surveys are foreseen prior to dredging taking place.	Pre-dredge surveys do not reveal any unidentified shipwrecks or other maritime heritage.	Pre-dredging seabed-survey reports	Once, before the Operations Phase starts	BP	BP	Included in project costs
D26	A site security plan will be developed that considers the security arrangements for each of the facilities including the modalities of support provided by government.	Owing to the sensitive nature, BP will not be in a position to share any details.					

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D27	Expat workers and national workers will undergo a briefing to raise awareness on health risks, prevention and available treatment and their responsibilities. There will be an active screening and medical treatment program for workers.	Briefing of workers on health risks, prevention, treatment and responsibilities + medical screening and treatment program for workers	Workers health program documentation	Once, before and/or at the start of the Operation Phase starts or as adjusted based on outcome of screening program.	Contractor/BP	BP	Included in project costs
D29	Develop and implement a flaring protocol with the intention to meet defined operational combustion performance.	Specifications in Flaring and Blowdown Philosophy for FPSO	Specifications in Flaring and Blowdown Philosophy for FPSO	Once, before initial flaring is initiated or as adjusted based on monitoring performance	BP	BP	Included in project costs
		Specifications in Flaring and Blowdown Philosophy for FLNG	Specifications in Flaring and Blowdown Philosophy for FLNG	Once, before initial flaring is initiated or as adjusted based on monitoring performance	Contractor/BP	Contractor, BP	Included in project costs
D30	Implementation of leak detection and repair programs for fugitive emissions.	Leak detection and repair programs for fugitive emissions	Leak detection and repair programs documentation	Specific to equipment	Contractors, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D31	Implementation of technically feasible and cost-effective measures to optimize energy efficiency and air emissions on the FPSO and FLNG. This could include where feasible waste heat recovery, flare gas recovery, vapor recovery and selected method of export compression on the FPSO, and boil-off gas recovery and control of fugitive emissions through design of the FPSO and FLNG.	Energy efficiency and air emissions measures adopted for the FLNG as specified in Basis of Design documentation	Basis of Design documentation for FLNG	Once, before the Operations Phase starts	Contractor	Contractor, BP	Included in project costs
		BPEO for energy efficiency highlights energy efficiency measures Energy efficiency and air emissions measures adopted for the FPSO as specified in Basis of Design documentation	BPEO for energy efficiency for FPSO Basis of Design documentation for FPSO	Once, before the Operations Phase starts	Contractor	BP	Included in project costs
D32	Use of project-produced gas as preferred fuel for FLNG, FPSO and QU processes instead of diesel or crude oil.	Preferential use of project-produced gas specified in Basis of Design of FPSO	Basis of Design of FPSO	Once, before the Operations Phase starts	BP	BP	Included in project costs
		QU Functional Specifications addresses preference for fuel gas	QU Functional Specifications	Once, before the Operations Phase starts	BP	BP	Included in project costs
		Fuel gas philosophy for FLNG	Fuel gas philosophy for FLNG	Once, before the Operations Phase starts	Operator, BP	Operator, BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D33	Aggregate greenhouse gas emissions from all offshore project facilities will be quantified annually in accordance with internationally recognized methodologies. The FPSO and FLNG will have fuel flow or emissions metering systems installed for equipment rated at 10 MW thermal or above. A predictive emission monitoring system (PEMS) will be used on equipment rated 10 MW thermal or above for the calculation of emissions of GHG, SOx and NOx.	See Chapter 10: Surveillance and Monitoring Plan					
		Fuel flow or emissions metering systems and PEMS installed on relevant equipment on the FPSO and FLNG	Basis of Design documentation for FPSO and FLNG (or equivalent)	Annually	Contractors, BP	BP	Included in project costs
D34	LNG and condensate carriers are expected to discharge ballast water according to the IMO International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM).	Compliance with ballast water management procedures, and use of a record book, as appropriate (vessels >400 GT)	LNG and condensate carrier vessel documentation	As per contractual obligation	Contractor	BP	Included in project costs
D35	FPSO and FLNG vessel will be certified according to Class and Flag requirements before leaving the shipyard. The vessels will be double-hulled.	Compliance with IMO inspection and certification requirements Subject to FLNG classification requirement during Operations Phase	FPSO and FLNG certification as maintained in vessel documentation	Once, prior to vessel arrival on site	Contractor	BP	Included in project costs
D36	An inspection and maintenance program will be developed and implemented with the intent of maintaining mechanical integrity of equipment, piping, relief and vent systems and devices, emergency shutdown systems, controls, pumps and instrumentation, and prevent uncontrolled releases of hazardous or polluting materials from the project.	Inspection and maintenance program for mechanical integrity and prevention of uncontrolled releases	Inspection and Maintenance Strategy	As frequently as determined by each respective inspection and maintenance program	Contractor, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D37	Chemicals used in the production process, flow assurance, maintenance, well intervention and management, desalination and fire management systems will be selected and managed with the intent to reduce the potential for environmental effects.	Selection and management of chemicals with reduced environmental effect potential	Chemical management procedure for FPSO	Once before start-up	BP	BP	Included in project costs
		Selection and management of chemicals with reduced environmental effect potential	Basis of design for FLNG	Once before start-up	Operator, BP	Operator, BP	Included in project costs
D38	If dredging activities are required for maintenance during the Operations Phase, a dredging management plan will be developed and implemented that defines the maintenance dredging methodology, identifies and assesses dredged materials disposal options and sites, characterized the chemical and physical composition and behavior of the sediment to be dredged, and defines the area of influence and the potential mitigation and monitoring measures.	Adherence to proper dredging methodology; selection of appropriate disposal options/sites; characterization of dredged sediment; identification of area of influence and potential mitigation and monitoring	Dredging management plan	Prior to any scheduled dredging operation	Contractor	BP	Included in project costs
D39	Given the principle of the need for parity either side of the border, the project has selected a location and design for the Nearshore/Hub terminal that has both the most beneficial and least potential adverse effect on the shoreline morphology of the options reviewed, while meeting the required conditions for safe approach of LNG carriers, subsequent mooring and operation of the facility (see Section 5.2.6).	Location and design of the Nearshore Hub/Terminal	Final FEED documentation	Once prior to initiation of operations	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D40	The location of project facilities at some distance offshore from the protected areas avoids most direct and indirect impacts from routine activities.	Location of project facilities	Final FEED documentation	Once prior to initiation of operations	BP	BP	Included in project costs
Air Quality and Greenhouse Gases							
Impact: IMP02: Reduction in ambient air quality (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M01	Maintaining routine maintenance procedures to help ensure that engines are operating at defined operational performance and specified emissions levels.	Maintenance Program for project vessels	Maintenance record books or system	As determined by each respective inspection and maintenance program and as adjusted following monitoring performance	Contractor	BP	Included in project costs
M02	Monitoring fuel consumption as a proxy for measuring performance and emissions. When practical, or as required by applicable regulations, vessel operators will be expected to utilize low-sulfur fuels to limit SOx production.	Fuel consumption records by fuel type and vessel	Emissions reporting system	Annual checks for offshore project vessels	Contractors, BP	BP	Included in project costs
M29	Use of dry low emissions (DLE) gas turbine drivers for the main refrigeration compressors on the FLNG.	Use of dry low emission technology on the FLNG	Basis of Design documentation for FLNG	Once prior to initiation of operations	Contractor	BP	Included in project costs
M30	Conduct monitoring of baseline air quality prior to the Construction Phase at receptor level to establish ground-level ambient air concentrations. Update air dispersion modelling if necessary when equipment specifications from vendors are available in detailed design phase.	See Chapter 10: Surveillance and Monitoring Plan					

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M31	Tug boats and other project support vessels not in operational use and moored at the Hub facility will be connected to electrical power provided by the Hub to the extent practical.	Tug boats and other project support vessels not in operational use and moored at the hub facility to be connected to electrical power provided by the QU platform Induction program of tug vessel masters covers mooring arrangements	BP-provided training materials / vessel contractors' training logs	Once prior to initiation of operations and before mobilization of new tug vessels	BP	BP	Included in project costs
Water Quality							
Impacts: IMP03: Reduction in ambient water quality from produced water and FLNG cooling water discharges and associated chemicals (Residual Impact: 2 – Low) IMP04: Changes in water quality from accidental loss of trash and debris (Residual Impact: 1 – Negligible)					**Countries:** Mauritania and Senegal		
M32	The seawater intake depth at the FLNG will be optimized to reduce the heated water plume. Cooling water effluent will not result in a temperature change of more than 3°C at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors, and assimilative capacity.	Seawater temperature change of less than 3°C at the edge of the mixing zone	FLNG Seawater cooling system philosophy	Once before performance acceptance test	Contractor	Contractor, BP	Included in project costs
M33	Monitoring use of added chemicals to produced water stream (corrosion inhibitors, scale inhibitors, coagulants/flocculants).	Quantity of added chemicals to the produced water discharge	Chemical dosage specifications and records	Annually	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M34	Verifying compliance with MARPOL Convention and implementation of a waste management plan, with the intent of reducing the likelihood of accidental loss.	Compliance with MARPOL restrictions for accidental solid waste loss, including implementation of a Waste Management Plan	Project vessels contractors Waste Management Plan	Annually for each project vessel	BP	BP	Included in project costs
M35	The seawater intake depth at the FPSO will be designed with the intent to reduce the need for use of antifoulant chemicals.	Seawater intake depth at the FPSO optimized to reduce the need for use of antifoulant chemicals	Final FEED documentation	Once prior to initiation of operations	BP	BP	Included in project costs
M36	Free chlorine in FLNG cooling water discharges to be sampled at point of discharge will be maintained below 0.2 parts per million (ppm).	Residual chlorine sampling point installed	FLNG Basis of Design documentation	Once prior to initiation of operations	BP	BP	Included in project costs
M37	Produced water will be treated prior to discharge with sufficient treatment. Oil and grease content of the produced water effluent discharge at sea will be compliant with applicable regulation and not exceed 42 mg/L daily maximum; 29 mg/L monthly average.	Produced water treatment system meeting specifications installed with in-line oil-in-water monitor	FPSO Basis of Design documentation	Once prior to initiation of operations	Contractor	BP	Included in project costs
M38	Produced water effluent quality will be monitored. The first 18 months of monitoring data will be used to assess the likely impacts of the effluent upon the receiving water body using an Environmental Risk Assessment approach, which is to be repeated following a material change in effluent composition or volume.	See Chapter 10: Surveillance and Monitoring Plan					
M39	The discharge of cooling water will be designed to reduce recirculation.	Optimization of cooling water discharge to reduce recirculation	FLNG Thermal recirculation study report	Once prior to initiation of operations	Contractor	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Coastal Erosion							
Impact: IMP05: Accretion or reduction in natural erosion of the Langue de Barbarie (relative to the case without the breakwater) of up to 13 m over 10 years near the Mauritania-Senegal border and extending southward approximately 8 km, accompanied by a maximum increase in coastal erosion rate (relative to the case without the breakwater) of approximately 6 m over 10 years further south, along approximately 2 km of coast, starting from the south end of the Hydrobase neighborhood (Residual Impact: 2 – Low)					**Country**: Senegal		
M40	a) To improve understanding of the long-term coastal dynamic equilibrium, the project will develop and implement a coastline monitoring plan during the project life cycle. Coastline monitoring will commence prior to breakwater construction, i.e. before 2020. This will include the collection of further bathymetric data along the Saint-Louis shore, including the Senegal River mouth. The project will aim to involve local academics in the implementation of the coastline monitoring plan. The relevant authorities and local communities will be informed of the monitoring results. b) The data collected as part of the implementation of the coastline monitoring plan will be used to update the coastline modeling (in Appendix I-3) to be completed before the construction of the breakwater in 2020. Additional modeling updates will be conducted at key stages of the project life cycle when new information with the potential to have a significant impact on the modeling results	See Chapter 10: Surveillance and Monitoring Plan					

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
	will become available. c) BP will seek the necessary authorizations to share relevant data for government led morphological studies initiatives and local academics. d) a contingency plan for the coastline will be developed by the project in consultation with the relevant authorities if the results of the coastline monitoring and modeling clearly and systematically demonstrate, over the duration of the project, negative impacts related to the GTA Phase 1 project which exceeds those currently identified in the GTA Phase 1 project ESIA report (in particular Section 7.3.3)						
M41	Provide specialist assistance to studies led by local or national authorities on Saint-Louis coastal management.	Specialist assistance provided to improve local coastal management processes	Project documentation	Once after technical assistance is provided	BP	BP	Included in project costs
Sediment Quality							
Impact: IMP07: Potential chemical leaching of solid waste materials and localized organic loading from epibiota (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M34	Verifying compliance with MARPOL Convention and implementation of a waste management plan, with the intent of reducing the likelihood of accidental loss.	Compliance with MARPOL restrictions for accidental solid waste loss, including implementation of a Waste Management Plan	Project vessels contractors Waste Management Plan	Annually for each project vessel	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Plankton & Fish and Other Fishery Resources							
Impact: IMP10: Entrainment and impingement of plankton and adult fish in FLNG cooling water at Nearshore Hub/Terminal. Entrainment and impingement of plankton and adult fish by FPSO (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M42	The seawater intake of the cooling water systems will be positioned taking into account technical constraints and appropriate screens or velocity caps will be fitted, if safe and practical, with the intent of avoiding entrainment and impingement of marine flora and fauna. The intake velocity will be below 1.0 m/s.	Seawater intake optimized to minimize entrainment, safety considerations not withstanding as per FLNG seawater cooling system philosophy	FLNG Seawater cooling system philosophy	Once before performance acceptance test	Contractor	Contractor, BP	Included in project costs
Birds							
Impacts: IMP12: Incineration of birds during flaring from the FPSO and FLNG during non-routine conditions (Residual Impact: 2 – Low) IMP13: Potential vessel strike resulting in bird injury or mortality (Residual Impact: 2 – Low) IMP14: Effects of routine vessel and facility discharges during operations impacting birds directly or indirectly (Residual Impact: 1 – Negligible)					**Countries:** Mauritania and Senegal		
M33	Monitoring use of added chemicals to produced water stream (corrosion inhibitors, scale inhibitors, coagulants/flocculants).	Quantity of added chemicals to the produced water discharge	Chemical dosage specifications and records	Annually	Contractors, BP	BP	Included in project costs
M35	The seawater intake depth at the FPSO will be designed with the intent to reduce the need for use of antifoulant chemicals.	Seawater intake depth at the FPSO optimized to reduce the need for use of antifoulant chemicals	Final FEED documentation	Once prior to initiation of operations	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M36	Free chlorine in FLNG cooling water discharges to be sampled at point of discharge will be maintained below 0.2 parts per million (ppm).	Residual chlorine sampling point installed	FLNG Basis of Design documentation	Once prior to initiation of operations	BP	BP	Included in project costs
M37	Produced water will be treated prior to discharge with sufficient treatment. Oil and grease content of the produced water effluent discharge at sea will be compliant with applicable regulation and not exceed 42 mg/L daily maximum; 29 mg/L monthly average.	Produced water treatment system meeting specifications installed with in-line oil-in-water monitor	FPSO Basis of Design documentation	Once prior to initiation of operations	Contractor	BP	Included in project costs
M38	Produced water effluent quality will be monitored. The first 18 months of monitoring data will be used to assess the likely impacts of the effluent upon the receiving water body using an Environmental Risk Assessment approach, which is to be repeated following a material change in effluent composition or volume.	See Chapter 10: Surveillance and Monitoring Plan					
M39	The discharge of cooling water will be designed to reduce recirculation.	Optimization of cooling water discharge to reduce recirculation	FLNG Thermal recirculation study report	Once prior to initiation of operations	Contractor	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Marine Mammals							
Impacts: IMP16: Potential vessel strike resulting in marine mammal injury or mortality (Residual Impact: 1 – Negligible) IMP17: Avoidance or displacement from vessel traffic or the FPSO; Noise disturbances from operations (liquefaction of LNG and transfer operations) (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M06	Vessel operators will implement vessel strike avoidance protocols to reduce the potential for vessel strike with marine mammals and sea turtles (including injured/dead protected species reporting).	Induction program of vessel masters covers vessel strike avoidance protocol	BP-provided training materials / vessel contractors' training logs	Once, before mobilization of vessels	Contractor	BP	Included in project costs
Sea Turtles							
Impacts: IMP19: Potential vessel strike resulting in sea turtle injury or mortality (Residual Impact: 1 – Negligible) IMP20: Avoidance or displacement from vessel traffic or the FPSO; Noise disturbances from operations (liquefaction of LNG and transfer operations) (Residual Impact: 2 – Low) IMP21: Direct and indirect effects of routine vessel discharges during operations (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M06	Vessel operators will implement vessel strike avoidance protocols to reduce the potential for vessel strike with marine mammals and sea turtles (including injured/dead protected species reporting).	Induction program of vessel masters covers vessel strike avoidance protocol	BP-provided training materials / vessel contractors' training logs	Once, before mobilization of vessels	Contractor	BP	Included in project costs
M33	Monitoring use of added chemicals to produced water stream (corrosion inhibitors, scale inhibitors, coagulants/flocculants).	Quantity of added chemicals to the produced water discharge	Chemical dosage specifications and records	Annually	Contractors, BP	BP	Included in project costs
M35	The seawater intake depth at the FPSO will be designed with the intent to reduce the need for use of antifoulant chemicals.	Seawater intake depth at the FPSO optimized to reduce the need for use of antifoulant chemicals	Final FEED documentation	Once prior to initiation of operations	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M36	Free chlorine in FLNG cooling water discharges to be sampled at point of discharge will be maintained below 0.2 parts per million (ppm).	Residual chlorine sampling point installed	FLNG Basis of Design documentation	Once prior to initiation of operations	BP	BP	Included in project costs
M37	Produced water will be treated prior to discharge with sufficient treatment. Oil and grease content of the produced water effluent discharge at sea will be compliant with applicable regulation and not exceed 42 mg/L daily maximum; 29 mg/L monthly average.	Produced water treatment system meeting specifications installed with in-line oil-in-water monitor	FPSO Basis of Design documentation	Once prior to initiation of operations	Contractor	BP	Included in project costs
M38	Produced water effluent quality will be monitored. The first 18 months of monitoring data will be used to assess the likely impacts of the effluent upon the receiving water body using an Environmental Risk Assessment approach, which is to be repeated following a material change in effluent composition or volume.	See Chapter 10: Surveillance and Monitoring Plan					
M39	The discharge of cooling water will be designed to reduce recirculation.	Optimization of cooling water discharge to reduce recirculation	FLNG Thermal recirculation study report	Once prior to initiation of operations	Contractor	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Threatened Species and Protected Areas							
Impacts: IMP23: Disturbance, possible auditory injury, vessel strike to threatened species from vessels, operations (Residual Impact: 1 – Negligible) IMP24: Introduction of non-native or invasive species (Residual Impact: 2 – Low) IMP25: Behavioral disturbances to fauna within protected areas or other areas of conservation interest (Residual Impact: 2 – Low) IMP26: Behavioral disturbances to threatened species (Residual Impact: 2 – Low) IMP27: Increase in airborne contaminants in protected areas or other areas of conservation interest (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M01	Maintaining routine maintenance procedures to help ensure that engines are operating at defined operational performance and specified emissions levels.	Maintenance Program for project vessels	Maintenance record books or system	As determined by each respective inspection and maintenance program and as adjusted following monitoring performance	Contractor	BP	Included in project costs
M02	Monitoring fuel consumption as a proxy for measuring performance and emissions. When practical, or as required by applicable regulations, vessel operators will be expected to utilize low-sulfur fuels to limit SOx production.	Fuel consumption records by fuel type and vessel	Emissions reporting system	Annual checks for offshore project vessels	Contractors, BP	BP	Included in project costs
M06	Vessel operators will implement vessel strike avoidance protocols to reduce the potential for vessel strike with marine mammals and sea turtles (including injured/dead protected species reporting).	Induction program of vessel masters covers vessel strike avoidance protocol	BP-provided training materials / vessel contractors' training logs	Once, before mobilization of vessels	Contractor	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M43	Implement a program of support to local protected area management initiatives through mutually agreed capacity building.	Support local protected area management via capacity building	Report on support provided to protected area management	Once, after support provided	BP	BP	Included in project costs
Biodiversity							
See Mitigation Measures listed to mitigate impacts on Plankton & Fish and Other Fishery Resources, Birds, Marine Mammals, Sea Turtles, Threatened Species and Protected Areas: M01, M02, M06, M33, M35, M36, M37, M38, M39, M42.							
Maritime Navigation							
Impact: IMP28: Risk of collision between project vessels and pirogues due to project vessels movements (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Operations Phase starts and Annually thereafter or as adjusted as informed by monitoring of offshore safety incidents and near-misses	BP	BP	Included in project costs
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Operations Phase starts and Annually thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M10	Equip the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with radar or infrared systems that can detect small fishing vessels during poor visibility/night time.	Project vessels equipped with radar or infrared systems	Project vessels equipment listing	Once, before the Operations Phase starts and before mobilization of new vessels	Contractor, BP	BP	Included in project costs
M11	Provide adequate lighting aboard the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with the intent of maintaining high visibility during poor visibility/night time. These vessels will also feature searchlights that can be used to shine on or signal approaching pirogues and foghorns for audible signaling.	Vessels well-lit during poor visibility or at night and equipped with searchlights	Project vessels equipment listing	Once, before the Operations Phase and before mobilization of new vessels	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-agreed training materials / vessel contractors' training logs	Once, before the Operations Phase and before mobilization of new vessels	Contractor, BP	BP	Included in project costs
M12	Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the exclusion safety zones.	Project patrol boat in place	Project vessels logs	Once, before the Operations Phase starts and Annually thereafter	Contractor, BP	BP	Included in project costs
M13	Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.	FLOs in place aboard the project patrol boats, if and when necessary	Project patrol boats Person on Board records	Once, before the Operations Phase starts and Annually thereafter	Contractor, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M14	Equipping the support vessels and the project patrol boat with lifesaving appliances approved by the Convention for Safety of Life at Sea (SOLAS) and IMO, which can be used to assist in rescuing fishermen in the water in line with international maritime protocols or in the event of an accident involving a pirogue with a project vessel. Assist with the rescue of any fishermen involved in a collision with a project vessel or following the capsizing of their vessel due to ship wake.	Lifesaving appliances in place in project vessels and assistance to fishermen provided in the event of an accident with a project vessel	Project vessels equipment listings	Once, before the Operations Phase starts	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Operations Phase starts	Contractor, BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessels HSSE incident reports	After a reported incident	Contractor, BP	BP	Included in project costs
M15	In case of a collision, BP will inform as soon as possible the relevant national authorities: the Mauritanian Coast Guard (Garde Côte Mauritanienne) in Mauritania and HASSMAR in Senegal.	National authorities informed in case of a collision	Records of information provided by the project to national authorities	After a reported collision	BP	BP	Included in project costs
M16	Ensuring that each project vessel keeps records of maritime safety incidents with pirogues and other vessels, including near misses, and that these are subsequently shared with the project. BP will monitor maritime safety incidents and adjust, if required, project specific maritime safety rules, security and search & rescue arrangements in place.	Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Operations Phase starts	BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessel HSSE incidents reports	Annually	BP	BP	Included in project costs
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Operations Phase starts and Annually	BP/Contractor	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
Artisanal Fisheries and Related Activities							
Impact: IMP29: Potential loss of artisanal fishing gears (nets and buoys) due to project vessel movements in artisanal fishing areas (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Operations Phase starts and Annually thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs
M12	Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the exclusion safety zones.	Project patrol boat in place	Project vessels logs	Once, before the Operations Phase starts and Annually thereafter	Contractor, BP	BP	Included in project costs
M13	Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.	FLOs in place aboard the project patrol boats, if and when necessary	Project patrol boats Person on Board records	Once, before the Operations Phase starts and Annually thereafter	Contractor, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Operations Phase starts and Annually	BP/Contractor	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
M20	Develop and implement a framework for interaction with artisanal fisheries, with provisions covering engagement with local communities on access to fishing grounds, grievance and recourse mechanism for damage to fishing gear, environmental awareness building, livelihood enhancement and the role of community liaison officers.	Framework for interaction with artisanal fisheries developed and implemented	Framework documentation Evidence of follow-up activities in conformance with Framework documentation	Once, before the Operations Phase starts and Annually thereafter	BP	BP	Included in project costs
M21	Project vessels to record incidents with fishing gears and report them to the project.	Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Operations Phase starts	BP	BP	Included in project costs
		Records of maritime incidents with other sea users	Records of incidents with other sea users'	Annually	Contractor	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M22	To the extent feasible, establish a maritime corridor or speed restrictions for project vessels within artisanal fishing areas.	Induction program of vessel masters covers speed restrictions in areas of artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Operations Phase starts and Annually if needed	Contractors, BP	BP	Included in project costs
M23	Implement an environmental awareness building program in association with local schools and community groups.	Environmental awareness program implemented in local schools and community groups	Environmental awareness program records	Once, before the Operations Phase starts and thereafter adjusted as needed following an assessment of program effectiveness	BP	BP	Included in project costs
Community Health, Safety and Security							
Impacts: IMP30: Risk of conflicts between artisanal fishermen and public security forces if some fishermen need to be escorted out of the exclusion safety zones (Residual Impact: 2 – Low) IMP31: Risk of terrorism act targeting the gas production facilities which in turn will raise the level of terrorism risk at a national level (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Operations Phase starts and Annually thereafter or as adjusted as informed by monitoring of offshore safety incidents and near-misses	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
M25	The project will seek to work with the public security forces to establish an appropriate response and security framework which may include resource, equipment, training and response protocols.	Owing to the sensitive nature, BP will not be in a position to share any details.					
M26	Include in the security stakeholder engagement plan, provisions around response, management and interface with Public security forces for security incidents scenario such as act of terrorism and unlawful entry in the exclusion safety zones.	Owing to the sensitive nature, BP will not be in a position to share any details.					

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Public Infrastructure and Services							
Impacts: IMP32: Placing additional demands on the public security forces limited resources since they will be required to be available 24/7 to handle a safety incident with artisanal fishermen or a search and rescue operation if needed (Residual Impact: 2 – Low) IMP33: Placing additional demands on National security authorities who will need to prevent and be available 24/7 to handle a national security incident at sea resulting from the presence of offshore gas production infrastructures (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Operations Phase starts and Annually thereafter or as adjusted as informed by monitoring of offshore safety incidents and near-misses	BP	BP	Included in project costs
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Operations Phase starts and Annually thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs
M10	Equip the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with radar or infrared systems that can detect small fishing vessels during poor visibility/night time.	Project vessels equipped with radar or infrared systems	Project vessels equipment listing	Once, before the Operations Phase starts and before mobilization of new vessels	Contractor, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M11	Provide adequate lighting aboard the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with the intent of maintaining high visibility during poor visibility/night time. These vessels will also feature searchlights that can be used to shine on or signal approaching pirogues and foghorns for audible signaling.	Vessels well-lit during poor visibility or at night and equipped with searchlights	Project vessels equipment listing	Once, before the Operations Phase and before mobilization of new vessels	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-agreed training materials / vessel contractors' training logs	Once, before the Operations Phase and before mobilization of new vessels	Contractor, BP	BP	Included in project costs
M12	Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the exclusion safety zones.	Project patrol boat in place	Project vessels logs	Once, before the Operations Phase starts and Annually thereafter	Contractor, BP	BP	Included in project costs
M13	Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.	FLOs in place aboard the project patrol boats, if and when necessary	Project patrol boats Person on Board records	Once, before the Operations Phase starts and Annually thereafter	Contractor, BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M14	Equipping the support vessels and the project patrol boat with lifesaving appliances approved by the Convention for Safety of Life at Sea (SOLAS) and IMO, which can be used to assist in rescuing fishermen in the water in line with international maritime protocols or in the event of an accident involving a pirogue with a project vessel. Assist with the rescue of any fishermen involved in a collision with a project vessel or following the capsizing of their vessel due to ship wake.	Lifesaving appliances in place in project vessels and assistance to fishermen provided in the event of an accident with a project vessel	Project vessels equipment listings	Once, before the Operations Phase starts	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Operations Phase starts	Contractor, BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessels HSSE incident reports	After a reported incident	Contractor, BP	BP	Included in project costs
M16	Ensuring that each project vessel keeps records of maritime safety incidents with pirogues and other vessels, including near misses, and that these are subsequently shared with the project. BP will monitor maritime safety incidents and adjust, if required, project specific maritime safety rules, security and search & rescue arrangements in place.	Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Operations Phase starts	BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessel HSSE incidents reports	Annually	BP	BP	Included in project costs
M25	The project will seek to work with the public security forces to establish an appropriate response and security framework which may include resource, equipment, training and response protocols.	Owing to the sensitive nature, BP will not be in a position to share any details.					

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M26	Include in the security stakeholder engagement plan, provisions around response, management and interface with Public security forces for security incidents scenario such as act of terrorism and unlawful entry in the exclusion safety zones.	Owing to the sensitive nature, BP will not be in a position to share any details.					
Social Climate							
Impact: IMP34: Social discontent in N'Diago and Saint-Louis due to the potential perception of loss of fishing grounds and fishing catches combined with the limited employment opportunities, the perception of unsatisfied grievances and/or compensation claims (e.g. for lost gear), and elevated safety risk for fishermen at sea due to presence of project vessels (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Operations Phase starts and Annually thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Operations Phase starts and Annually	BP/Contractor	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
M20	Develop and implement a framework for interaction with artisanal fisheries, with provisions covering engagement with local communities on access to fishing grounds, grievance and recourse mechanism for damage to fishing gear, environmental awareness building, livelihood enhancement and the role of community liaison officers.	Framework for interaction with artisanal fisheries developed and implemented	Framework documentation Evidence of follow-up activities in conformance with Framework documentation	Once, before the Operations Phase starts and Annually thereafter	BP	BP	Included in project costs
M23	Implement an environmental awareness building program in association with local schools and community groups.	Environmental awareness program implemented in local schools and community groups	Environmental awareness program records	Once, before the Operations Phase starts and thereafter adjusted as needed following an assessment of program effectiveness	BP	BP	Included in project costs
M24	Provide technical assistance to mutually agreed marine resource research programs notably the national oceanographic research centers of both countries (CRODT and IMROP).	Technical assistance provided to marine resource research program with CRODT and IMROP	BP technical assistance records	Once, before the Operations Phase starts adjusted as needed following an assessment of program effectiveness	BP	BP	Included in project costs

Table 9-2. ESMP-Operations Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M27	Developing a social investment program to enhance project benefits for the directly affected communities N'Diago and Saint-Louis communities, including livelihood enhancement activities.	Social investment program to enhance project benefits for the communities of N'Diago and Saint-Louis developed	Social investment program documentation	Once, before the Operations Phase starts and Annually thereafter adjusted as needed following an assessment of program effectiveness	BP	BP	Included in project costs
M28	Engaging in an on-going dialogue with national, regional and local authorities to monitor the social climate in the local communities in order to help identify and support, if needed, ad hoc measures to prevent social discontent linked to project activities and its escalation into conflicts.	Periodic meetings between project representatives and national, regional and local authorities to monitor the social climate and, if needed, identification of support to ad hoc measures to prevent social discontent linked to project activities	Project meeting records	Once, before the Operations Phase starts and Annually	BP	BP	Included in project costs
M44	Review the social climate in N'Diago and in Saint-Louis prior to the Operations Phase to adjust as needed the mitigation measures identified to avoid or reduce social discontent.	Report on social climate in N'Diago and Saint-Louis with adjusted mitigation measures if needed	Report on social climate	Once, before the Operations Phase starts	BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles.

	D&OC and Mitigation Measure	Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Multiple Components of the Biophysical and Social Environment - Design and Operational Control Measures							
D19	The relevant maritime, port or shipping authorities will be notified of all permanent offshore facilities as safety zones and routine shipping routes to be used by project-related vessels. Permanent facility locations will be demarcated on nautical charts.	Relevant maritime, port or shipping authorities notified of all permanent offshore facilities, as well as safety zones and routine shipping routes to be used by project-related vessels	Notification sent by the project to relevant maritime, port or shipping authorities	Once, before the Decommissioning Phase starts and following permanent changes in zoning during the decommissioning phase	BP	BP	Included in project costs
D20	Project vessels will follow the Convention on International Regulations for Preventing Collisions at Sea (COLREGs) adopted by the IMO.	Project vessels procedures indicating that they follow COLREG	Project vessel documentation	Once, before the Decommissioning Phase starts and before mobilization of new vessels	Contractors, BP	BP	Included in project costs
D21	Main project vessels will be equipped with Universal Shipborne Automatic Identification System (AIS), a system of transponders installed on vessels which transmit over two dedicated digital marine VHF channels.	Equipment of the main project vessels with AIS	Project vessel documentation	Once, before the Decommissioning Phase starts and before mobilization of new vessels subject to advances in communication technology at time of decommissioning	Contractors, BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D22	Standard communication procedures will be used in international maritime traffic and shipping, aided by project patrol boats or standby vessels near the drilling, pipelay and Nearshore Hub/Terminal Area to prevent collision with larger vessels.	Communication procedures used by project vessels	Project vessel documentation	Once, before the Decommissioning Phase starts and before mobilization of new vessels	Contractors, BP	BP	Included in project costs
		Proper demarcation of the exclusion safety zones	Visual recognition of the demarcation of the exclusion safety zones				
D23	Information will be provided to the national industrial fishing fleet of both Mauritania and Senegal to communicate and record the exclusion safety zones and applicable navigational charts.	Information provided to national industrial fishing fleets on exclusion safety zones and applicable navigational charts	Notification sent by the project to authorities in charge of or organizations representing national industrial fishing	Once, before the Decommissioning Phase starts and following permanent changes in zoning during the decommissioning phase	BP	BP	Included in project costs
D24	Exclusion safety zones will be demarcated on applicable navigational charts, and a communication procedure will be developed to communicate the location of the exclusion safety zones to the local fishing communities. This is intended to allow pirogues to avoid the exclusion safety zones.	Location of exclusion safety zones communicated to local fishing communities	Records of information provided by the project to local fishing communities	Once, before the Decommissioning Phase starts and quarterly or as adjusted based on monitoring of exclusion zone breaches during the decommissioning phase	BP	BP	Included in project costs
D26	A site security plan will be developed that considers the security arrangements for each of the facilities including the modalities of support provided by government.	Owing to the sensitive nature, BP will not be in a position to share any details.					

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D41	Contractors will be expected to comply with the applicable legal requirements and standards at the time of decommissioning, including HSSE standards and performance requirements.	Contractor compliance with applicable legal requirements and standards	Bridging document between BP HSSE and contractors HSE/HSSE requirements	Once, at contract execution	Contractor, BP	BP	Included in project costs
D42	A preliminary decommissioning plan will be developed for the offshore project facilities, which considers well abandonment, removal of hydrocarbons from flowlines, facility and subsea decommissioning along with disposal options[179] for equipment and materials.	Preliminary decommissioning plan	Preliminary decommis-sioning plan documentation	Once following completion of the preliminary plan	BP	BP	Included in project costs
D43	A final detailed decommissioning plan will be developed closer to the Decommissioning Phase for the offshore project facilities, which considers well abandonment, removal of hydrocarbons from flowlines, facility and subsea decommissioning along with disposal options[180] for equipment and materials.	Detailed decommissioning plan	Detailed decommis-sioning plan documentation	Once, before the Decommissioning Phase starts	BP	BP	Included in project costs

179 In this case, disposal includes treatment, reuse, recycling and final disposal practices.
180 In this case, disposal includes treatment, reuse, recycling and final disposal practices.

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D44	Well abandonment will be carried out in line with applicable good industrial practice and applicable legislation. A seabed survey will be conducted at the end of the well abandonment program to survey the seabed for debris.	Well abandonment conducted in compliance with applicable good industrial decommissioning practices and applicable legislation; survey wells following abandonment	Well Plug and Abandon Basis of Design, plus a seabed survey report	Once following completion of the plan and following completion of survey	Contractor	BP	Included in project costs
D45	The relevant maritime, port or shipping authorities will be notified of all offshore facilities that remain in situ following decommissioning, as well as corresponding safety zones. The presence of these permanent facility locations will be demarcated on nautical charts.	Relevant maritime, port or shipping authorities notified of all permanent offshore facilities that remain in situ following decommissioning, as well as corresponding safety zones.	Notification sent by the project to relevant maritime, port or shipping authorities	Once, before the end of the Decommissioning Phase	BP	BP	Included in project costs
Coastal Erosion							
Impact: IMP05: Accretion or reduction in natural erosion of the Langue de Barbarie (relative to the case without the breakwater) of up to 13 m over 10 years near the Mauritania-Senegal border and extending southward approximately 8 km, accompanied by a maximum increase in coastal erosion rate (relative to the case without the breakwater) of approximately 6 m over 10 years further south, along approximately 2 km of coast, starting from the south end of the Hydrobase neighborhood (Residual Impact: 2 – Low)					**Country**: Senegal		
M40	a) To improve understanding of the long-term coastal dynamic equilibrium, the project will develop and implement a coastline monitoring plan during the project life cycle. Coastline monitoring will commence prior to breakwater construction, i.e. before 2020. This will include the collection of further bathymetric data along the Saint-Louis	See Chapter 10: Surveillance and Monitoring Plan					

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
	shore, including the Senegal River mouth. The project will aim to involve local academics in the implementation of the coastline monitoring plan. The relevant authorities and local communities will be informed of the monitoring results. b) The data collected as part of the implementation of the coastline monitoring plan will be used to update the coastline modeling (in Appendix I-3) to be completed before the construction of the breakwater in 2020. Additional modeling updates will be conducted at key stages of the project life cycle when new information with the potential to have a significant impact on the modeling results will become available. c) BP will seek the necessary authorizations to share relevant data for government led morphological studies initiatives and local academics. d) a contingency plan for the coastline will be developed by the project in consultation with the relevant authorities if the results of the coastline monitoring and modeling clearly and systematically demonstrate, over the duration of the project, negative impacts related to the GTA Phase 1 project which exceeds those currently identified in the GTA Phase 1 project ESIA report (in particular Section 7.3.3)						

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M41	Provide specialist assistance to studies led by local or national authorities on Saint-Louis coastal management.	Specialist assistance provided to improve local coastal management processes	Project documentation	Before the Decommissioning Phase	BP	BP	Included in project costs
M45	A final decommissioning plan will be developed for approval by the authorities near the end of the operational lifetime, which takes into consideration further morphological studies and data collection as applicable.	Regulatory approval of the final decommissioning plan	Final decommis-sioning plan documentation and regulator approval	Once, before the Decommissioning Phase starts	BP	BP	Included in project costs
Marine Mammals, Sea Turtles, Threatened Species and Protected Areas and Biodiversity							
Impacts: IMP16: Potential vessel strike with mortality to individual marine mammal (Residual Impact: 1 – Negligible) IMP19: Potential vessel strike with mortality to individual turtle (Residual Impact: 1 – Negligible) IMP23: Disturbance, possible auditory injury, vessel strike to threatened species from vessels, operations (Residual Impact: 1 – Negligible) IMP24: Introduction of non-native or invasive species (Residual Impact: 2 – Low) IMP25: Behavioral disturbances to fauna within protected areas or other areas of conservation interest (Residual Impact: 2 – Low) IMP26: Behavioral disturbances to threatened species (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M06	Vessel operators will implement vessel strike avoidance protocols to reduce the potential for vessel strike with marine mammals and sea turtles (including injured/dead protected species reporting).	Vessel strike avoidance protocol Induction program of vessel masters covers vessel strike avoidance protocol	BP-provided training materials / vessel contractors' training logs	Once, before the Decommissioning Phase starts	Contractor	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Maritime Navigation							
Impact: IMP28: Risk of collision between project vessels and pirogues due to project vessels movements (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Decommissioning Phase starts and Semi-annually thereafter	BP	BP	Included in project costs
M09	Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.	Notification to mariners in the appropriate form and language provided to artisanal fishermen	Records of notification provided by the project to artisanal fishermen	Once, before the Decommissioning Phase starts and Quarterly thereafter or as adjusted based on schedule of project activities	BP	BP	Included in project costs
M10	Equip the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with radar or infrared systems that can detect small fishing vessels during poor visibility/night time.	Project vessels equipped with radar or infrared systems	Project vessels equipment listing	Once for offshore project vessels before mobilization or as adjusted based on advances in technology at the time of decommissioning	Contractor, BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M11	Provide adequate lighting aboard the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with the intent of maintaining high visibility during poor visibility/night time. These vessels will also feature searchlights that can be used to shine on or signal approaching pirogues and foghorns for audible signaling.	Vessels well-lit during poor visibility or at night and equipped with searchlights Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	Project vessels equipment listing BP-provided training materials / vessel contractors' training logs	Once, before offshore project vessel mobilization	Contractor, BP	BP	Included in project costs
M12	Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the safety exclusion zones.	Project patrol boat in place	Project vessels logs	Once, before the Decommissioning Phase starts and Semi-annually	Contractor, BP	BP	Included in project costs
M13	Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.	FLOs in place aboard the project patrol boats, if and when necessary	Project patrol boats Person on Board records	Once, before the Decommissioning Phase starts and Quarterly or as adjusted based on advances in technology at the time of decommissioning	Contractor, BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M14	Equipping the support vessels and the project patrol boat with lifesaving appliances approved by the Convention for Safety of Life at Sea (SOLAS) and IMO, which can be used to assist in rescuing fishermen in the water in line with international maritime protocols or in the event of an accident involving a pirogue with a project vessel. Assist with the rescue of any fishermen involved in a collision with a project vessel or following the capsizing of their vessel due to ship wake.	Lifesaving appliances in place in project vessels and assistance to fishermen provided in the event of an accident with a project vessel	Project vessels equipment listings	Once, before the Decommissioning Phase starts	Contractor, BP	BP	Included in project costs
		Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Decommissioning Phase starts	Contractor, BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessels HSSE incident reports	After a reported incident	Contractor, BP	BP	Included in project costs
M15	In case of a collision, BP will inform as soon as possible the relevant national authorities: the Mauritanian Coast Guard (Garde Côte Mauritanienne) in Mauritania and HASSMAR in Senegal.	National authorities informed in case of a collision	Records of information provided by the project to national authorities	After a reported collision	BP	BP	Included in project costs
M16	Ensuring that each project vessel keeps records of maritime safety incidents with pirogues and other vessels, including near misses, and that these are subsequently shared with the project. BP will monitor maritime safety incidents and adjust, if required, project specific maritime safety rules, security and search & rescue arrangements in place.	Induction program of vessel masters covers protocol for reporting on interaction with artisanal fishing	BP-provided training materials / vessel contractors' training logs	Once, before the Decommissioning Phase starts	Contractors, BP	BP	Included in project costs
		Records of maritime safety incidents	Project vessels HSSE incidents reports	Quarterly	Contractor, BP	BP	Included in project costs
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Decommissioning Phase starts and Quarterly	BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Decommissioning Phase starts and Quarterly	BP/Contractor	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Decommissioning Phase starts and Annually	BP	BP	Included in project costs
Community Health, Safety and Security							
Impacts: IMP30: Risk of conflicts between artisanal fishermen and public security forces if some fishermen need to be escorted out of the exclusion safety zones (Residual Impact: 1 – Negligible) IMP31: Risk of terrorism act targeting the gas production facilities which in turn will raise the level of terrorism risk at a national level (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M08	Develop and implement a training and awareness program targeting local fishing communities on the specific maritime safety rules associated with the project.	Training and awareness program on the specific maritime safety rules associated with the project implemented in local fishing communities	Training and awareness program records	Once, before the Decommissioning Phase starts and Semi-annually thereafter	BP	BP	Included in project costs
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Decommissioning Phase starts and Quarterly	BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Decommissioning Phase starts and Annually	BP	BP	Included in project costs
M25	The project will seek to work with the public security forces to establish an appropriate response and security framework which may include resource, equipment, training and response protocols.	Owing to the sensitive nature, BP will not be in a position to share any details.					
M26	Include in the security stakeholder engagement plan, provisions around response, management and interface with Public security forces for security incidents scenario such as act of terrorism and unlawful entry in the exclusion safety zones.	Owing to the sensitive nature, BP will not be in a position to share any details.					
Social Climate							
Impact: IMP34: Social discontent in N'Diago and Saint-Louis due to the potential perception of loss of fishing grounds and fishing catches combined with the limited employment opportunities, the perception of unsatisfied grievances and/or compensation claims (e.g. for lost gear), and elevated safety risk for fishermen at sea due to presence of project vessels (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M17	Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.	Accessible grievance mechanism in place including monitoring of claims and resolutions	Project grievance mechanism records	Once, before the Decommissioning Phase starts and Quarterly	BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M18	Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities.	CLOs in place for N'Diago and Saint-Louis	Project Human Resources records	Once, before the Decommissioning Phase starts and Quarterly	BP, Contractor	BP	Included in project costs
M19	Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.	Meetings between the project representatives and community councils in N'Diago and in Saint-Louis	Project meeting records	Once, before the Decommissioning Phase starts and Annually	BP	BP	Included in project costs
M24	Provide technical assistance to mutually agreed marine resource research programs notably the national oceanographic research centers of both countries (CRODT and IMROP).	Technical assistance provided to marine resource research program with CRODT and IMROP	BP technical assistance records	Once, before the end of the Decommissioning Phase adjusted as needed following an assessment of program effectiveness during the Decommissioning Phase	BP	BP	Included in project costs
M27	Developing a social investment program to enhance project benefits for the directly affected communities N'Diago and Saint-Louis communities, including livelihood enhancement activities.	Social investment program to enhance project benefits for the communities of N'Diago and Saint-Louis developed	Social investment program documentation	During the Decommissioning Phase	BP	BP	Included in project costs

Table 9-3. ESMP-Decommissioning Phase: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M28	Engaging in an on-going dialogue with national, regional and local authorities to monitor the social climate in the local communities in order to help identify and support, if needed, ad hoc measures to prevent social discontent linked to project activities and its escalation into conflicts.	Periodic meetings between project representatives and national, regional and local authorities to monitor the social climate and, if needed, identification of support to ad hoc measures to prevent social discontent linked to project activities	Project meeting records	During the Decommissioning Phase	BP	BP	Included in project costs
M46	Review the social climate in N'Diago and in Saint-Louis prior to the Decommissioning Phase to adjust as needed the mitigation measures identified to avoid or reduce social discontent.	Report on social climate in N'Diago and Saint-Louis with adjusted mitigation measures if needed	Report on social climate	Once, before the Decommissioning Phase starts	BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles.

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Multiple Components of the Biophysical and Social Environment - Design and Operational Control Measures							
D101	Wells are designed to documented BP engineering practices and procedures related to well design and construction in line with recognized international standards. A number of these practices and procedures relate specifically to blowout preventers (BOPs and subsea X-mas trees), other well control barriers and isolation of any permeable zone.	Design of the wells complies with documented BP engineering practices and the construction is in line with recognized international standards	Well Basis of Design documentation Well handover documentation	Once, before the approval of the well design and the construction process Following handover of well construction to well production	Contractors	BP	Included in project costs
D102	BP will perform assurance audits prior to drillship acceptance to confirm all critical systems such as subsea BOP and well control surface equipment are meeting performance standards.	Assurance audits confirming that all critical systems such as subsea BOP and well control surface equipment are meeting performance standards	Rig intake and start-up operating practice documentation	Once, before the de-mobilization of the drillship	Contractors	BP	Included in project costs
D103	Design measures will be incorporated into the FPSO and FLNG to contain minor spills, e.g. bunded areas on the process decks to contain any small oil spills, spill containment connected to the drains and slop tanks, and minimization of potential spills or overflows from diesel storage and transfer systems through good tank design and metering. The FPSO and FLNG vessel will be double-hulled.	Design measures to contain minor spill incorporated into the new FPSO and FLNG and both are double-hulled	FPSO and FLNG Basis of Design documentation	Once, before the approval of the FPSO and FLNG designs.	Contractors	Contractors, BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D104	Management and mitigation measures will be in place to prevent and/or minimize the likelihood of a spill from the installation and operation of the subsea facilities. This may include flowline design specification, use of appropriate design codes (e.g. for corrosion allowance), use of corrosion inhibitor. BP will also implement a risk-based proactive pipeline inspection and maintenance program.	Management and mitigation measures in place for prevention and/or minimization of the likelihood of a spill for the installation and operation of the subsea facilities	Subsea Basis of Design Leak test records included in Completion Database Final as Built Verification International Oil Pollution Prevention Certificate	Once, prior to start-up Marine assurance on-going	Contractors	BP	Included in project costs
		Risk-based proactive pipeline monitoring and inspection program in place	Risk-based proactive pipeline monitoring and inspection program documentation	Once, before the approval of design and operational procedures	BP	BP	Included in project costs
D105	Reels and hoses used for hydrocarbon and chemical transfer will be designed, operated and maintained to prevent spills. Operational procedures will be put in place to prevent spill risk, including the use of drip trays and other measures to prevent spillages from, for instance valves, or lubricant changes.	Design, operation and maintenance of reels and hoses for hydrocarbon and chemical transfers and operational procedure in place prevent spills	Project documentation with information on design, operation and maintenance of reels and hoses and operational procedures Vendor Data Sheets	As determined by each respective inspection and maintenance program	Contractors, BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D106	Fuels, chemicals and lubricating oil will be stored in designated containment areas/storage tanks on board project vessels.	Fuels, chemicals and lubricating oil stored in designated containment areas/storage tanks on board project vessels	Visual recognition of location of fuels, chemicals and lubricating oil storage Procedures for chemicals and fuel handling and storage	Once, before the project vessels start their operations	Contractors	BP	Included in project costs
D107	Conduct routine maintenance and inspection of safety critical equipment during construction and operation.	Routine maintenance and inspection of safety critical equipment conducted	Reports of routine maintenance and inspections	Once, before the project starts and subsequently as determined by each respective inspection and maintenance program	Contractors, BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D108	Processes and procedures will be in place with the intent of maintaining navigational safety at all times during the project. Obstruction lights, navigation lights and foghorns will be kept in working condition on board the drillship, PSVs, FPSO and breakwater/hub. Radio communication systems will be in place and in working order for contacting other marine vessels as necessary.	Navigational safety processes and procedures in place on board the drillship, PSVs, FPSO and breakwater/hub	Project vessels navigation safety processes and procedures documentation	Once, before the project starts and before mobilization of new vessels	Contractors, BP	BP	Included in project costs
		Induction program of vessel masters	BP-provided training materials / vessel contractors' training logs	Once, before the project starts and before mobilization of new vessels	Contractors, BP	BP	Included in project costs
		Navigational safety equipment and communication systems in working order on board the drillship, PSVs, FPSO and breakwater/hub	Visual recognition of navigational safety equipment on board	Once, before each project phase starts and subsequently as determined by marine assurance program	Contractors, BP	BP	Included in project costs
D109	An exclusion safety zone (estimated to be a 500-m wide radius) will be established around the drillship, FPSO and hub/breakwater within which non-project related vessels are prohibited. Operational procedures will be put in place to further reduce vessel collision risk for instance by a restriction on visiting vessels in bad weather, defined vessel no-go areas within the exclusion safety zone, agreed approach procedures to drillship, FPSO and FLNG/breakwater.	Exclusion safety zones applied around the drillship, FPSO and hub/breakwater	Documentary evidence of the exclusion safety zones Applicable navigational charts	Once, before each project phase starts and following changes in zoning	Contractors, BP	BP	Included in project costs
		Operational procedures in place to further reduce vessel collision risk	Operational procedures to reduce vessel collision risk documentation	Once, before each project phase starts	Contractors, BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D110	Measures will be implemented aimed at reducing the risk of oil spills from supply, patrol and installation vessels, including selection of vessels which comply with IMO codes for prevention of oil pollution; all vessels will have onboard Shipboard Oil Pollution Emergency Plans (SOPEPs), as required.	Measures aimed at reducing the risk of oil spills implemented on supply, patrol and installation vessels	Project vessels oil spill risk reduction documentation International Oil Pollution Prevention Certificate	Once, before the project vessels start their operations	Contractors, BP	BP	Included in project costs
		SOPEP on board all project vessels	International Oil Pollution Prevention Certificate	Once, before the project vessels start their operations	Contractors, BP	BP	Included in project costs
D111	Develop a Source Control Emergency Response Plan (SCERP), with provisions for well containment and capping and relief well planning.	SCERP developed	SCERP documentation	Once, before the project starts	BP	BP	Included in project costs
D112	Develop an Oil Spill Contingency Plan (OSCP), which will cover a range of response strategies for different spill scenarios.	OSCP developed	OSCP documentation	Once, before each project phase starts and Annually thereafter	BP	BP	Included in project costs
D113	Tier 1 spill response equipment will be available and maintained in conformance with internal procedures and good international industry practice throughout construction, operations and decommissioning.	Tier 1 spill response equipment will be available and maintained	Visual recognition and inspection records	Once, before the project starts and annually	BP	BP	Included in project costs
D114	Contractual arrangements will be in place with specialist contractors who can support spill response. This includes procedures for verifying their availability and capability.	Contractual arrangements with specialist contractors who can support spill response in place	Contracts	Once, before the project starts and subsequently as per renewal schedule	BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
D115	Conduct routine spill response drills and training.	Routine spill response drills and training conducted	Drills and training reports	Once, before the project starts and subsequently as per agreed exercise program	BP	BP	Included in project costs
D116	Development of an oil spill sensitivity map highlighting resources at risk.	Oil spill sensitivity map highlighting resources at risk	Map	Once, before the project starts	BP	BP	Included in project costs
D117	BP will undertake an assessment (e.g. Spill Impact Mitigation Assessment (SIMA)) to evaluate the risks and benefits of different response tools or techniques before implementation.	Assessment evaluating the risks and benefits of different response tools or techniques	Assessment report	Once, before drilling starts	BP	BP	Included in project costs
D118	BP will seek regulatory approval for any use of dispersants or in-situ burning as required as per provisions in the OSCP.	Regulator's approval for use of dispersants or in-situ burning	Correspondence	Once, before the project starts	BP	BP	Included in project costs
D119	Contractor will be required to report all incidents, including near-misses to BP using established protocols.	Incidents including near-misses reported to BP	Contractors HSSE incident reports	After a reported incident	Contractors	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Water Quality							
Impacts: IMP101: Changes in water quality from elevated hydrocarbon concentrations in both water column and at the sea surface from a well blowout (Residual Impact: 2 – Low) IMP102: Changes in water quality from elevated hydrocarbon concentrations in both water column and at the sea surface from FPSO failure due to a ship collision (Residual Impact: 2 – Low) IMP103: Changes in water quality within the Senegal River estuary from elevated hydrocarbon concentrations in the water column from FPSO failure due to a ship collision (Residual Impact: 2 – Low) IMP104: Changes in water quality from elevated hydrocarbon concentrations in both water column and at the sea surface from pipelaying vessel collision (Senegal waters) (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M103	In the unlikely event of a spill reaching the shoreline, a Shoreline Clean-up and Assessment Technique (SCAT) program will be implemented to inform shoreline clean-up and remediation as applicable.	SCAT program implemented if oil is likely to reach the shoreline	SCAT program implementation documentation	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M104	In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.	A shoreline clean-up and remediation team mobilized to the affected areas in the event that oil reaches the shoreline	Mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
		Specialized expertise engaged to mitigate impacts to sensitive areas and wildlife species as needed	Specialized expertise mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
M105	In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.	Incident reported and notified	Incident notification records	Following the accidental event	BP	BP	Included in spill response costs
M112	In the unlikely event of a spill of high intensity, specific monitoring (e.g., environmental effects monitoring) may be required and developed in consultation with applicable national authorities.	See Chapter 10: Surveillance and Monitoring Plan					

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure	Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Birds, Marine Mammals and Sea Turtles						
Impacts: *Birds* IMP105: Exposure of birds to elevated hydrocarbons within a regional area; some lethal impacts and numerous sublethal impacts from direct and indirect effects from exposure to oil from a blowout (Residual Impact: 3 – Medium) IMP106: Exposure of birds to elevated hydrocarbons within a regional area; some lethal impacts and numerous sublethal impacts from direct and indirect effects from exposure to oil from FPSO failure due to a ship collision (Residual Impact: 3 – Medium) IMP107: Exposure of birds to elevated hydrocarbons within a regional area; some lethal impacts and numerous sublethal impacts from direct and indirect effects from exposure to oil from pipelaying vessel collision (Residual Impact: 3 – Medium) *Marine Mammals* IMP108: Exposure of Mediterranean monk seals to elevated hydrocarbons within a regional area; assuming lethal impact(s) from direct and indirect effects from exposure to oil from the blowout spill (Residual Impact: 3 – Medium) IMP109: Exposure of Mediterranean monk seals to elevated hydrocarbons within a regional area; assuming lethal impact(s) from direct and indirect effects from exposure to oil from FPSO failure due to a ship collision (Residual Impact: 3 – Medium) IMP110: Exposure of Mediterranean monk seals to elevated hydrocarbons within a regional area; assuming lethal impact(s) from direct and indirect effects from exposure to oil from pipelaying vessel collision (Residual Impact: 3 – Medium) *Sea Turtles* IMP111: Exposure of sea turtles to elevated hydrocarbons within a regional area; some lethal impacts to turtles of all age groups and numerous sublethal impacts to turtles from direct and indirect effects from exposure to oil from FPSO failure due to a ship collision (Residual Impact: 3 – Medium) IMP112: Exposure of sea turtles to elevated hydrocarbons within a regional area; some lethal impacts to turtles of all age groups and numerous sublethal impacts to turtles from direct and indirect effects from exposure to oil from pipelaying vessel collision (Residual Impact: 3 – Medium)				**Countries**: Mauritania and Senegal		

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M103	In the unlikely event of a spill reaching the shoreline, a Shoreline Clean-up and Assessment Technique (SCAT) program will be implemented to inform shoreline clean-up and remediation as applicable.	SCAT program implemented if oil is likely to reach the shoreline	SCAT program implementation documentation	Following the accidental event	BP	BP	Included in spill response costs
M104	In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.	A shoreline clean-up and remediation team mobilized to the affected areas in the event that oil reaches the shoreline	Mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
		Specialized expertise engaged to mitigate impacts to sensitive areas and wildlife species as needed	Specialized expertise mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
M105	In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.	Incident reported and notified	Incident notification records	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M112	In the unlikely event of a spill of high intensity, specific monitoring (e.g., environmental effects monitoring) may be required and developed in consultation with applicable national authorities.	See Chapter 10: Surveillance and Monitoring Plan					
Threatened Species and Protected Areas							
Impacts: IMP113: Oiling of water column or coastline including impacts to areas designated as marine or onshore protected areas. Impacts could include, loss of vegetation, habitat destruction, and injury or death to marine or terrestrial fauna from a blowout (Residual Impact: 2 – Low) IMP114: Oiling of threatened species resulting in mortality from a blowout (Residual Impact: 1 – Negligible to 3 – Medium) IMP115: Oiling of water column or coastline including impacts to areas designated as marine or onshore protected areas. Impacts could include, loss of vegetation, habitat destruction, and injury or death to marine or terrestrial fauna from FPSO failure due to a ship collision (Residual Impact: 2 – Low) IMP116: Oiling of threatened species resulting in mortality from FPSO failure due to a ship collision (Residual Impact: 1 – Negligible to 3 – Medium) IMP117: Oiling of water column or coastline including impacts to areas designated as marine or onshore protected areas. Impacts could include, loss of vegetation, habitat destruction, and injury or death to marine or terrestrial fauna from pipelaying vessel collision (Residual Impact: 2 – Low) IMP118: Oiling of threatened species resulting in mortality from pipelaying vessel collision (Residual Impact: 1 – Negligible to 3 – Medium)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M103	In the unlikely event of a spill reaching the shoreline, a Shoreline Clean-up and Assessment Technique (SCAT) program will be implemented to inform shoreline clean-up and remediation as applicable.	SCAT program implemented if oil is likely to reach the shoreline	SCAT program implementation documentation	Following the accidental event	BP	BP	Included in spill response costs
M104	In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.	A shoreline clean-up and remediation team mobilized to the affected areas in the event that oil reaches the shoreline	Mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
		Specialized expertise engaged to mitigate impacts to sensitive areas and wildlife species as needed	Specialized expertise mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
M105	In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.	Incident reported and notified	Incident notification records	Following the accidental event	BP	BP	Included in spill response costs
M112	In the unlikely event of a spill of high intensity, specific monitoring (e.g., environmental effects monitoring) may be required and developed in consultation with applicable national authorities.	See Chapter 10: Surveillance and Monitoring Plan					

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M113	Provide training in oil spill response planning and techniques to management staff of the designated National Parks and Marine Protected Areas that based on the ESIA spill modelling results could potentially be affected.	Training in oil spill response planning and techniques provided to designated National Parks and Marine Protected Areas	Training reports	Once, after the training	BP	BP	Included in spill response costs
Biodiversity							
See Mitigation Measures listed to mitigate impacts on Marine Mammals, Sea Turtles, Birds, Threatened Species and Protected Areas: M101, M102, M103, M104, M105, M112, M113.							
Land & Seabed Occupation and Use							
Impacts: IMP119: Oil spill of coastline on close to 400 km, from approximately Legweichich in Mauritania to Dakar in Senegal due to a well blowout (Residual Impact: 1 – Negligible) IMP120: Oil spill of coastline on close to 400 km, from approximately Legweichich in Mauritania to Dakar in Senegal, and on the shore of <20 km along the Senegal River estuary, due to a failure of FPSO due to a ship collision (Residual Impact: 1 – Negligible) IMP121: Oil spill of coastline on about 200 km, from approximately PK 144 in Mauritania to Fass Boye in Senegal due to a pipelaying vessel collision (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M103	In the unlikely event of a spill reaching the shoreline, a Shoreline Clean-up and Assessment Technique (SCAT) program will be implemented to inform shoreline clean-up and remediation as applicable.	SCAT program implemented if oil is likely to reach the shoreline	SCAT program implementation documentation	Following the accidental event	BP	BP	Included in spill response costs
M104	In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.	A shoreline clean-up and remediation team mobilized to the affected areas in the event that oil reaches the shoreline	Mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
		Specialized expertise engaged to mitigate impacts to sensitive areas and wildlife species as needed	Specialized expertise mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
M105	In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.	Incident reported and notified	Incident notification records	Following the accidental event	BP	BP	Included in spill response costs
M106	In the unlikely event of a spill, establish a grievance mechanism easily accessible to affected stakeholders that includes monitoring of claims and the resolution thereof.	Grievance mechanism in place	Grievance mechanism documentation	Before the project starts	BP	BP	Included in project costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M107	In the unlikely event of a spill, work with national authorities as requested, to inform relevant stakeholders (including artisanal fishermen) on: 1) the location of the spill; 2) cleanup operations; 3) applicability of temporary exclusion zones; and 4) grievance mechanism, as applicable. In relation to fishermen, this will include providing timely communication, offering them the opportunity to remove gear from affected areas, reducing impact on fishing gear.	Crisis Communication plan implemented	Crisis Communication plan documentation	Following the accidental event	BP	BP	Included in spill response costs
M108	In the unlikely event of a spill, in coordination with national authorities if requested, monitor and support ways to address the concerns of stakeholders regarding potential impacts of the spill.	Concerns of stakeholders regarding potential impacts of the spill recorded	CLO records Grievance mechanism	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Industrial Fisheries							
Impacts: IMP122: Temporary loss of industrial fishing catches due to spill impacts on plankton, fish and other fishery resources (Residual Impact: 2 – Low) IMP123: Temporary preclusion of industrial fishing in the spill response area for up to >450 industrial vessels (2017 numbers) (2017 numbers) (Residual Impact: 2 – Low) IMP124: Temporary loss of catches and revenues for industrial fishing operators (Residual Impact: 2 – Low) IMP125: Temporary loss of revenues for national economies due to the temporary disruption of industrial fisheries (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill in place	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M105	In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.	Incident reported and notified	Incident notification records	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M106	In the unlikely event of a spill, establish a grievance mechanism easily accessible to affected stakeholders that includes monitoring of claims and the resolution thereof.	Grievance mechanism in place	Grievance mechanism documentation	Before the project starts	BP	BP	Included in project costs
M107	In the unlikely event of a spill, work with national authorities as requested, to inform relevant stakeholders (including artisanal fishermen) on: 1) the location of the spill; 2) cleanup operations; 3) applicability of temporary exclusion zones; and 4) grievance mechanism, as applicable. In relation to fishermen, this will include providing timely communication, offering them the opportunity to remove gear from affected areas, reducing impact on fishing gear.	Crisis Communication plan implemented	Crisis Communication plan documentation	Following the accidental event	BP	BP	Included in spill response costs
M108	In the unlikely event of a spill, in coordination with national authorities if requested, monitor and support ways to address the concerns of stakeholders regarding potential impacts of the spill.	Concerns of stakeholders regarding potential impacts of the spill recorded	CLO records Grievance mechanism	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Artisanal Fisheries and Related Activities							
Impacts: IMP126: Temporary loss of artisanal fishing catches due to spill impacts on plankton, fish and other fishery resources (Residual Impact: 2 – Low) IMP127: Temporary preclusion of artisanal fishing in the spill response area for up to over 25,000 artisanal fishing units (2017 numbers) (Residual Impact: 2 – Low) IMP128: Temporary loss of revenues for up to about 80,000 artisanal fishermen (2017 numbers) (Residual Impact: 2 – Low) IMP129: Temporary loss of revenues for up to about 700,000 people involved in activities related to artisanal fisheries (2017 numbers) (Residual Impact: 2 – Low) IMP130: Temporary loss of revenues for national economies due to the temporary disruption of artisanal fisheries (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill in place	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M105	In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.	Incident reported and notified	Incident notification records	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M106	In the unlikely event of a spill, establish a grievance mechanism easily accessible to affected stakeholders that includes monitoring of claims and the resolution thereof.	Grievance mechanism in place	Grievance mechanism documentation	Before the project starts	BP	BP	Included in project costs
M107	In the unlikely event of a spill, work with national authorities as requested, to inform relevant stakeholders (including artisanal fishermen) on: 1) the location of the spill; 2) cleanup operations; 3) applicability of temporary exclusion zones; and 4) grievance mechanism, as applicable. In relation to fishermen, this will include providing timely communication, offering them the opportunity to remove gear from affected areas, reducing impact on fishing gear.	Crisis Communication plan implemented	Crisis Communication plan documentation	Following the accidental event	BP	BP	Included in spill response costs
M108	In the unlikely event of a spill, in coordination with national authorities if requested, monitor and support ways to address the concerns of stakeholders regarding potential impacts of the spill.	Concerns of stakeholders regarding potential impacts of the spill recorded	CLO records Grievance mechanism	Following the accidental event	BP	BP	Included in spill response costs
M109	In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency fund to assist affected vulnerable households in artisanal fishing communities if needed.	Emergency fund implemented to assist affected vulnerable households in artisanal fishing communities if needed	Emergency fund documentation	Following the accidental event until normal activities in affected communities can resume	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M110	In the unlikely event of a spill, prepare and implement, in coordination with national authorities if requested, a Livelihood Restoration Plan for affected communities.	Livelihood Restoration Plan implemented for affected communities	Livelihood Restoration Plan documentation	Following the accidental event until normal activities in affected communities can resume	BP	BP	Included in spill response costs
M111	In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency plan to ensure food security of affected vulnerable households and groups if needed.	Food security emergency plan implemented for affected vulnerable households and groups if needed	Food security emergency plan documentation	Following the accidental event and once a month until normal activities in affected communities can resume	BP	BP	Included in spill response costs
M112	In the unlikely event of a spill of high intensity, specific monitoring (e.g., environmental effects monitoring) may be required and developed in consultation with applicable national authorities.	See Chapter 10: Surveillance and Monitoring Plan					

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Community Livelihoods							
Impacts: IMP131: Temporary decrease of the capacity of the coastal communities to cover day to day needs due to the disruption of their revenues, with a risk of sliding into poverty and vulnerability (Residual Impact: 2 – Low) IMP132: Temporary shortage of the main staple of coastal communities due to the disruption of artisanal fish catches, with potential ramifications on the diet of the households at a national level (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M103	In the unlikely event of a spill reaching the shoreline, a Shoreline Clean-up and Assessment Technique (SCAT) program will be implemented to inform shoreline clean-up and remediation as applicable.	SCAT program implemented if oil is likely to reach the shoreline	SCAT program implementation documentation	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M104	In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.	A shoreline clean-up and remediation team mobilized to the affected areas in the event that oil reaches the shoreline	Mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
		Specialized expertise engaged to mitigate impacts to sensitive areas and wildlife species as needed	Specialized expertise mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
M105	In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.	Incident reported and notified	Incident notification records	Following the accidental event	BP	BP	Included in spill response costs
M106	In the unlikely event of a spill, establish a grievance mechanism easily accessible to affected stakeholders that includes monitoring of claims and the resolution thereof.	Grievance mechanism in place	Grievance mechanism documentation	Before the project starts	BP	BP	Included in project costs
M107	In the unlikely event of a spill, work with national authorities as requested, to inform relevant stakeholders (including artisanal fishermen) on: 1) the location of the spill; 2) cleanup operations; 3) applicability of temporary exclusion zones; and 4) grievance mechanism, as applicable. In relation to fishermen, this will include providing timely communication, offering them the opportunity to remove gear from affected areas, reducing impact on fishing gear.	Crisis Communication plan implemented	Crisis Communication plan documentation	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M108	In the unlikely event of a spill, in coordination with national authorities if requested, monitor and support ways to address the concerns of stakeholders regarding potential impacts of the spill.	Concerns of stakeholders regarding potential impacts of the spill recorded	CLO records Grievance mechanism	Following the accidental event	BP	BP	Included in spill response costs
M109	In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency fund to assist affected vulnerable households in artisanal fishing communities if needed.	Emergency fund implemented to assist affected vulnerable households in artisanal fishing communities if needed	Emergency fund documentation	Following the accidental event until normal activities in affected communities can resume	BP	BP	Included in spill response costs
M110	In the unlikely event of a spill, prepare and implement, in coordination with national authorities if requested, a Livelihood Restoration Plan for affected communities.	Livelihood Restoration Plan implemented for affected communities	Livelihood Restoration Plan documentation	Following the accidental event until normal activities in affected communities can resume	BP	BP	Included in spill response costs
M111	In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency plan to ensure food security of affected vulnerable households and groups if needed.	Food security emergency plan implemented for affected vulnerable households and groups if needed	Food security emergency plan documentation	Following the accidental event and once a month until normal activities in affected communities can resume	BP	BP	Included in spill response costs
M112	In the unlikely event of a spill of high intensity, specific monitoring (e.g., environmental effects monitoring) may be required and developed in consultation with applicable national authorities.	See Chapter 10: Surveillance and Monitoring Plan					

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Women and Vulnerable Groups							
Impact: IMP133: Increased vulnerability of women and vulnerable groups of fishing communities, and, in particular, those of the Langue de Barbarie (Residual Impact: 2 – Low)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M103	In the unlikely event of a spill reaching the shoreline, a Shoreline Clean-up and Assessment Technique (SCAT) program will be implemented to inform shoreline clean-up and remediation as applicable.	SCAT program implemented if oil is likely to reach the shoreline	SCAT program implementation documentation	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M104	In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.	A shoreline clean-up and remediation team mobilized to the affected areas in the event that oil reaches the shoreline	Mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
		Specialized expertise engaged to mitigate impacts to sensitive areas and wildlife species as needed	Specialized expertise mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
M108	In the unlikely event of a spill, in coordination with national authorities if requested, monitor and support ways to address the concerns of stakeholders regarding potential impacts of the spill.	Concerns of stakeholders regarding potential impacts of the spill recorded	CLO records Grievance mechanism	Following the accidental event	BP	BP	Included in spill response costs
M109	In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency fund to assist affected vulnerable households in artisanal fishing communities if needed.	Emergency fund implemented to assist affected vulnerable households in artisanal fishing communities if needed	Emergency fund documentation	Following the accidental event until normal activities in affected communities can resume	BP	BP	Included in spill response costs
M111	In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency plan to ensure food security of affected vulnerable households and groups if needed.	Food security emergency plan implemented for affected vulnerable households and groups if needed	Food security emergency plan documentation	Following the accidental event and once a month until normal activities in affected communities can resume	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
Social Climate							
Impact: IMP134: Risks of social unrest in coastal communities and escalating opposition to oil and gas activities nationwide, with a risk of violence in fishing communities in Senegal (Residual Impact: 1 – Negligible)					**Countries**: Mauritania and Senegal		
M101	In the unlikely event of a spill, tactical response methods that may be considered under the OSCP include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.	Tactical responses methods in place in the event of an oil spill	Documentation covering tactical response	Once, before the project starts and if and when required	BP	BP	Included in project costs
M102	All response measures will be continuously monitored to ensure that they remain effective. The response team will maintain situational awareness of the event and response effort.	Monitoring of response measures ensuring their effectiveness in place	Monitoring system documentation	Following the accidental event, regular verification will be conducted until the incident is closed	BP	BP	Included in spill response costs
M103	In the unlikely event of a spill reaching the shoreline, a Shoreline Clean-up and Assessment Technique (SCAT) program will be implemented to inform shoreline clean-up and remediation as applicable.	SCAT program implemented if oil is likely to reach the shoreline	SCAT program implementation documentation	Following the accidental event	BP	BP	Included in spill response costs

Table 9-4. ESMP-Accidental Events: Mitigation Measures and Associated Primary Roles… cont'd

D&OC and Mitigation Measure		Objectively Verifiable Indicator	Source for Verification	Frequency of Verification	Primary Role for Implementation of Measure	Primary Role for Monitoring of Implementation	Cost of Implementation in US$
M104	In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.	A shoreline clean-up and remediation team mobilized to the affected areas in the event that oil reaches the shoreline	Mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
		Specialized expertise engaged to mitigate impacts to sensitive areas and wildlife species as needed	Specialized expertise mobilization documentation	Following the accidental event	BP	BP	Included in spill response costs
M106	In the unlikely event of a spill, establish a grievance mechanism easily accessible to affected stakeholders that includes monitoring of claims and the resolution thereof.	Grievance mechanism in place	Grievance mechanism documentation	Before the project starts	BP	BP	Included in project costs
M107	In the unlikely event of a spill, work with national authorities as requested, to inform relevant stakeholders (including artisanal fishermen) on: 1) the location of the spill; 2) cleanup operations; 3) applicability of temporary exclusion zones; and 4) grievance mechanism, as applicable. In relation to fishermen, this will include providing timely communication, offering them the opportunity to remove gear from affected areas, reducing impact on fishing gear.	Crisis Communication plan implemented	Crisis Communication plan documentation	Following the accidental event	BP	BP	Included in spill response costs
M108	In the unlikely event of a spill, in coordination with national authorities if requested, monitor and support ways to address the concerns of stakeholders regarding potential impacts of the spill.	Concerns of stakeholders regarding potential impacts of the spill recorded	CLO records Grievance mechanism	Following the accidental event	BP	BP	Included in spill response costs

Table 9-5. List of Additional Studies and Plans Announced in the Measures of the Environmental and Social Management Plan.

Additional Study or Plan	Measure to Which the Study or Plan is Linked	Approximate Schedule for the Preparation of the Document
Related to Routine Activities		
Waste Management Plan	D06: A waste management plan will be developed and implemented to avoid unauthorized waste discharges and transfers, with written procedures for collection, segregation, storage, processing and disposal of waste, including use of equipment and record keeping. M34: Verifying compliance with MARPOL Convention and implementation of a waste management plan, with the intent of reducing the likelihood of accidental loss.	As requested during the Technical Committee pre-validation meeting in Senegal, a preliminary waste management plan has been added in Appendix S of the ESIA. The waste management plan will be revised based on the nature of the waste to be managed during each phase of the project: construction, operations and decommissioning.
Pipeline and FLNG Hydrotesting Plan	D12: A pipeline and FLNG hydrotesting plan will be developed and implemented, detailing hydrotesting requirements, and demonstrating, based on an environmental risk assessment approach, the chemical additives to be selected as well as likely concentrations, volumes and frequencies of discharges. The plan will include a strategy to minimize environmental impact.	The hydrotesting plan will be ready before the start of the hydrostatic tests.
Dredging Management Plan	D13: A dredging management plan will be developed for large dredging works (breakwater, disposal areas, potential sand borrow areas offshore) and implemented that defines the dredging methodology, identifies and assesses dredged materials disposal options and sites, characterizes the composition and behavior of the sediment to be dredged, and defines the area of influence and the potential mitigation and monitoring measures. In addition, pre- and post-dredged survey will be performed. D38: If dredging activities are required for maintenance during the Operations Phase, a dredging management plan will be developed and implemented that defines the maintenance dredging methodology, identifies and assesses dredged materials disposal options and sites, characterized the chemical and physical composition and behavior of the sediment to be dredged, and defines the area of influence and the potential mitigation and monitoring measures.	A dredging management plan will be ready before the start of the dredging activities during the Construction Phase. If dredging work is required during the Operations Phase, the dredging management plan will be updated before conducting this work.

Additional Study or Plan	Measure to Which the Study or Plan is Linked	Approximate Schedule for the Preparation of the Document
Geophysical and Geotechnical Surveys	D18: The seabed in the project areas has been mapped as part of an extensive geophysical and geotechnical survey carried out by the project. The survey has confirmed that the project seabed infrastructure does not pose a risk to the submarine telecommunication cables. D25: The seabed has been mapped as part of an extensive geophysical and geotechnical survey carried out by the project. The survey has not identified any shipwrecks or other maritime heritage on the seabed. Further seabed surveys are foreseen prior to dredging taking place.	A geophysical and geotechnical survey has already been conducted and its results have been considered in the preparation of this ESIA. Other surveys are planned prior to dredging taking place, thus during the Construction Phase.
Site Security Plan	D26: A site security plan will be developed that considers the security arrangements for each of the facilities including the modalities of support provided by government.	The preparation of the security plan has begun and it will be completed during the Construction Phase.
Preliminary Decommissioning Plan	D42: A preliminary decommissioning plan will be developed for the offshore project facilities, which considers well abandonment, removal of hydrocarbons from flowlines, facility and subsea decommissioning along with disposal options for equipment and materials.	As requested during the Technical Committee pre-validation meeting in Senegal, a preliminary decommissioning plan has been added in Appendix T of the ESIA.
Final Detailed Decommissioning Plan	D43: A final detailed decommissioning plan will be developed closer to the Decommissioning Phase for the offshore project facilities, which considers well abandonment, removal of hydrocarbons from flowlines, facility and subsea decommissioning along with disposal options for equipment and materials. M45: A final decommissioning plan will be developed for approval by the authorities near the end of the operational lifetime, which takes into consideration further morphological studies and data collection as applicable.	A final decommissioning plan will be completed as per the timeline of the exploration and production contract/ exploration and production sharing contract.
Underwater Sound Modeling	M07: Collection and analysis of acoustic data from the area to determine background sound levels and marine mammal presence/absence, and underwater sound modeling to determine distances to various thresholds.	This study will be prepared during the Construction Phase.
Security Stakeholder Engagement Plan	M26: Include in the security stakeholder engagement plan, provisions around response, management and interface with Public security forces for security incidents scenario such as act of terrorism and unlawful entry in the exclusion safety zones.	The security stakeholder engagement plan will be prepared during the Construction Phase.

Additional Study or Plan	Measure to Which the Study or Plan is Linked	Approximate Schedule for the Preparation of the Document
Receptor Baseline Air Quality Study	M30: Conduct monitoring of baseline air quality prior to the Construction Phase at receptor level to establish ground-level ambient air concentrations. Update air dispersion modelling if necessary when equipment specifications from vendors are available in detailed design phase.	This study will be prepared during the Construction Phase.
Coastline Monitoring Plan	M40: a) To improve understanding of the long-term coastal dynamic equilibrium, the project will develop and implement a coastline monitoring plan during the project life cycle. Coastline monitoring will commence prior to breakwater construction, i.e. before 2020. This will include the collection of further bathymetric data along the Saint-Louis shore, including the Senegal River mouth. The project will aim to involve local academics in the implementation of the coastline monitoring plan. The relevant authorities and local communities will be informed of the monitoring results. b) The data collected as part of the implementation of the coastline monitoring plan will be used to update the coastline modeling (in Appendix I-3) to be completed before the construction of the breakwater in 2020. Additional modeling updates will be conducted at key stages of the project life cycle when new information with the potential to have a significant impact on the modeling results will become available. c) BP will seek the necessary authorizations to share relevant data for government led morphological studies initiatives and local academics. d) a contingency plan for the coastline will be developed by the project in consultation with the relevant authorities if the results of the coastline monitoring and modeling clearly and systematically demonstrate, over the duration of the project, negative impacts related to the GTA Phase 1 project which exceeds those currently identified in the GTA Phase 1 project ESIA report (in particular Section 7.3.3)	This plan will be prepared during the Construction Phase.
Capacity Building Plan	See Section 9.5 of the ESIA	2019
Related to accidental events		
Source Control Emergency Response Plan (SCERP)	D111: Develop a Source Control Emergency Response Plan (SCERP), with provisions for well containment and capping and relief well planning.	2019
Oil Spill Contingency Plan (OSCP)	D112: Develop an Oil Spill Contingency Plan (OSCP), which will cover a range of response strategies for different spill scenarios.	2019

Table 9-6. Summarized Budget for the Capacity Building Plan.

Capacity Building Programs Supported by BP	Main Recipient Institution*	Total Estimated Project Contribution
Training for the development of national institutional capacities for environmental monitoring of oil and gas activities offshore Mauritania	DCE	US$ 250,000
Training for the development of national institutional capacities for environmental monitoring of oil and gas activities offshore Senegal	Technical Committee	US$ 250,000
Technical support for the monitoring of the ESMP and SMP in Mauritania	DCE	US$ 200,000
Technical support for the monitoring of the ESMP and SMP in Senegal	Technical Committee	US$ 200,000
Total	Environmental Regulators	US$ 900,000

CHAPTER 10: SURVEILLANCE AND MONITORING PLAN

10.0 SURVEILLANCE AND MONITORING PLAN

This chapter presents the Surveillance and Monitoring Plan (SMP) developed for the GTA Phase 1 gas production project.

10.1 Objective of the SMP

The overall purpose of the SMP is to evaluate that the mitigation measures identified in the ESMP generate the expected results in regard to avoiding or reducing potential impacts on the biophysical or social environments.

The SMP complements the ESMP and aims to identify:

- Actual impact on physical, biological and socioeconomic receptors associated with the project;
- Effects not anticipated in the present impact assessment;
- Effects exceeding or below the levels anticipated in the present impact assessment;
- Appropriate mitigation measures for effects not anticipated or exceeding levels anticipated in the impact assessment; and
- Need for corrective action to be agreed with regulatory authorities.

Outcomes of the SMP will be recorded in appropriate systems, and will be used to establish the need for corrective actions to be undertaken by contractors or BP throughout Construction, Operations and Decommissioning Phases. In some cases, these actions may have to be discussed and agreed with the regulators before they are implemented.

The GTA Phase 1 project will aim at implementing monitoring activities described in the current chapter through contracts with relevant national academics (universities, research institutes) where practicable, and for relevant monitoring activities whenever appropriate. This is considered an effective way to sustainably build the local academic capability on oil and gas industry and offshore environment both in terms of equipment and expertise.

10.2 SMP Operational Tools

The SMP focuses on impacts which result from routine project operations, as qualified below. In case of an accidental event, a specific and customized surveillance and monitoring plan may have to be developed and implemented by BP in accordance with the type and extent of the event and the hydrocarbon release with the intent of obtaining an understanding of the extent of the impact. This type of monitoring is captured under mitigation measure M112 in Chapter 7.

The SMP provides a table, Table 10-1 (see below), that is applicable to all three project phases. For potential negative impacts higher than 1 – Negligible, the SMP provides:

- Performance objectives for actions associated with each potential impact;
- Performance indicators, with their source and frequency of verification; and
- Primary roles for monitoring of performance and cost of this performance monitoring.

10.3 SMP Implementation and Reporting

The SMP is intended to be utilized by BP E&S personnel in carrying out, liaising with or overseeing contractors responsible for construction, operational and decommissioning activities. The responsibility of implementing the SMP lies with different people within the project or operation team. In general, the monitoring will be executed by personnel who have received appropriate induction and training to carry out the tasks at hand. These may be contractor personnel, specialist consultants or

BP staff. The accountability for verifying execution of the tasks will however remain with BP personnel in accordance with their assigned role during construction or operations.

Protocols and procedures will be put in place to systematically document and record the delivery of the mitigation based on monitoring and potential corrective actions. Records/documents will be kept on file so that they can be made available to relevant people, including national authorities and external auditors as required.

The outcome of surveillance and monitoring activities will be analyzed to identify trends and potential corrective actions. The monitoring frequency, methodology and technology may be adjusted as appropriate based on the results of monitoring.

If a mitigation is not having the desired effect, or if effects not previously anticipated occur, BP will identify and discuss as appropriate with regulators, the feasibility of corrective actions and/or additional mitigation measures that need to be implemented to meet the performance objectives.

The approach taken will also allow verification of whether changes in the project execution strategy or operations have the potential to affect the conclusions of the ESIA, environmental and social risks, contractual requirements, and ability to deliver commitments.

During the Construction Phase, the delivery of monitoring commitments and any corrective action will be tracked using a project management system (action trackers, regular review meetings, dashboard, etc.) as needed, to feed a continual performance improvement process.

During the Operations Phase, the reports and monitoring data will be subject to regular review as part of the Performance Improvement Cycle under BP's overarching Operational Management System (OMS). The performance review takes an integrated and holistic view to support the identification of OMS environmental and social gaps to systematically identify and prioritize improvements, to be implemented.

During the Construction, Operations and Decommissioning Phases, the performance will be regularly reported to management. During the Operations Phase, the reporting will be carried out in accordance with BP wide reporting requirements as applicable. The outcome of specific monitoring programs stipulated in the SMP will also be reported to Mauritanian and Senegalese authorities at a frequency to be agreed with the regulator or in conformance with regulatory requirements.

10.4 Monitoring of the SMP by the National Authorities

The implementation of the SMP will be monitored by the Mauritanian and Senegalese authorities. A monitoring plan has been developed for this purpose. It is provided in Appendix U of this report. The purpose of this plan is to provide a monitoring tool to the authorities, detachable from the rest of the ESIA if needed. The plan covers both the monitoring of the implementation of the ESMP, presented in Chapter 9 of this report, and the monitoring of the implementation of the surveillance and monitoring plan (SMP), presented in Chapter 10.

The monitoring plan includes five tables that constitute operational tools for the authorities:

- Table U-1: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Construction Phase;
- Table U-2: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Operations Phase;
- Table U-3: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Decommissioning Phase;
- Table U-4: ESMP Monitoring by the Mauritanian and Senegalese Authorities - Accidental events; and
- Table U-5: SMP Monitoring by the Mauritanian and Senegalese Authorities.

The following information are specified in the first four tables used for the monitoring of the ESMP:

- Potential impacts, by biophysical and social resource;
- Country where the impact could occur;
- Project Design & Operation Controls measures to mitigate impacts;
- Mitigation measures to avoid or reduce non-negligible negative impacts;
- Residual impact assessment;
- Operator monitoring elements (as a reminder);
- Authorities monitoring indicator;
- Monitoring activity to be carried out by the authorities;
- Authorities monitoring schedule;
- Potential institution responsible for monitoring in Mauritania;
- Potential institution responsible for monitoring in Senegal; and
- Cost of the monitoring activity by the authorities.

In Table U-5 for monitoring the SMP, the following information is provided:

- Potential impacts, by biophysical and social resource;
- Operator monitoring measures;
- Operator monitoring elements (as a reminder);
- Authorities monitoring indicator;
- Monitoring activity to be carried out by the authorities;
- Authorities monitoring schedule;
- Potential institution responsible for monitoring in Mauritania;
- Potential institution responsible for monitoring in Senegal; and
- Cost of the monitoring activity by the authorities.

In Mauritania, potential monitoring authorities may be identified by the DCE. In Senegal, potential monitoring authorities include the Technical Committee, including ANAM, DEEC, HASSMAR and the Ministry of Fisheries and Maritime Economy.

The monitoring activities to be carried out by the authorities include reading of monitoring reports and management plans provided by the GTA Phase 1 project as well as other project documents, and project facilities inspections and visits[181]. There are no monitoring costs associated with document reading. For inspections and visits, the GTA Phase 1 project plans for the transportation by boat or helicopter as used by the project personnel to reach the project facility and accommodation at the facility depending on the duration of the inspection/visit. The cost of this transportation and accommodation will be covered by the GTA Phase 1 project.

[181] A set of visits are planned in the monitoring plan. Inspections will be ad hoc visits by the authorities to verify information provided in the documents produced by the GTA Phase 1 project after review of these documents.

Relevant authorities in Mauritania and Senegal have expressed a need to build up capacities to monitor offshore oil and gas activities which are new to Senegal and recent to Mauritania

Section 9.5 of the ESIA provides an outline of the capacity building plan for the Mauritanian and Senegalese authorities for the monitoring of the ESMP and SMP. A detailed capacity building plan will be prepared by BP in 2019 in collaboration with the relevant authorities. The budget associated with the capacity building plan in the context of the ESIA is presented in Table 9-6 of Chapter 9.

Table 10-1. SMP: Monitoring Measures and Associated Primary Roles.

Abbreviations:

Co: Construction Phase | De: Decommissioning Phase | D: Design & Operational Control Measure | MON: Monitoring Measure
Op: Operations Phase | IMP: Impact | M: Mitigation Measure

Monitoring Measure		Project Phase	Performance Objective	Performance Indicator	Source for Verification of Performance	Frequency of Monitoring[182]	Primary Role for Monitoring of Performance	Cost of Monitoring in US$
Air Quality and Greenhouse Gases								
Corresponding to the impacts:								
IMP01: Reduction in ambient air quality (NOx and SOx only). (Residual impact: 2 – Low) / Co Phase					*D and M Measures: D01, D02, D03, D04, M01, M02*			
IMP02: Reduction in ambient air quality. (Residual impact: 2 – Low) / Op Phase					*D and M Measures: D01, D02, D04, D15, D29, D30, D31, D32, D33, M01, M02, M29, M30, M31*			
MON1	Monitoring of baseline air quality before start of significant construction	Co	Obtaining specific data on air quality at receptor level before the project	Air quality measurements	Air quality baseline report	Once before construction	BP	Included in project costs
MON2 (also M02)	Recording fuel consumption and type of fuels used	Co, Op	Reduction in SOx emissions, resulting in no significant reduction of ambient air quality	Fuel volumes and types of fuels	Fuel consumption records	Quarterly	BP, Contractor	Included in project costs
MON3 (also D04)	Recording of flaring events	Co, Op	Reduction in volume of hydrocarbons flared	Flare emissions (volume of hydrocarbons flared)	Emissions records	Quarterly	BP, Contractor	Included in project costs
MON4 (also D33)	Predictive emission monitoring system (PEMS) used on both the FLNG and FPSO	Op	Regular monitoring of emissions on both the FLNG and FPSO	emissions of GHG, SOx and NOx	PEMS records	Quarterly	BP, Contractor	Included in project costs
Water Quality								
Corresponding to the impacts:								
IMP03: Reduction in ambient water quality from FPSO produced water and FLNG cooling water discharges and associated chemicals. (Residual impact: 2 – Low) / Op Phase					*D and M Measures: D01, D05, D06, D07, D11, D34, D35, D36, D37, D38, M32, M33, M35, M36, M37, M38, M39*			
IMP04: Changes in water quality from accidental loss of trash and debris. (Residual impact: 1 – Negligible) / Op Phase					*D and M Measures: D01, D05, D06, D07, D11, D34, D35, D36, D37, D38, M34*			
MON5 (also M33)	Monitor use of added chemicals to overall process system (corrosion inhibitors, scale inhibitors, coagulants/flocculants)	Op	Reduce use of added chemicals to the overall process system to a level that maintains defined performance criteria without compromising installations safety	Record of chemical additions to process system	Chemical use / purchase records	Annual review of chemical use / purchase records	BP, Contractor	Included in project costs
MON6 (also M36)	Monitor free chlorine in FLNG cooling water discharge	Op	Maintain free chlorine below 0.2 ppm in FLNG cooling water discharge	Monthly average of free chlorine measurements in FLNG cooling water discharge	FLNG cooling water sampling records	Daily and monthly	Contractor	Included in project costs
MON7 (also M37)	Monitoring of oil and grease content of the produced water effluent	Op	Effluent quality not to exceed 42 mg/L daily maximum; 29 mg/L monthly average	Daily and monthly records of discharge quality	FPSO discharge monitoring records	Daily and monthly	BP	Included in project costs
MON8 (also M38)	Monitor quality of the produced water effluent from the FPSO, to inform and complete an Environmental Risk Assessment during the first 18 months of the FPSO operation phase or following a material change in effluent composition or volume[183]	Op	Confirm environmental impact (risk) of produced water discharge using a risk-based approach	Record of naturally occurring compounds of produced water Record of chemical additions to process system Result of a WET test done as per the OSPAR methodology 2012/5	Produced water naturally occurring compounds analysis report(s) Chemical use / purchase records Laboratory report for the WET test	One analysis of naturally occurring compounds and one WET test during the first 18 months, or following a material change in effluent composition or volume	BP	Included in project costs

[182] Monitoring frequency is for internal purpose only. The frequency of reporting on the monitoring results will be as per regulatory requirements or as agreed with the regulator.
[183] Given the limited added value of biomarkers in these types of monitoring, and noting that effective use of biomarkers in monitoring programs in Senegalese waters would require significant development and application of region-specific methods in key species and associated assessment criteria, it can be argued that an environmental risk based modelling approach as proposed in the ESIA offers the best method for assessing potentially significant effects of produced water discharges at the population and ecosystem levels.

Monitoring Measure		Project Phase	Performance Objective	Performance Indicator	Source for Verification of Performance	Frequency of Monitoring[182]	Primary Role for Monitoring of Performance	Cost of Monitoring in US$
Coastal Erosion								
Corresponding to the impact:								
IMP05: Accretion or reduction in natural erosion of the Langue de Barbarie (relative to the case without the breakwater) of up to 13 m over 10 years near the Mauritania-Senegal border and extending southward approximately 8 km, accompanied by a maximum increase in coastal erosion rate (relative to the case without the breakwater) of approximately 6 m over 10 years further south, along approximately 2 km of coast, starting from the south end of the Hydrobase neighborhood (Residual impact: 2 – Low) / Op and De Phases					*D and M Measures: D39, D42, M40, M41, M45*			
MON9 (also M40)	Develop and implement a coastline monitoring plan[184, 185].	Co, Op, De	Provide bathymetric and oceanographic data for further modeling during project detailed design. Verification of predicted morphological change based on additional site-specific bathymetry and oceanography data along the coastline from Saint-Louis to the Senegal River mouth	Completion of data collection and use of data in modeling conducted as part of project detailed design Monitoring plan	Bathymetric and oceanographic data and modeling report Monitoring plan developed based on modelling results	Once during the project detailed design stage to inform the modelling and then as informed by the monitoring plan during operations and decommissioning	BP	Included in project costs
Sediment Quality								
Corresponding to the impacts:								
IMP03: Reduction in ambient water quality from FPSO produced water and FLNG cooling water discharges and associated chemicals. (Residual impact: 2 – Low) / Op Phase					*D and M Measures: D01, D05, D06, D07, D11, D34, D35, D36, D37, D38, M32, M33, M35, M36, M37, M38, M39*			
IMP06: Changes in bottom contours, grain size, and some chemical parameters from dredging activities and discharge of drilling muds and cuttings discharges. (Residual impact: 2 – Low) / Co Phase					*D and M Measures: D01, D05, D06, D09, D10, D13, M03*			
MON10	Sediment sampling in the Offshore Area, near the FPSO for physico-chemical analysis of sediments (EBS)	Co, Op	Assessment of the potential spread of constituents of concern arising from produced water	Measured levels of produced water tracer compounds in sediments	EBS follow-up reports	FPSO: two surveys (one before FPSO installation; one within 6 years following startup), with any subsequent monitoring strategy to be determined based on survey results	BP, Contractor	Included in project costs
MON11	ROV visual survey of epibenthic community and seabed at drill sites	Co, Op	Evaluate recovery of benthic communities and seabed at drilling sites	Observed recovery of benthic communities at one or two offshore drilling sites during well workover operations / well interventions	ROV survey report	Offshore Area: one post-drill survey for one well	BP, Contractor	Included in project costs
MON12	Survey pre- and post-dredging	Co	Establish extent of seabed disturbance from dredging activity	Difference between pre- and post-dredging, where applicable	Post-Dredging report	Before and after dredging.	BP, Contractor	Included in project costs
Benthic Communities								
Corresponding to the impacts:								
IMP08: Disturbance to benthic communities from resuspension and deposition of sediments in close proximity to dredging activities. (Residual impact: 1 – Negligible) / Co Phase					*D and M Measures: D01, D05, D06, D08, D09, D10, D13, M03*			
IMP09: Introduction of aquatic invasive species. (Residual impact: 2 – Low) / Co Phase					*D and M Measures: D01, D05, D06, D08, D09, D10, D13*			
MON12	Survey pre- and post-dredging	Co	Establish extent of seabed disturbance from dredging activity	Difference between pre- and post-dredging, where applicable	Dredging report	Before and after dredging.	BP, Contractor	Included in project costs
MON13	Review main project vessel records to ensure compliance with ballast water management procedures	Co	Reducing the potential introduction of alien invasive species into Mauritania and Senegal waters via ballast water discharges of main project vessels	Compliance by project vessel operators to ballast water management procedures	Vessel ballast water management records	Immediately prior to project vessel entrance into local waters	BP, Contractor	Included in project costs

[184] The monitoring plan will include nearshore bathymetric survey, beach profile and coastline position surveys. The survey measurements will be sufficient to identify key coastline features and support additional coastline modelling if necessary. Surveys will be set up to allow repeatability so that changes over time can be assessed.

[185] It is to be noted that the currently proposed beach profile monitoring (included in the coastline monitoring plan) covers the Mauritania and Senegal coastline from North of N'Diago (latitude 1,800,000 - WGS84/UTM 28N) to South of the breach (latitude 1,756,200 - WGS84/UTM 28N).

Monitoring Measure		Project Phase	Performance Objective	Performance Indicator	Source for Verification of Performance	Frequency of Monitoring[182]	Primary Role for Monitoring of Performance	Cost of Monitoring in US$
Plankton & Fish and Other Fishery Resources								
Corresponding to the impact:								
IMP10: Entrainment and impingement of plankton and adult fish in FLNG cooling water at Nearshore Hub/Terminal. Entrainment and impingement of plankton and adult fish by FPSO. (Residual impact: 1 – Negligible) / Op Phase					*D and M Measures: D01, D05, D06, D34, M42*			
MON14	Ichthyoplankton surveys at and near the FLNG and at a reference station	Op	Monitor the seasonal variability of ichthyoplankton potentially entrained into the FLNG cooling water systems	Collection of ichthyoplankton from the source water body at and near the FLNG to establish seasonal species diversity and abundance and estimated number of entrained ichthyoplankton	Ichthyoplankton survey reports	Quarterly during the first 3 years of FLNG operation, to be adjusted depending upon quarterly findings	BP	Included in project costs
MON15	Monitoring of fish fauna associating with the Nearshore Terminal/Hub	Op	Monitor structure-associated fish diversity near the Nearshore Hub/Terminal structure (relative to water column and seafloor habitat in similar water depths)	Collection of fish fauna data from the Nearshore Terminal/Hub to determine species composition and relative abundance of fishes associating with the structure	Assessment reports	Once before installation, and then every year in same season for up to 5 years, with any subsequent monitoring strategy to be determined based on survey results	BP	Included in project costs
Birds								
Corresponding to the impacts:								
IMP13: Potential vessel strike resulting in bird injury or mortality. (Residual impact: 2 – Low) / Op Phase					*D and M Measures: D01, D05, D06, D15, D16, D17, D29*			
MON16	Monitor and record project vessel collisions with marine mammals, sea turtles, and birds	Op	Monitor project vessel collisions with marine mammals, sea turtles, and birds	Record project vessel collisions with marine mammals, sea turtles, and birds	Project vessel collision records; protected species reporting	Continuously during vessel operations	BP	Included in project costs
Marine Mammals and Sea Turtles								
Corresponding to the impacts:								
IMP15: Auditory impairment [of marine mammals] due to sound from construction activities, particularly pile driving and VSP survey. (Residual impact: 1 – Negligible) / Co Phase					*D and M Measures: M04, M05, M07*			
IMP16: Potential vessel strike resulting in marine mammal injury or mortality. (Residual impact: 1 – Negligible) / Co, Op and De Phases					*D and M Measures: D41, D42, D43, M06*			
IMP18: Avoidance or displacement [of sea turtles] from areas under construction for some species; attraction to other species as a foraging strategy; Noise disturbances from construction activities, particularly pile driving and VSP surveys; loss of foraging habitats from proposed construction. (Residual impact: 1-Negligible) / Co Phase					*D and M Measures: M04, M05, M07*			
IMP19: Potential vessel strike resulting in sea turtle injury or mortality. (Residual impact: 1 – Negligible) / Co, Op and De Phases					*D and M Measures: D41, D42, D43, M06*			
MON17	Pile driving mitigation monitoring program during pile driving operations;	Co	Reduce acoustic-related injury to marine mammals and sea turtles from pile driving operations	Record of mitigation measures being implemented, e.g. soft start.	Pile driving reports	During pile driving operations	Contractor	Included in project costs
MON18	VSP mitigation monitoring program and observations during VSP operations	Co	Reduce acoustic-related injury to marine mammals and sea turtles from VSP operations	Record of marine mammal and sea turtle observations within an exclusion zone	VSP survey mitigation monitoring report	During VSP surveys	Contractor	Included in project costs
MON19	Ambient underwater sound recording program	Co	Understand the background sound characteristics of the area	Documentation of ambient underwater sound	Ambient sound measurement reports	Sound recording program, beginning prior to construction	BP	Included in project costs
MON16	Monitor and record vessel collisions with marine mammals, sea turtles, and birds	Co, Op, De	Monitor project vessel collisions with marine mammals, sea turtles, and birds	Record project vessel collisions with marine mammals, sea turtles, and birds	Project vessel collision records; protected species reporting	Continuously during vessel operations	BP, Contractor	Included in project costs

Monitoring Measure		Project Phase	Performance Objective	Performance Indicator	Source for Verification of Performance	Frequency of Monitoring[182]	Primary Role for Monitoring of Performance	Cost of Monitoring in US$
Threatened Species and Protected Areas								
See Monitoring Measures listed to monitor impacts on Plankton & Fish and Other Fishery Resources, Birds, Marine Mammals and Sea Turtles								
Biodiversity								
See Monitoring Measures listed to monitor impacts on Benthic Communities, Plankton & Fish and Other Fishery Resources, Birds, Marine Mammals and Sea Turtles, Threatened Species and Protected Areas								
Maritime Navigation								
Corresponding to the impact:								
IMP28: Risk of collision between project vessels and pirogues due to project vessels movements. (Residual impact: 2 – Low in Co and Op Phases and 1 – Negligible in De Phase) / C, Op and De Phases					*D and M Measures: D19, D20, D21, D22, D23, D43, M08, M09, M10, M11, M12, M13, M14, M15, M16, M17, M18, M19*			
MON20	Monitoring of safety incidents involving project vessels and other sea users, notably artisanal fishing boats	Co, Op, De	No collisions between project vessels and non-project vessels, notably artisanal fishing boats	Number of collisions and number of near misses between project vessels and non-project vessels	HSSE project records	Continuous during Construction, Operations and Decommissioning Phases	BP	Included in project costs
			No fatality due to a collision between project vessels and non-project vessels, notably artisanal fishing boats	Number of fatalities during collision between project vessels and non-project vessels	HSSE project records	Continuous during Construction, Operations and Decommissioning Phases	BP	Included in project costs
Artisanal Fisheries								
Corresponding to the impact:								
IMP29: Potential loss of artisanal fishing gears (nets and buoys) due to project vessels movements in artisanal fishing areas. (Residual impact: 2 – Low) / Co, Op and De Phases					*D and M Measures: D19, D23, D24, M09, M12, M13, M17, M18, M19, M20, M21, M22, M23, M24, M27*			
MON21	Monitoring of loss of artisanal fishing gears due to project vessel movements	Co, Op, De	Minimal losses of fishing gears	Number of gear losses reported	CLO records Grievance mechanism records	Every month during the Construction Phase + Every 6 months during Operations Phase and Decommissioning Phase	BP	Included in project costs
			Grievances associated with loss of fishing gears are addressed as per the grievance procedure	Number of claims closed vs. claims submitted	CLO records Grievance mechanism records	Every month during the Construction Phase + Every 6 months during Operations Phase and Decommissioning Phase	BP	Included in project costs
Community Health, Safety and Security								
Corresponding to the impacts:								
IMP30: Risk of conflicts between artisanal fishermen and public security forces if some fishermen need to be escorted out of the exclusion safety zones. (Residual impact: 2 – Low during Co and Op Phases and 1 – Negligible during De Phase) / Co, Op and De Phases					*D and M Measures: D23, D26, D43, M08, M17, M19, M25, M26*			
MON22	Monitoring entries attempts by fishermen into the exclusion safety zones where intervention by public security forces is required	Co, Op, De	Fishing interaction control measures are effective, and reduce the number of unauthorized entries or breaches of security by artisanal fishermen.	Number of unauthorized access incidents where intervention from public security forces is required	HSSE project records CLO records	Continuous during the Construction Phase, Operations Phase and Decommissioning Phase	BP	Included in project costs

Monitoring Measure		Project Phase	Performance Objective	Performance Indicator	Source for Verification of Performance	Frequency of Monitoring[182]	Primary Role for Monitoring of Performance	Cost of Monitoring in US$
Public Infrastructure and Services								
Corresponding to the impacts:								
IMP32: Placing additional demands on the public security forces limited resources since they will be required to be available 24/7 to handle a safety incident with artisanal fishermen or a search and rescue operation if needed. (Residual impact: 1 – Negligible in Co Phase and 2 – Low in Op Phase) / Co and Op Phases					*D and M Measures: D24, D26, D27, D28, M08, M09, M10, M11, M12, M13, M14, M16, M25, M26*			
MON23	Monitoring the number of times public security forces are called in to handle project related safety incidents or search and rescue operations.	Co, Op	Reduce number of incidents where support from public security forces is required to handle project related safety incidents or search and rescue operations	Number of incidents where public security forces are called in to handle project related safety incidents or search and rescue operations	HSSE project records	Continuous during the Construction Phase, Operations Phase and Decommissioning Phase	BP	Included in project costs
Social Climate								
Corresponding to the impact:								
IMP34: Social discontent in N'Diago and Saint-Louis due to the potential perception of loss of fishing grounds and fishing catches combined with the limited employment opportunities, the perception of unsatisfied grievances and/or compensation claims (e.g. for lost gear), and elevated safety risk for fishermen at sea due to presence of project vessels. (Residual impact: 2 – Low in Co and Op Phases and 1 – Negligible in De Phase) / Co, Op, De Phases					*D and M Measures: D19, D24, D43, M09, M17, M18, M19, M20, M23, M24, M27, M28. M44, M46*			
MON24	Monitor social discontent in N'Diago and Saint-Louis	Co, Op, De	No project related social unrest and minimum social discontent in N'Diago and Saint-Louis	Type of grievances received, or public expressions of discontent reported.	CLO records Grievance mechanism records BP External Affairs Managers in Mauritania and Senegal records	Continuous during the Construction Phase and Operations Phase	BP	Included in project costs

CHAPTER 11: CONCLUSION

11.0 CONCLUSION

BP, in partnership with Kosmos, PETROSEN and SMHPM, is planning to conduct the GTA Phase 1 project to develop natural gas reserves located in deep water offshore of Mauritania and Senegal. The objective of the project is to extract, process, and export condensate and liquefied natural gas (LNG). Up to 2.5 million tonnes of LNG will be produced per year. The project will also make natural gas available for use in both countries.

The infrastructure and operations required either in Mauritania or in Senegal for GTA Phase 1 has been detailed in this ESIA. The project includes three key areas located on the maritime border of the two countries: an Offshore Area, a Nearshore Hub/Terminal Area and a Pipeline Area. It also comprises an on-land component called the Support Operations Areas, which includes a supply base in the Port of Dakar and/or a supply base in the Port of Nouakchott, and facilities at the airports of both Dakar and Nouakchott.

The Offshore Area is located about 125 km from the coast and in about 2,700 m water depth. It is where the gas reservoirs under the bottom of the seabed have been identified. The gas will be collected via 12 subsea wells and a subsea production system.

The Nearshore Hub/Terminal Area is located about 10 to 11 km from the coast, in a water depth of about 33 m. It is located approximately 16 km from N'Diago in Mauritania and 13 km from Saint-Louis in Senegal. The nearshore infrastructure will include a breakwater approximately 1 km long, associated berthing facilities, a FLNG vessel and a quarters and utilities platform for workers. Aboard the FLNG, processing will cool the natural gas to bring it to a liquid state (LNG), thus enabling storage and long-distance transportation by large vessels. These vessels will visit the Nearshore Hub/Terminal on a periodic basis.

The Pipeline Area is a narrow corridor where pipelines on the seafloor will connect offshore and nearshore infrastructure. In this corridor, the infrastructure will include a FPSO vessel for the gas pre-processing including the removal of liquids from the gas. These liquids, called condensate, will be offloaded and exported from the FPSO on a periodic basis by large vessels. The FPSO will be located in around 120 m water depth, approximately 40 km from the coast.

The Support Operations Areas will serve as the onshore logistics and supply centers during all phases of project activities.

The project includes three phases:

- The Preparation, Construction and Installation Phase, termed the Construction Phase in the ESIA. It will consist of construction and installation of infrastructures and drilling of the wells. This phase is expected to start in 2018;
- The Operations Phase. This will be the phase during which gas will be produced. There will also be ongoing development drilling but for the purpose of the ESIA, development drilling is grouped under the Construction Phase. The first facilities are expected to be operational on location end of 2021. The Operations Phase of the Phase 1 development is based on an anticipated 20 year contract duration of the FLNG vessel; and
- The Decommissioning Phase. During this phase, the gas production will cease and equipment may be retired (cleaned and left in place) or removed. This phase will start after the Operations Phase and could last several years. A detailed decommissioning plan will be established prior to this phase and will comply with regulatory requirements applicable at the time of decommissioning.

The ESIA prepared for the GTA Phase 1 project has involved the following steps:

- Identify the Mauritanian and Senegalese environmental laws and regulations, the international conventions and protocols and the good international industry practice applicable to the project;

- Provide a detailed description of the planned project: the infrastructures, equipment and operations planned in each project area, and during each project phase;
- Consider potential alternatives to the proposed project;
- Provide a comprehensive characterization of the biophysical and the social environments of the project area;
- Identify and address stakeholders' questions and concerns regarding the project through a public consultation process during which 2,600 people were consulted;
- Assess the potential impacts of the project, by area and by project phase;
- Recommend mitigation measures to avoid or reduce non-negligible negative impacts; and
- Develop an ESMP and a SMP.

Additionally, a Risk Study (*Étude de dangers*) and Occupational Risk assessment have been conducted as part of the ESIA.

The impact assessment considered potential interactions between the proposed project and the host environment, and then classified the significance of each potential impact. Routine activities of the project and potential accidental event scenarios were both considered in the impact assessment.

The detailed review of the project included consideration of a range of Design and Operational Controls measures built into the project by BP with the intent to avoid or reduce negative impacts on the environment in line with the mitigation hierarchy. BP has integrated 45 Design and Operational Control measures to avoid or reduce the impacts from routine activities and 19 to avoid or reduce negative impacts in case of accidental events. These measures are listed in the ESIA and have been considered in the impact assessment.

The impact analysis considered impact consequence and impact likelihood to determine overall impact significance. The determination of impact consequence was based on the integration of three criteria: intensity, extent and duration of the impact. Intensity determination relates to the degree of disturbance associated with each impact: low, moderate or high. Impact extent pertains to how widespread the impact is expected to be: immediate vicinity, local or regional. Impact duration describes the length of time over which the effects of an impact occur: shorter term or long term. Impact likelihood is the probability of an occurrence of an impact. The various categories of likelihood have been characterized as follows:

- Likely (>50% to 100% or may happen a few times per year);
- Occasional (>10% to 50% or may happen a few times during the lifetime of the project);
- Rare (1% to 10% or may possibly happen once during the lifetime of the project); or
- Remote (<1% or unlikely to happen at all during the lifetime of the project).

The matrix integrating impact consequence with impact likelihood provided the basis for determining overall impact significance. With this matrix, the negative impacts were assigned a numerical rating ranging from 1 through 4: 1 – Negligible, 2 – Low, 3 – Medium and 4 – High. Beneficial impacts were noted as positive but did not have a numerical rating.

The assessment has identified positive impacts from routine activities, including the following:

- Introduction of hard substrate in areas of unconsolidated sediments around project infrastructures, such as the breakwater, suitable for attachment and colonization by marine flora and fauna.
- Organic input and food source to benthic communities with sloughing associated with the project infrastructures.

- Protection from fishing pressure of fishes and some invertebrates attracted to the project infrastructures where the exclusion safety zones will be applied and where fishing boats will not be allowed.
- New artisanal fishing ground at the end of the project due to the artificial reef effect of the breakwater, assuming that it will not be removed during the Decommissioning Phase.
- Employment opportunities for: 1) During the Construction Phase up to 25 people on shore in Dakar and/or Nouakchott and up to 30 people on vessels, and up to 20 people from Saint-Louis and N'Diago as community and fisheries liaison officers. In addition, BP's local content approach in the contractor selection process includes an expectation that contractors give consideration to local sourcing in terms of people, goods and services in their final execution plans; 2) 20-40 people in Dakar and/or Nouakchott, progressively up to 400 people from Mauritania and Senegal on offshore facilities, and local Fisheries Liaison Officers or Community Liaison Officers will also be required in N'Diago and Saint-Louis during the course of the Operations Phase. The national recruitment effort will also take into consideration existing resources in local communities, where possible; and 3) 20-40 people in Dakar and/or Nouakchott and an additional number of people from Mauritania and/or Senegal on vessels during the Decommissioning Phase.
- Business opportunities for: 1) up to 3-5 National service providers in Dakar and/or Nouakchott for onshore logistics services and vessels during the Construction Phase; 2) 2-3 National service providers in Dakar and/or Nouakchott for onshore logistics services in addition to the use of service providers for potentially up to 16 vessels during the Operations Phase; and 3) a few National service providers in Dakar and/or Nouakchott for onshore logistics services and additional service providers for vessels during the Decommissioning Phase.
- Additional business opportunities, indirect employment and multiplier effects that could be created through local procurement policy to support the supply chain for the project during each project phase. The exact nature of these additional opportunities will become evident as the project progresses.

However, the most significant benefits of the project for Mauritania and Senegal are at a national level. These benefits include revenues: income revenues through the shares of PETROSEN and SMHPM in the project, the states' shares of LNG sales, and taxes. Additionally, the project will make gas available for use in both countries.

Negative impacts from the project's routine activities were assessed. Over 50 impacts were rated 1 – Negligible. The assessment also identified 34 potential non-negligible impacts: 26 were rated 2 – Low and 8 were rated 3 – Medium or 4 – High prior to implementation of additional mitigation measures.

The eight potential negative impacts rated 3 – Medium or 4 – High prior to mitigation measures are the following:

- IMP01: Reduction in ambient air quality (NOx and SOx only) during the Construction Phase.
- IMP02: Reduction in ambient air quality during the Operations Phase.
- IMP28: Risk of collision between project vessels and pirogues due to project vessels movements during the Construction and the Operations Phases.
- IMP30: Risk of conflicts between artisanal fishermen and public security forces if some fishermen need to be escorted out of the exclusion safety zones during the Construction and the Operations Phases.
- IMP31: Risk of terrorism act targeting the gas production facilities which in turn will raise the level of terrorism risk at a national level during the Operations and Decommissioning Phases.
- IMP32: Placing additional demands on the public security forces limited resources since they will be required to be available 24 hours per day/7 days per week (24/7) to handle a safety incident with artisanal fishermen or a search and rescue operation if needed during Operations Phase.

- IMP33: Placing additional demands on National security authorities who will need to prevent and be available 24/7 to handle a national security incident at sea resulting from the presence of offshore gas production infrastructures during Operations Phase.

- IMP34: Social discontent in N'Diago and Saint-Louis due to the potential perception of loss of fishing grounds and fishing catches combined with the limited employment opportunities, the perception of unsatisfied grievances and/or compensation claims (e.g., for lost gear), and elevated safety risk for fishermen at sea due to presence of project vessels during Construction and Operations Phases.

The ESIA has recommended 46 mitigation measures to reduce the potential negative impacts of routine activities in addition to the 45 Design and Operational Control measures being implemented. The mitigation measures include, for instance, the following:

- M02: Monitoring fuel consumption as a proxy for measuring performance and emissions. When practical, or as required by applicable regulations, vessel operators will be expected to utilize low-sulfur fuels to limit SOx production.

- M09: Provide regular notices to mariners in the appropriate form and language to artisanal fishermen on project infrastructure, associated exclusion safety zones, travel and approach plans and the approximate timing of project activities.

- M10: Equip the support vessels and other project vessels that regularly move outside the construction or operational exclusion safety zones with radar or infrared systems that can detect small fishing vessels during poor visibility/night time.

- M12: Having a project patrol boat to monitor the exclusion safety zones, including patrolling ahead of the approach or exiting of larger project vessels into or out of the exclusion safety zones.

- M13: Where there is a risk of vessel interaction, using the services of local fishermen liaison officers (FLOs) aboard the project patrol boats in the areas of artisanal fishing.

- M17: Establishing a grievance mechanism easily accessible to fishing communities members that includes monitoring of claims and the resolution thereof.

- M18: Maintaining a community liaison officer (CLO) for N'Diago and Saint-Louis to provide a direct link with the fishing communities in all matters related to the project.

- M19: Collaboration with a community council of formally nominated representatives of local key stakeholders from N'Diago and Saint-Louis set up to review local fishing communities' concerns and grievances related to the project.

- M20: Develop and implement a framework for interaction with artisanal fisheries, with provisions covering engagement with local communities on access to fishing grounds, grievance and recourse mechanism for damage to fishing gear, environmental awareness building, livelihood enhancement and the role of community liaison officers.

- M24: Provide technical assistance to mutually agreed marine resource research programs notably the national oceanographic research centers of both countries (CRODT and IMROP).

- M25: The project will seek to work with the public security forces to establish an appropriate response and security framework which may include resource, equipment, training and response protocols.

- M26: Include in the security stakeholder engagement plan, provisions around response, management and interface with public security forces for security incidents scenario such as act of terrorism and unlawful entry in the exclusion safety zones.

- M27: Developing a social investment program to enhance project benefits for the directly affected N'Diago and Saint-Louis communities, including livelihood enhancement activities.

With the implementation of the full set of 45 Design and Operational Control measures and 46 mitigation measures, all the residual impacts of routine activities are deemed 1 – Negligible or 2 – Low.

As a prelude to the impact assessment, a large number of potential project-specific accidental event scenarios were evaluated for detailed analysis. Three potential accidental event scenarios corresponding to worst credible cases were retained: a well blowout in the Offshore Area, a collision with the FPSO in the Pipeline Area, and a pipelaying vessel collision in the Nearshore Hub/Terminal Area. These planning scenarios were considered to represent the most challenging response conditions, due to either location, oil type or volume or highest environmental impact. The likelihood of these three accidental event scenarios occurring during the life of the project are considered remote, with probability of occurrence noted as follows:

- Well blowout: 1/455 years (0.2%);
- Failure of FPSO due to a ship collision: 1/392 years (0.2%); and
- Pipelaying vessel collision: in-between 1/10,000 years to 1/100,000 years (0.01 to 0.001%).

Potential spill scenarios for each of the three accidental events were examined using oil spill modeling to assess the fate of a hydrocarbon spill. While the consequences of a spill in a worst-case scenario could affect several resources, the adverse impacts would be variable depending upon a variety of factors, including spill trajectory, degree of weathering, and volumes reaching the coast.

Since the accidental event scenarios are highly unlikely to happen (remote likelihood), there were several instances where overall impact significance was rated 1 – Negligible. Out of the 34 potential non-negligible impacts, 15 were rated 2 – Low and 19 were rated 3 – Medium. The 19 potential impacts deemed 3 – Medium prior to mitigation measures are the following:

- IMP105: Exposure of birds to elevated hydrocarbons within a regional area; some lethal impacts and numerous sublethal impacts from direct and indirect effects from exposure to oil from a blowout.
- IMP106: Exposure of birds to elevated hydrocarbons within a regional area; some lethal impacts and numerous sublethal impacts from direct and indirect effects from exposure to oil from FPSO failure due to a ship collision.
- IMP107: Exposure of birds to elevated hydrocarbons within a regional area; some lethal impacts and numerous sublethal impacts from direct and indirect effects from exposure to oil from pipelaying vessel collision.
- IMP108: Exposure of Mediterranean monk seals (an Endangered species) to elevated hydrocarbons within a regional area; assuming lethal impact(s) from direct and indirect effects from exposure to oil from the blowout spill.
- IMP109: Exposure of Mediterranean monk seals to elevated hydrocarbons within a regional area; assuming lethal impact(s) from direct and indirect effects from exposure to oil from FPSO failure due to a ship collision.
- IMP110: Exposure of Mediterranean monk seals to elevated hydrocarbons within a regional area; assuming lethal impact(s) from direct and indirect effects from exposure to oil from pipelaying vessel collision.
- IMP111: Exposure of sea turtles to elevated hydrocarbons within a regional area; some lethal impacts to turtles of all age groups and numerous sublethal impacts to turtles from direct and indirect effects from exposure to oil from FPSO failure due to a ship collision.
- IMP112: Exposure of sea turtles to elevated hydrocarbons within a regional area; some lethal impacts to turtles of all age groups and numerous sublethal impacts to turtles from direct and indirect effects from exposure to oil from pipelaying vessel collision.

- IMP114: Oiling of threatened species resulting in mortality from a blowout.
- IMP116: Oiling of threatened species resulting in mortality from FPSO failure due to a ship collision.
- IMP118: Oiling of threatened species resulting in mortality from pipelaying vessel collision.
- IMP126: Temporary loss of artisanal fishing catches due to spill impacts on plankton, fish and other fishery resources.
- IMP127: Temporary preclusion of artisanal fishing in the spill response area for up to over 25,000 artisanal fishing units (2017 numbers).
- IMP128: Temporary loss of revenues for up to about 80,000 artisanal fishermen (2017 numbers).
- IMP131: Temporary loss of revenues for up to about 700,000 people involved in activities related to artisanal fisheries (2017 numbers).
- IMP130: Temporary loss of revenues for national economies due to the temporary disruption of artisanal fisheries.
- IMP131: Temporary decrease of the capacity of the coastal communities to cover day to day needs due to the disruption of their revenues, with a risk of sliding into poverty and vulnerability.
- IMP132: Temporary shortage of the main staple of coastal communities due to the disruption of artisanal fish catches, with potential ramifications on the diet of households at a national level.
- IMP133: Increased vulnerability of women and vulnerable groups of fishing communities, and in particular those of the Langue de Barbarie.

The ESIA has recommended 13 mitigation measures to reduce the potential negative impacts in case of accidental events. These mitigation measures are in addition to the 19 Design and Operational Controls measures already planned for the project. The mitigation measures include, for instance, the following:

- M101: In the unlikely event of a spill, tactical response methods that may be considered under the Oil Spill Contingency Plan (OSCP) include: surveillance and monitoring, offshore containment and recovery; subsea and at surface dispersant application; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response.
- M104: In the unlikely event of a spill reaching the shoreline, a shoreline clean-up and remediation team will be mobilized to the affected areas. BP will also engage specialized expertise to mitigate impacts to sensitive areas and wildlife species as needed.
- M105: In the unlikely event of a spill, follow national regulatory requirements for reporting and notification, using established protocols, which extends to all relevant external stakeholders.
- M106: In the unlikely event of a spill, establish a grievance mechanism easily accessible to affected stakeholders that includes monitoring of claims and the resolution thereof.
- M107: In the unlikely event of a spill, work with national authorities as requested, to inform relevant stakeholders (including artisanal fishermen) on: 1) the location of the spill; 2) cleanup operations; 3) applicability of temporary exclusion zones; and 4) grievance mechanism, as applicable. In relation to fishermen, this will include providing timely communication, offering them the opportunity to remove gear from affected areas, reducing impact on fishing gear.
- M108: In the unlikely event of a spill, in coordination with national authorities if requested, monitor and support ways to address the concerns of stakeholders regarding potential impacts of the spill.

- M109: In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency fund to assist affected vulnerable households in artisanal fishing communities if needed.
- M110: In the unlikely event of a spill, prepare and implement, in coordination with national authorities if requested, a Livelihood Restoration Plan for affected communities.
- M111: In the unlikely event of a spill, implement, in coordination with national authorities if requested, an emergency plan to ensure food security of affected vulnerable households and groups if needed.

With the implementation of the full set of 19 Design and Operational Control measures and 13 mitigation measures, the significance of the 34 impacts is reduced: 23 residual impacts of accidental events are deemed 1 – Negligible or 2 – Low. The remaining 11 residual impacts rated 3 – Medium are those on birds, marine mammals, sea turtles, threatened species and protected areas, and biodiversity.

It should be noted that the impact assessment of potential accidental events, based on the worst-case oil spill modeling scenarios, is a conservative prediction without the benefit of prevention, preparedness and response activities. In the event of an oil spill, BP would put in place appropriate spill response procedures. These procedures should reduce the volumes spilled and/or enhance the dispersion of oil, thus reducing the potential of exposure of sensitive resources to the spilled oil.

By identifying a range of representative worst-case oil spill scenarios, the ESIA has provided information to plan and prepare for the entire range of potential spill scenarios. Response strategies are based on a tiered approach which is accepted industry wide. The established three-tiered structure allows the planning of an effective response to any oil spill, from small operational spillages to a worst-case release at sea.

As part of the project overall planning process, an OSCP and supporting documents will be developed by BP. They will provide guidance on how BP will respond to an oil spill within any tier. When proper Design and Operational Control measures and mitigation measures are applied, including an OSCP, the likelihood of a spill and the consequences resulting from a spill are reduced. All these measures are included in the comprehensive ESMP included in the ESIA.

During the course of the project, the actions listed in the ESMP will be reviewed periodically to determine that its provisions are being implemented and to confirm that the planned measures remain appropriate to effectively mitigate the predicted impacts. Findings will be identified and the actions listed in the ESMP will be amended as necessary in pursuit of continual improvement.

A GTA project HSSE manager will be appointed by BP to oversee the implementation of the ESMP. The appointed BP project HSSE manager will be responsible for internal reporting of environmental performance for review and as a basis for improving the actions identified in the ESMP. The Mauritanian and Senegalese authorities, notably the DCE in Mauritania and the Technical Committee in Senegal, will retain oversight responsibility for reviewing the project compliance with the approved ESMP.

As a result of continuous improvement, or during the course of the project lifetime, new practices, procedures or technologies may be proposed and adopted that require a revision of a currently identified actions or sources and frequencies of verification in the ESMP. The intent of the original action will be taken into consideration in the decision of implementing such new practice, procedure or technology.

In addition to the ESMP, the ESIA includes an SMP. The overall purpose of the SMP is to verify that the mitigation measures identified in the ESMP generate the expected results in regard to avoiding or reducing potential impacts on the biophysical or social resources.

Based on the judgment of the ESIA professionals, as supported by the comprehensive ESIA documentation, the proposed GTA Phase 1 project is deemed acceptable considering the assessment of the following: 1) the project description, including the Design and Operational Control measures built into the project; 2) existing regulatory requirements; 3) characterized biophysical and social host environments and their perceived sensitivities to impact; 4) identified potential impacts associated with all phases of the project; and 5) implementation and monitoring of recommended mitigation measures listed in the ESMP and the SMP.

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