LNG Regasification Terminal on the bank of Hooghly River at Kukrahati, West Bengal

Bengal Concessions Private Limited
(A subsidiary of HE Terminals Private Limited)

Risk Assessment

March 2019

www.erm.com

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1 RISK ASSESSMENT

1.1 INTRODUCTION

The Risk Assessment (RA) aims to provide a systematic analysis of the major risks that may arise as a result of the operation of the proposed LNG storage and regasification facility at Kukrahati, Purba Medinipur District, West Bengal. The RA process outlines rational evaluation of the identified risks based on their significance and provides the outline for appropriate preventive and risk mitigation measures. The output from the risk assessment will contribute towards strengthening of the Emergency Response Disaster Management Plan (ERDMP) in order to prevent damage to personnel, infrastructure and receptors in the immediate vicinity of the terminal. Additionally, the results of the risk assessment can also provide valuable inputs for keeping risk at As Low as Reasonably Practicable (ALARP) and arriving at decisions for mitigation of high risk events.

The following section describes the objectives, methodology of the risk assessment study and assessment for each of the potential risk separately. This includes identification of major hazards, hazard screening and ranking, frequency and consequence analysis for major hazards. The hazards have been quantitatively evaluated through a criteria base risk evaluation matrix. Risk mitigation measures to reduce significant risks to acceptable levels have also been recommended as a part of the risk assessment study.

1.1.1 *Objective of the Risk Assessment*

The overall objective of this risk assessment with respect to the proposed LNG Project involves identification and evaluation of major risks, prioritizing risks identified based on their hazard consequences and using the outcome to guide development of ERDMP. Hence, in order to ensure effective management of any emergency situations that may arise during transferring of LNG from the LNG Carriers to the on land storage tanks, the following specific objectives need to be achieved.

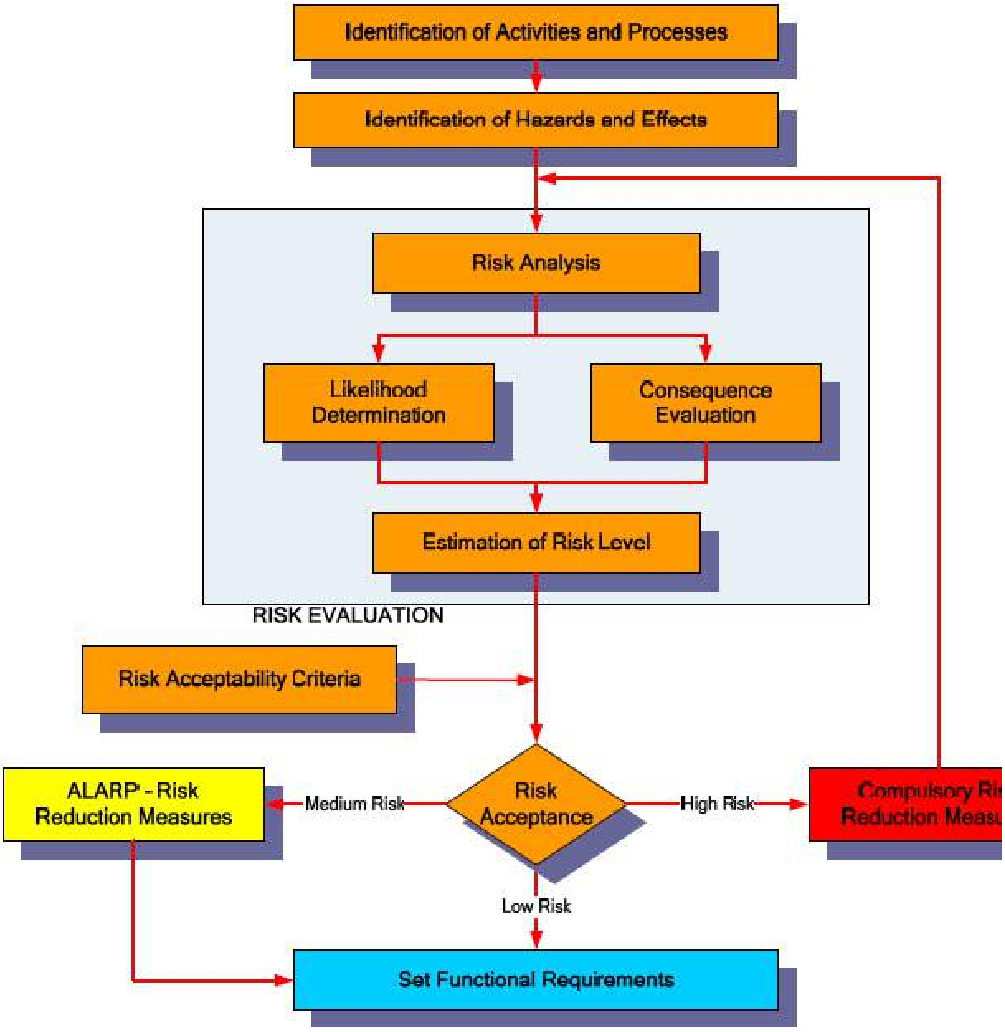
- Identify potential risk scenarios that may arise due to unloading of LNG from carrier to the Onland storage of LNG in the tanks with a total capacity of 60,000 cu.m
- Review existing information and historical databases to arrive at possible likelihood of such risk scenarios;
- Predict the consequences of such potential risk scenarios and if consequences are observed to be high, establish the same through application of quantitative simulations; and
- Recommend feasible preventive and risk mitigation measures as well as provide inputs for developing ERDMP.

1.1.2 Risk Assessment Methodology

The risk assessment process is primarily based on likelihood of occurrence of the risks identified and their possible hazard consequences particularly being evaluated through hypothetical accident scenarios. With respect to the proposed Project, major risks viz. leak and rupture of storage tanks and unloading arms have been assessed and evaluated through a risk matrix generated to combine the risk severity and likelihood factor. Risk associated with the proposed Project have been determined semi-quantitatively as the product of likelihood (probability) and severity (consequence) factors by using order of magnitude data [*risk ranking = severity (consequence) factor x likelihood (probability factor*)]. Significance of Project related risks was then established through their classification as high, medium, low, very low depending upon risk ranking.

The risk matrix is widely accepted as standardized method of risk assessment and is preferred over purely quantitative methods, given that its inherent limitations to define a risk event are certain. Application of this tool has resulted in the prioritization of the potential risks associated with the proposed Project thus providing the basis for drawing up risk mitigation measures and leading to formulation of plans for risk and emergency management. The overall approach is summarized below in ***Figure 1.1.***

Figure 1.1 Risk Assessment Methodology



1.1.3 *Hazard Identification*

Hazard identification for the purposes of risk assessment involves the qualitative review of the Project design and operations including relevant information provided by BCPL. Available literature related to LNG terminal risk assessment worldwide, terminal design and configuration, work procedures were reviewed in light of the proposed Project activities. Information (including historical data) related to possible hazards associated with LNG unloading and storage in the onland stanks sourced from veritable secondary sources of the upstream oil and gas industry *viz*. OSHA, UNEP, API, OGP, EGIG etc.

Based on the result of this exercise, potential hazards that may arise due to proposed Project were identified and a qualitative understanding of their probability and significance were obtained. It is to be noted here that many of these potential hazards could be triggered by natural events like earthquakes, floods and such factors have been considered in arriving at probable frequency of occurrence of such hazards.

Taking into account the applicability of different risk aspects the following hazards have been identified with respect to the proposed Project which has been dealt in detail in the subsequent sections:

- Spillage of fuel oil from LNG Carrier Vessel;
- Accidental release of LNG resulting from the LNG Carriers moving outside the operational reach of the unloading arms or the failure of a cargo transfer hose during the transfer process; and
- Accidental release of LNG from storage tanks leading to pool fire, jet fire and/or flash fire.

Hazards from LNG

LNG is an extremely cold, non-toxic, non-corrosive and flammable substance. If LNG is accidentally released from a temperature-controlled container, it is likely to contact warm surfaces and air that transfer heat into the liquid. The heat input begins to vaporise some of the liquid, returning the liquid to the gaseous phase. The relative proportions of liquid and gaseous phases immediately following a release depend on the release conditions. The liquid phase will form an LNG pool on the ground which will begin to "*boil*", due to heat input from the surrounding environment. Immediately following vaporisation, the gas is colder and heavier than the surrounding air and forms a vapour cloud. As the gas disperses, it mixes with the surrounding air and warms up. The vapour cloud will only ignite if it encounters an ignition source while concentrated within its flammability range.

Downstream of the vaporisers the natural gas will be in the gas phase. A release from piping and equipment will result in a gaseous phase release directly.

The hazard effects of LNG in the event of an accidental release from tanks, piping or equipment, including the characteristics of the possible hazardous effects have been described below.

Cryogenic Burns

LNG can cause frosting if it comes in contact with skin of personnel handling it. LNG vapours upon LNG evaporation being cold, may cause frosting of lungs, though chemically it does not react with lungs. The process equipment and pipeline are well designed and thermally insulated with mitigations in place to prevent any leakage.

Toxicity & Asphyxiation

No occupational exposure limit is prescribed for methane. It is an asphyxiate gas which displaces oxygen when there is a high concentration of methane in air. High concentration of methane in air normally occurs very close to the leakage source. Risk of asphyxiation increases as methane is an odourless gas. Recommended concentration is 19.5% of oxygen (v/v) in air.

Fire Hazards

LNG vaporises quickly as it absorbs heat from the surroundings. Methane vapours are flammable between concentration of lower flammability limit of 5 %(v/v) and higher flammability limit of 15% (v/v). LNG at its boiling point of -162ºC is denser than air (at ambient temperature of 25ºC) while it becomes lighter as it mixes with air.

Pool Fire

A pool fire occurs when a flammable liquid is released from a pipeline or storage tank onto the ground and ignited. A pool formed from the release of liquid LNG will initially spread due to the gravitational and surface tension forces acting on it. As the pool spreads, it will absorb heat from its surroundings causing evaporation from the pool surface. Ignition of this vapor leads to a pool fire.

Jet Fire

Jet fires result from ignited releases of pressurized flammable gas or superheated/pressurized liquid through a hole from a pipeline or storage tank. The momentum of the release carries the material forward in a long plume entraining air to give a flammable mixture. Jet fires only occur where the LNG is being handled under pressure or when handled in gas phase as unobstructed release.

Flash Fire

Following an LNG release, a large proportion of the liquid will evaporate immediately to form a cloud of methane, initially located around the release point. If this cloud is not ignited immediately, it will move with the wind and be diluted as a result of air entrainment. Similarly, a gas release may not be ignited immediately and will disperse in the air.

The dispersing vapour cloud may subsequently come in contact with an ignition source and burn rapidly with a sudden flash. If the source of material which created the cloud is still present, then the fire will flash back to the source giving a pool fire or, if under pressure, a jet fire. Direct contact with the burning vapours may cause fatalities but the short duration of the flash fire means that thermal radiation effects are not significant outside the cloud and thus no fatalities are expected outside of the flash fire envelope.

Vapour Cloud Explosion

A flash fire is the most likely outcome upon ignition of a dispersing vapour cloud from an LNG release. If ignited in open areas (i.e. unconfined conditions), pure methane is not known to generate damaging overpressures (explosion). However, if the gas is ignited in areas where there is significant degree of confinement and congestion an explosion may result.

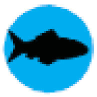
To summarize, a liquid phase release may result in a flash fire, vapour cloud explosion, pool fire or jet fire. A gas phase release can result in a flash fire, fireball or jet fire.

Effects of Oil Spill

The effects of an oil spill will depend on a variety of factors including, the quantity and type of oil spilled, and how it interacts with the marine environment. Prevailing weather conditions will also influence the oil's physical characteristics and its behaviour. Other key factors include the biological and ecological attributes of the area; the ecological significance of key species and their sensitivity to oil pollution as well as the time of year. It is important to remember that the clean-up techniques selected will also have a bearing on the environmental effects of a spill.

Based on the environmental sensitivity of the region wherein the project is proposed to be set up, the following potential consequences have been considered and discussed in the ***Table 1.1*** below.

Table 1.1 Environmental & Economic Consequences of Oil Spills in the Project Area

Environmental Sensitivity	Potential Effects
 FISH	Wild fish swim away from oil spills and long-term effects on local populations are avoided. However, fish populations moving back into an area following a spill may take some time to recover. Fisheries can also be disrupted if migration routes are changed as a result of an oil spill.
 DOLPHIN	Due to the tendency of oil to float at the surface, marine mammals and reptiles are at risk as they must surface to breathe. The oil can potentially cause harm to nasal tissues and eyes and whilst mortalities caused by oil have been recorded, the majority of mortalities which coincide with oil spills have usually been found to result from other causes.

In addition to the aforesaid effects, oil spill can also affect the shorelines particularly muddy shorelines. Pollutants that do penetrate the fine sediments can persists for many years increasing the likelihood of longer term effects.

1.1.4 *Risk Scenarios*

Taking into account unloading arm and storage failure consequences, the following hypothetical risk scenarios (Refer to ***Table 1.2***) have been considered for failure consequence modelling. The frequency analysis is discussed in next section.

Table 1.2 Risk Scenarios Assumed

SN	Description	Accident Scenario	Estimated Length, m	Temperature °C	Pressure bar g
1	LNG unloading arm (12”)	20 mm	18	- 158	5
2	LNG unloading arm (12”)	50 mm	18	- 158	5
3	LNG unloading arm (12”)	Full rupture	18	- 158	5
4	LNG Storage tank 30000 m^3	50 mm	-	-158	5
5	LNG Storage tank – 30000 m^3	100 mm	-	-158	5
6	LNG Storage tank – 30000 m^3	200 mm	-	-158	5
7	LNG Storage tank 40000 m^3	50 mm	-	-158	5
8	LNG Storage tank 40000 m^3	100 mm	-	-158	5
9	LNG Storage tank 40000 m^3	200 mm	-	-158	5

1.1.5 *Frequency Analysis*

The frequency analysis of the hazards identified with respect to the proposed Project was undertaken to estimate the likelihood of their occurrences during the Project life cycle. Hazard frequencies in relation to the proposed Project were estimated based on the analysis of historical accident frequency data and professional judgment. Based on the range of probabilities arrived at for different potential hazards that may be encountered from process related pipeline and high pressure buried pipeline failures, the following frequency categories and criteria have been defined (refer to ***Table 1.3***).

Table 1.3 Frequency Categories and Criteria

Likelihood Ranking	Criteria Ranking (cases/year)	Frequency Class
5	Likely to occur often in the life of the project, with a probability greater than 10^{-1}	Frequent
4	Will occur several times in the life of project, with a probability of occurrence less than 10^{-1}, but greater than 10^{-2}	Probable
3	Likely to occur sometime in the life of a project, with a probability of occurrence less than 10^{-2}, but greater than 10^{-3}	Occasional/Rare
2	Unlikely but possible to occur in the life of a project, with a probability of occurrence less than 10^{-3}, but greater than 10^{-6}	Remote
1	So unlikely it can be assumed that occurrence may not be experienced, with a probability of occurrence less than 10^{-6}	Improbable

Source: Guidelines for Developing Quantitative Safety Risk Criteria – Centre for Chemical Process and Safety

Frequency Analysis – Oil Spills

Based on limitations regarding availability of oil spill incident data for India, the frequency analysis of oil spills with respect to the proposed project is based on the following report - "*Water Transport Accident Statistics*" as prepared by the International Association of Oil & Gas Producers. This datasheet provides information on water transport accident statistics which comprises of global data plus more detailed regional/national data where relevant or where available.

The report identifies vessel collision, contact, fire/explosion, structural failure, transfer spill, unauthorized discharge and grounding as the possible causes of oil spills. The spill frequency with respect to each of the aforesaid causes has been presented in the ***Table 1.4*** below.

Table 1.4 Oil Spill Frequencies

Accident Type	Oil Spill Frequency (spills per ship per year)	Oil Spill Rate (tonnes per ship per year)	Average Oil Spill Size (tonnes)
Collision	1.5×10^{-3}	4.49	2922
Contact	7.2×10^{-4}	0.11	148
Fire/Explosion	5.1×10^{-4}	1.52	2973
Structural Failure	1.3×10^{-3}	5.68	4435
Transfer spill	1.7×10^{-3}	0.23	133
Unauthorized storage	5.1×10^{-4}	0.21	408
Grounding	5.6×10^{-4}	5.20	9227
TOTAL	$\mathbf{6.9 \times 10^{-3}}$	**17.43**	**2522**

Source: Water Transport Accident Statistics – OGP

With the project involving unloading of LNG through carriers to LNG tank, collision and transfer spills have been identified as the most credible scenarios with spill frequencies of $\mathbf{1.5 \times 10^{-3}}$ and $\mathbf{1.7 \times 10^{-3}}$ per year respectively.

Similar observations were made with respect to the analysis of the *International Tanker Owners Pollution Federation Limited (ITOPF) Oil Tanker Spill Statistics 2015* which reveals that small (<7 tons) and medium (7-700 tons) sized spills account for 95% of all the incidents recorded; with a large percentage of these spills, 40% and 29% respectively, occurred during loading and discharging operations which normally takes place in ports/jetties. Large spill account for the remaining 5% of all the incidents recorded, and occurrence of such incidents have significantly decreased over the last 46 years. In 50% of the cases the larger spills occurred when the vessels were underway in open water; allisions, collisions and grounding accounted for 59% of the causes for these spills.

Hence based on the discussion, the probability of oil spills from the aforesaid accidental events for the proposed LNG storage and regasification facility is identified to be as "*Occasional/Rare*" (Refer ***Table 1.3***).

Frequency Analysis – Liquid LNG Unloading

COVO[1] report revealed failure frequencies of 4.5×10^{-3} and 4.5×10^{-5} for leaks and full bore ruptures of LNG unloading arms. As per the HSE's FRED (Failure Rate and Event Data), for these unloading arms failures, it is assumed that all unloading arms handling liquefied gases have emergency release couplings (ERC) designed to achieve a quick release with a minimum of spillage. The coupler failures specified here are events where the ERC parts without the valves in the coupling closing. Incidents where the coupling parts correctly will lead to minimal spillage.

The failure frequency within the 'hole' description is split among representative release sizes of 20mm, 50mm and 150mm based on the distribution for individual unloading arms diameter of 12 inches. The failure frequency of full bore rupture (guillotine break) is described above.

Frequency Analysis – LNG Storage Tanks

An effort has been made to understand the causal factors for offshore and onshore LNG tankage failure through review of the *Journal of Loss Prevention in the Process Industries 28 (2014) 23-35*. The journal indicates that failure of LNG storage tanks (both onshore and offshore) occurs under the following circumstances:

- Tank rupture owing to overpressure
- Tank rupture owing to overfilling
- Tank rupture owing to under pressure

The failure frequency of LNG stored within the membrane based tanks of LNG Carrier and the onshore concrete based tanks with membrane is established based on review of the *UK HSE Database - Failure Rate and Event Data for use within Risk Assessments (28/06/2012)*. The LNG refrigerated vessel failure rates based on the type of has been presented in ***Table 1.5*** below

Table 1.5 LNG Refrigerated Vessel - Failure Rates based on Type of Release

Sl. No	Type of Release	Failure Rate for Double Walled Vessel (per vessel per year)	Frequency
1	Catastrophic	5.0×10^{-8}	Improbable
2	Major Failure	1.0×10^{-6}	Improbable
3	Minor Failure	3.0×10^{-6}	Remote
4	Vapour Release	4.0×10^{-5}	Remote

Source: UK HSE Database

[1] Cremer and Warner Ltd. Assessment of Industrial Risks in the Rijnmond Area (the COVO study), August 1979, published by D.Reidel Publishing Company, Dordrecht, Holland, 1982.

1.1.6 *Consequence Analysis*

In parallel with the frequency analysis, hazard prediction / consequence analysis exercises were undertaken to assess the likely impact due to Project related risks on onsite personnel, infrastructure and environment. Overall, the consequence analysis takes into account the following aspects:

- Nature of impact on environment and community;
- Occupational health and safety;
- Asset and property damage;
- Corporate image; and
- Timeline for restoration of property damage.

The following criteria for consequence rankings (Refer ***Table 1.6)*** have been drawn up in context of the possible consequences of the risk events that may occur during the proposed Project operations:

Table 1.6 Severity Categories & Criteria

Consequence	Ranking	Criteria Definition
Catastrophic	5	• Leads to irreversible damage to marine and coastal ecological habitat. • Permanent loss of economic livelihood • Multiple fatalities/permanent total disability to more than 50 persons. • International media coverage • Loss of corporate image and reputation
Major	4	• Temporary loss of economic livelihood • Restoration of wildlife and ecological habitat within 5-10 years. • Single fatality/permanent total disability to one or more persons • National stakeholder concern and media coverage.
Moderate	3	• Restoration of wildlife and ecological habitat within 2-5 years • Short term hospitalization & rehabilitation leading to recovery • State wide media coverage
Minor	2	• Restoration of wildlife and ecological habitat 1-2 years. • Medical treatment injuries • Local stakeholder concern and public attention
Insignificant	1	• Restoration of wildlife and ecological habitat in less than I year. • First Aid treatment • No media coverage

Risk Evaluation

Based on ranking of likelihood and frequencies, each identified hazard has been evaluated based on the likelihood of occurrence and the magnitude of consequences. The significance of the risk is expressed as the product of likelihood and the consequence of the risk event, expressed as follows:
Significance = Likelihood x Consequence
The ***Table 1.7*** below illustrates all possible product results for the five likelihood and consequence categories while the
Table 1.8 assigns risk significance criteria in three regions that identify the limit of risk acceptability. Depending on the position of the intersection of a column with a row in the risk matrix, hazard prone activities have been

classified as low, medium and high thereby qualifying for a set of risk reduction / mitigation strategies.

Table 1.7 Risk Matrix

			Likelihood →				
			Frequent	Probable	Unlikely	Remote	Improbable
			5	4	3	2	1
Consequence →	Catastrophic	5	25	20	15	10	5
	Major	4	20	16	12	8	4
	Moderate	3	15	12	9	6	3
	Minor	2	10	8	6	4	2
	Insignificant	1	5	4	3	2	1

Table 1.8 Risk Criteria & Action Requirements

S.N.	Risk Significance	Criteria Definition & Action Requirements
1	**High (16 - 25)**	**"Risk requires attention"** – Project HSE Management need to ensure that necessary mitigation are adopted to ensure that possible risk remains within acceptable limits
2	**Medium (10 – 15)**	**"Risk is tolerable"** – Project HSE Management needs to adopt necessary measures to prevent any change/modification of existing risk controls and ensure implementation of all practicable controls.
3	**Low (5 – 9)**	**"Risk is acceptable"** – Project related risks are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered.
4	**Very Low (1 – 4)**	**"Risk is acceptable"** – All risks are managed by well-established controls and routine processes/procedures. Additional risk controls need not to be considered

Consequence Analysis – Marine Unloading Arms

The consequences of possible failure of unloading arms is generally predicted based on the hypothetical failure scenario considered and defining parameters such as meteorological conditions (stability class), leak hole & rupture size and orientation, pipeline pressure & temperature, physicochemical properties of chemicals released etc.

In case of pipe rupture containing LNG (as in the case of unloading arms involved in transfer of LNG from LNG Carriers to onshore storage tanks) immediate ignition will cause a pool fire, while in case of delayed ignition LNG will vaporize at a rate equal to the release rate and produce a cloud denser than air spreading according to the weather conditions. If the cloud reaches concentrations between upper and lower flammability level (5-15% by volume) the mixture can be ignited if contacted by an ignition source and either a flash fire or an explosion will take place.

In case of rupture containing high pressure natural gas immediate ignition will cause a jet fire, while in case of delayed ignition natural gas will disperse according to the weather conditions. If the cloud reaches concentrations between upper and lower flammability level (5-15% by volume) the mixture can be ignited if contacted by an ignition source and either a flash fire or an explosion will take place.

Taking into account the above failure consequences and frequency analysis as discussed in the earlier section the following hypothetical risk scenarios (Refer ***Table 1.9***) have been considered for failure consequence modelling with respect to 12″ dia LNG unloading arm.

Table 1.9 Pipeline Risk Modelling Scenarios

Scenario	Pipeline	Accident Scenario	Design Pressure (bar)	Pipeline Temperature	Potential Risk
1	12″ LNG unloading arm	Leak of 20mm dia	5	-158°C	Jet Fire
2	12″ LNG unloading arm	Leak of 50mm dia	5	-158°C	Jet Fire
3	12″ LNG unloading arm	Complete rupture (12″)	5	-158°C	Jet Fire

The pipeline failure risk scenarios have been modeled using ALOHA and interpreted in terms of Thermal Radiation Level of Concern (LOC) encompassing the following threshold values (measured in kilowatts per square meter) to create the default threat zones:

Red: 10 kW/ (sq. m) -- potentially lethal within 60 sec;

Orange: 5 kW/ (sq. m) -- second-degree burns within 60 sec; and

Yellow: 2 kW/ (sq. m) -- pain within 60 sec.

The risk scenarios modelled for the LNG unloading arm and evacuation pipeline is presented below.

Scenario 1: LNG Unloading Arm Leak (20mm dia)

The threat modelled for an LNG unloading arm leak (20mm dia) has been presented in the below section.

THREAT ZONE:
Threat Modeled: Thermal radiation from jet fire

Red : <10meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: <10meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

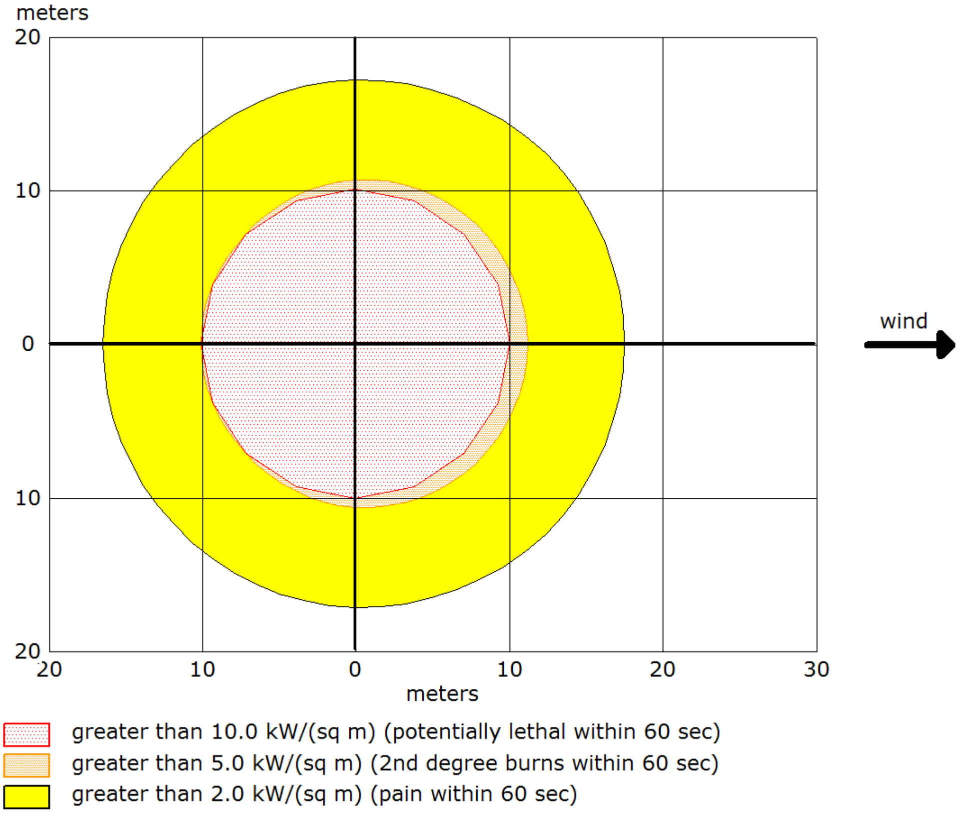
Yellow: <10meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of unloading LNG unloading arm leak (20mm dia) and ignition will be experienced within a radial distance of <10m from source with potential lethal effects within 1 minute.

Scenario 2: LNG Unloading Arm Leak (50mm dia)

The jet fire threat zone plot for release and ignition of natural gas from LNG unloading arm leak (50mm dia) is represented in ***Figure 1.2*** below.

Figure 1.2 Threat Zone Plot– LNG Unloading Arm Leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 10 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 11 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

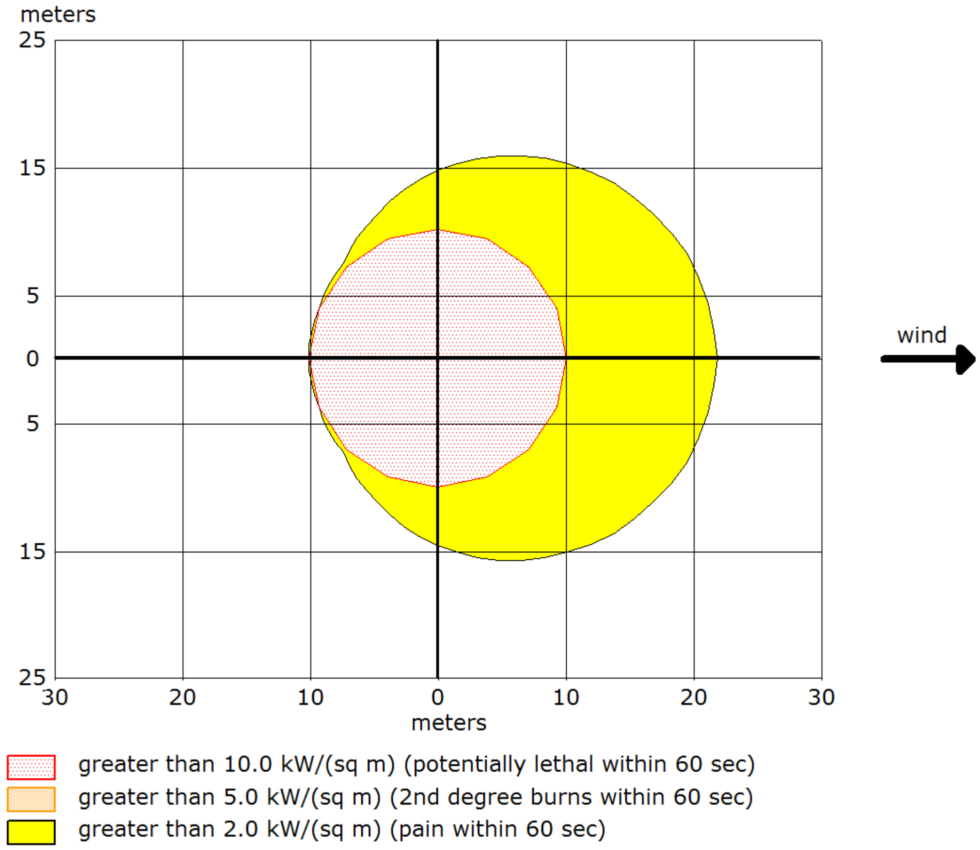
Yellow: 18 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of unloading LNG unloading arm leak (50mm dia) and ignition will be experienced within a radial distance of 10m from source with potential lethal effects within 1 minute.

Scenario 3: LNG Unloading Arm Rupture (12" dia)

The jet fire threat zone plot for release and ignition of natural gas from LNG unloading arm rupture (12" dia) of is represented in ***Figure 1.3*** below.

Figure 1.3 Threat Zone Plot–LNG Unloading Arm Rupture



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 10 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 10 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

Yellow: 22 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of cryogenic LNG unloading arm rupture will be experienced to a maximum radial distance of 10m from the source with potential lethal effects within 1 minute.

For LNG unloading arm, the likelihood ranking is considered to be "2" with jet fire probability of ~$4.5x10^{-5}$; whereas the consequence ranking has been identified to be as "2" as given for a worst case scenario (rupture) lethal effects is likely to be experienced within a radial zone 10m. Again with the unloading operations to be undertaken at sea, potential for fatalities is considered to be low.

Risk Ranking – Unloading Arm Rupture (Worst Case Scenario)

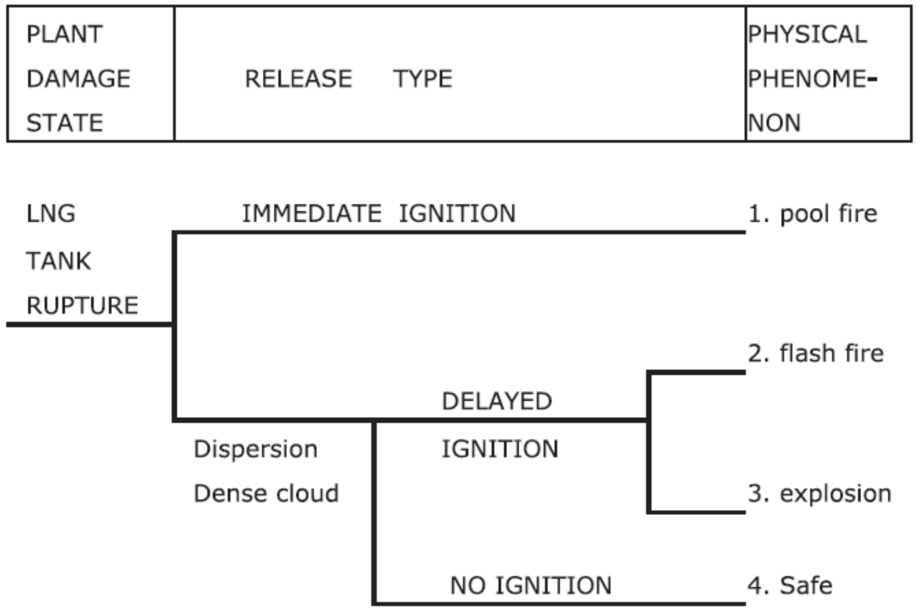
Likelihood ranking	**2**	**Consequence ranking**	**2**
Risk Ranking & Significance = 4 i.e. "Low" i.e. All risks are managed by well-established controls and routine processes/procedures			

Consequence Analysis – Tankages

The structural characteristics of membrane based LNG storage tanks and the historical experience shows that a scenario of loss caused by release of LNG from the storage tank is considered non-credible (*Pitblado, R.M., Baik,J., Hughes G.J., Ferro C., 2004*). The deviation of process that can generate a hazardous substance release may be: overpressure in storage tank, formation of empty storage tanks, overfilling of storage tanks, low temperature leaving the evaporator and subsequent release from natural gas transmission line, overpressure in vaporizers and discharge from the Pressure Safety Valve (PSV). It should be noted that whatever the initial cause of depression in the tank, the thermodynamic behaviour tends to favour the LNG vaporization and minimize vulnerability to depression.

In case of LNG tank rupture it is assumed that the roof of the tank will fail and either immediate or delayed ignition will occur. In case of immediate ignition there will be a pool fire, while in case of delayed ignition LNG will vaporize and produce a cloud denser than air spreading according to the weather conditions (wind speed, ambient temperature, class of atmospheric stability, humidity). LNG concentrations depend on the amount of the released LNG and the atmospheric and meteorological conditions. If the cloud reaches concentrations between upper and lower flammability level (5-15% by volume) the mixture can be ignited if contacted by an ignition source and either a flash fire or an explosion will take place (Refer ***Figure 1.4***).

Figure 1.4 LNG Tank Rupture – Potential Consequences



Source: Integrated risk assessment for LNG terminals O.N. Aneziris, I.A. Papazoglou, M. Konstantinidou, Z. Nivolianitou National Centre for Scientific Research "DEMOKRITOS", Terma Patriarchou Grigoriou, Aghia Paraskevi 15310, Greece*

Taking into account the above tankage failure consequences and frequency analysis the following hypothetical risk scenarios (Refer ***Table 1.10***) have been considered for modelling with respect to the storage of natural gas in tanks at the terminal.

Table 1.10 LNG Storage Tankages – Risk Modelling Scenarios

Scenario	Tank	Tank Diameter (m)	Tank Height (m)	Tank Volume (m^3)	Accident Scenario
1	LNG Tank -1	47	25	30,000	50mm leak
2		47	25	30,000	100mm leak
3		47	25	30,000	200mm leak (worst case)

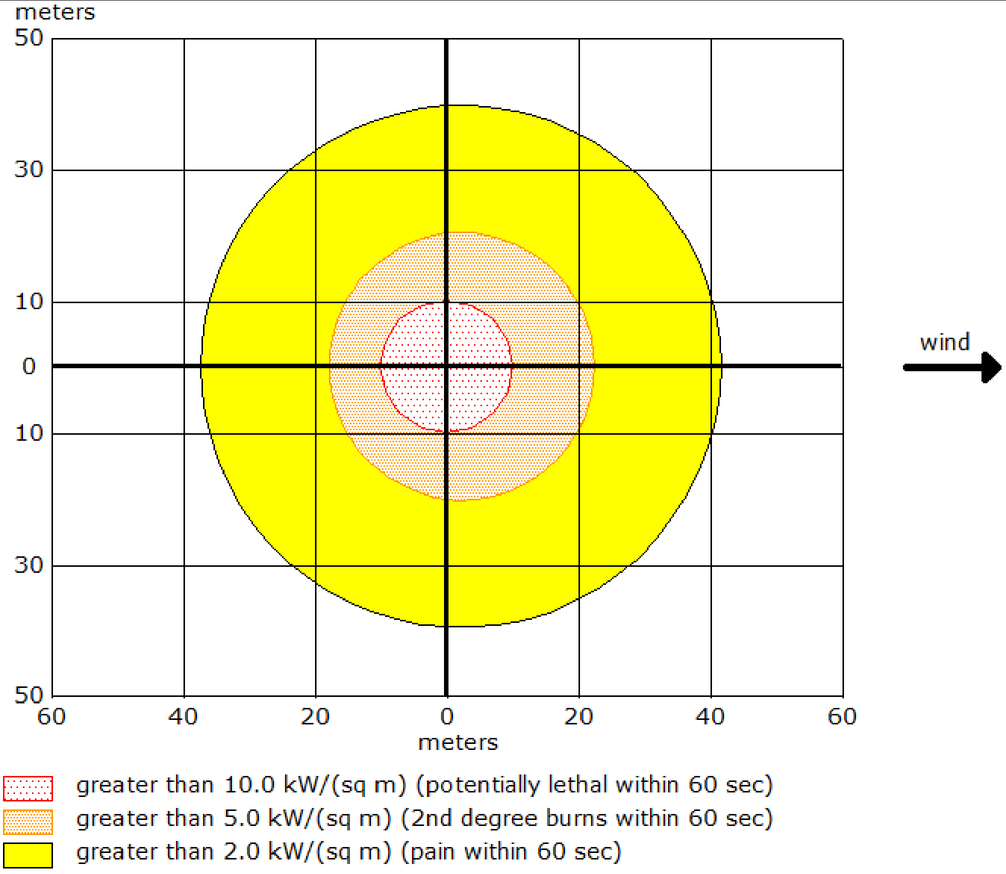
4	LNG Tank - 2	47	32	40,000	50mm leak
5		47	32	40,000	100mm leak
6		47	32	40,000	200mm leak (worst case)

As in the case of pipelines, the tankage failure risk scenarios have been modeled using ALOHA and interpreted in terms of Thermal Radiation Level of Concern (LOC) encompassing the following threshold values (measured in kilowatts per square meter) to create the default threat zones:

Red: 10 kW/ (sq. m) -- potentially lethal within 60 sec;
Orange: 5 kW/ (sq. m) -- second-degree burns within 60 sec; and
Yellow: 2 kW/ (sq. m) -- pain within 60 sec
Scenario 1: LNG Storage Tank-1 Leak (50mm dia)

The jet fire threat zone plot for release and ignition of LNG from storage tank-1 leak of 100mm dia at terminal is represented in ***Figure 1.5*** below.

Figure 1.5 Threat Zone Plot –LNG Storage Tank-1 Leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 10 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 22 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

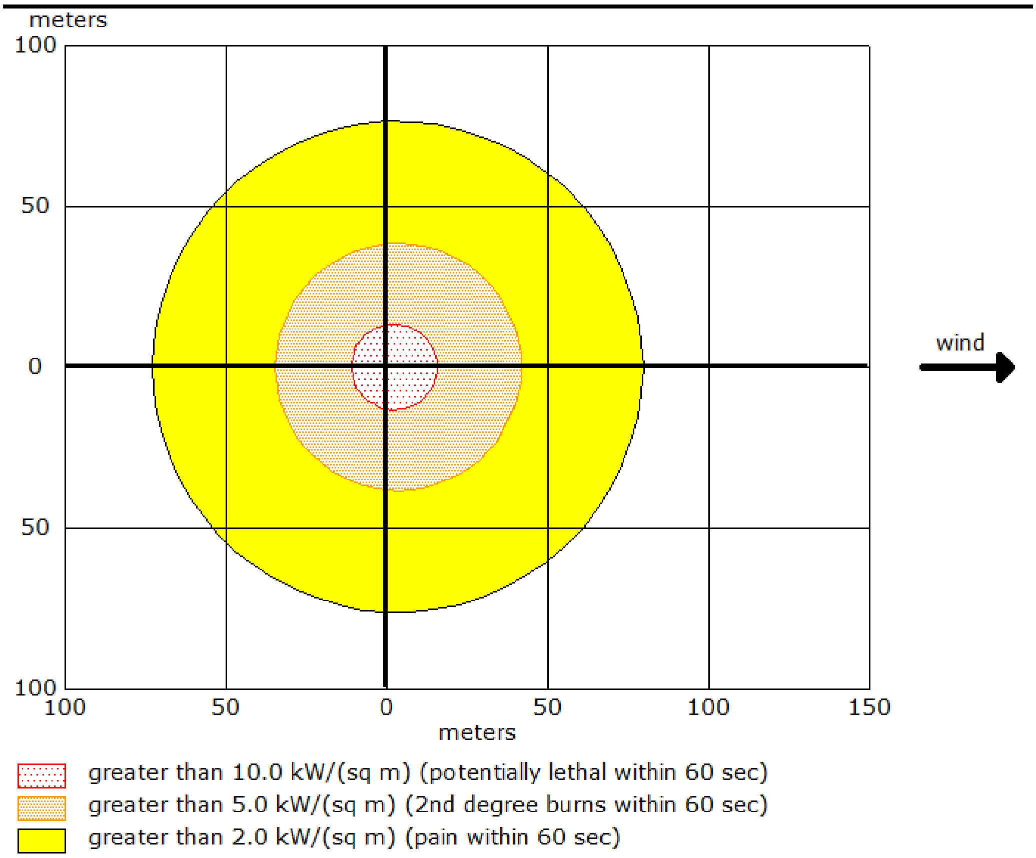
Yellow: 42 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of LNG from the storage tank-1 leak (50mm) will be experienced to a maximum radial distance of 10m from the source with potential lethal effects within 1 minute.

Scenario 2: LNG Storage Tank-1 Leak (100mm dia)

The jet fire threat zone plot for release and ignition of LNG from storage tank-1 leak of 100mm dia at the terminal is represented in ***Figure 1.6*** below.

Figure 1.6 *Threat Zone Plot –LNG Storage Tank-1 Leak (100mm dia)*



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 16 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 42 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

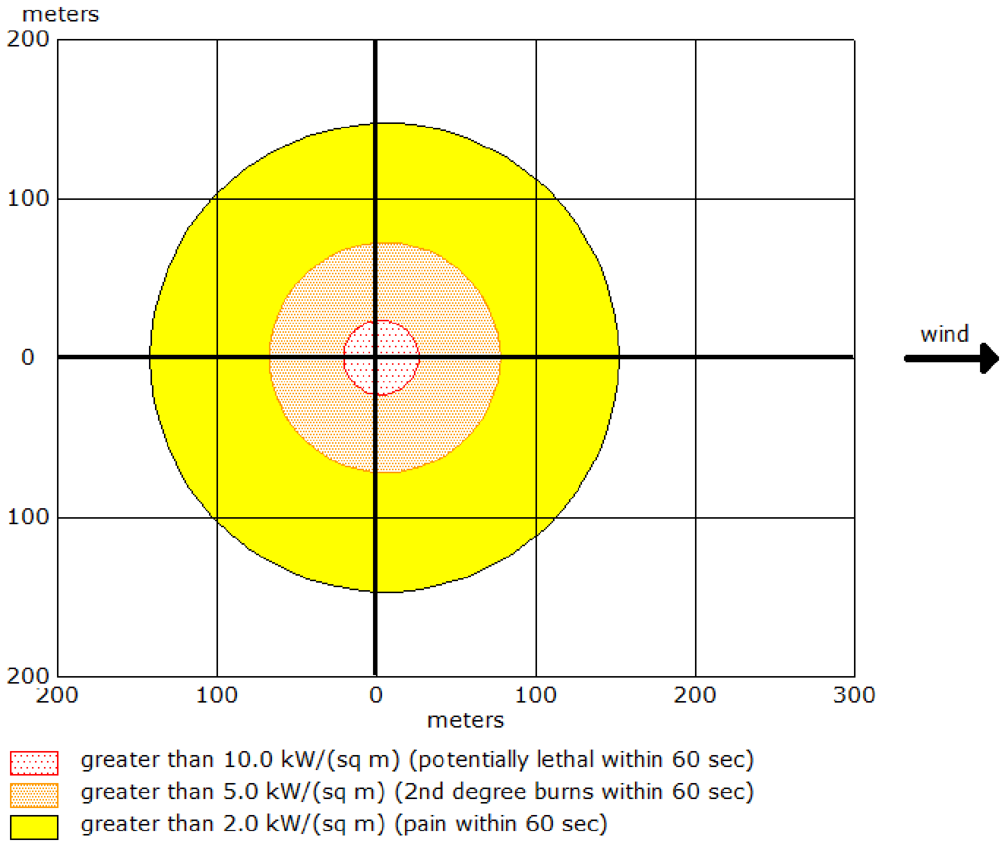
Yellow: 80 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of LNG from the storage tank -1 leak (100mm) will be experienced to a maximum radial distance of 16m from the source with potential lethal effects within 1 minute.

Scenario 3: LNG Storage Tank-1 Leak (200mm dia)

The jet fire threat zone plot for release and ignition of LNG from storage tank-1 leak of 200mm dia (worst case) at the terminal is represented in ***Figure 1.7*** below.

Figure 1.7 Threat Zone Plot –LNG Storage Tank-1 Leak (200mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 27 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 78 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

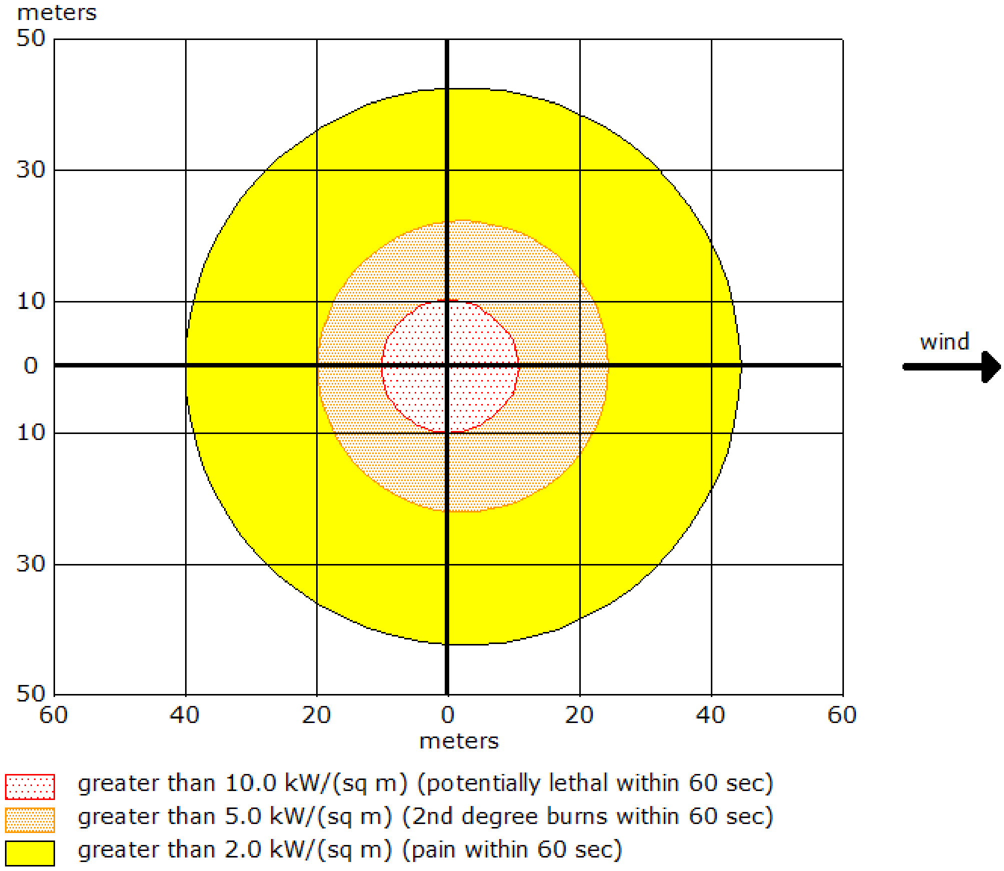
Yellow: 152 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of LNG from the storage tank-1 leak (200mm) will be experienced to a maximum radial distance of 27m from the source with potential lethal effects within 1 minute.

Scenario 1: LNG Storage Tank-2 Leak (50mm dia)

The jet fire threat zone plot for release and ignition of LNG from storage tank-1 leak of 100mm dia at terminal is represented in ***Figure 1.8*** below.

Figure 1.8 Threat Zone Plot –LNG Storage Tank-2 Leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 11 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 24 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

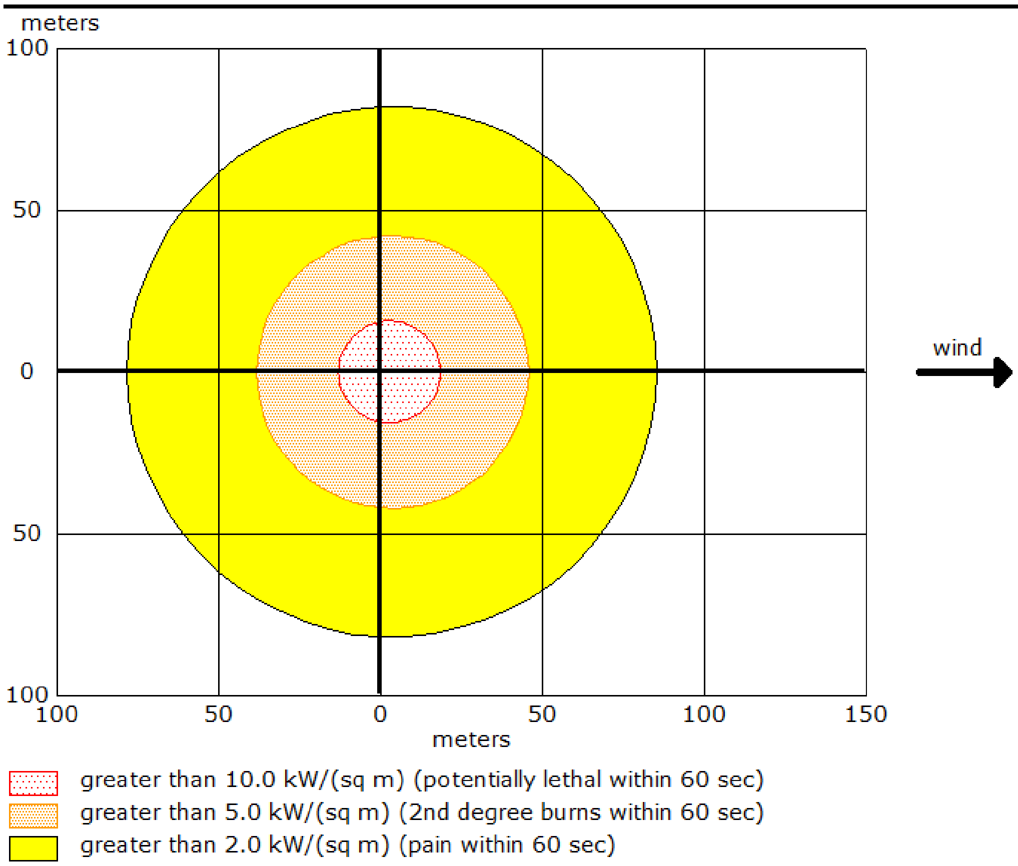
Yellow: 45 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of LNG from the storage tank-2 leak (50mm) will be experienced to a maximum radial distance of 11m from the source with potential lethal effects within 1 minute.

Scenario 2: LNG Storage Tank-1 Leak (100mm dia)

The jet fire threat zone plot for release and ignition of LNG from storage tank-2 leak of 100mm dia at the terminal is represented in ***Figure 1.9*** below.

Figure 1.9 Threat Zone Plot –LNG Storage Tank-2 Leak (100mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 19 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 46 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

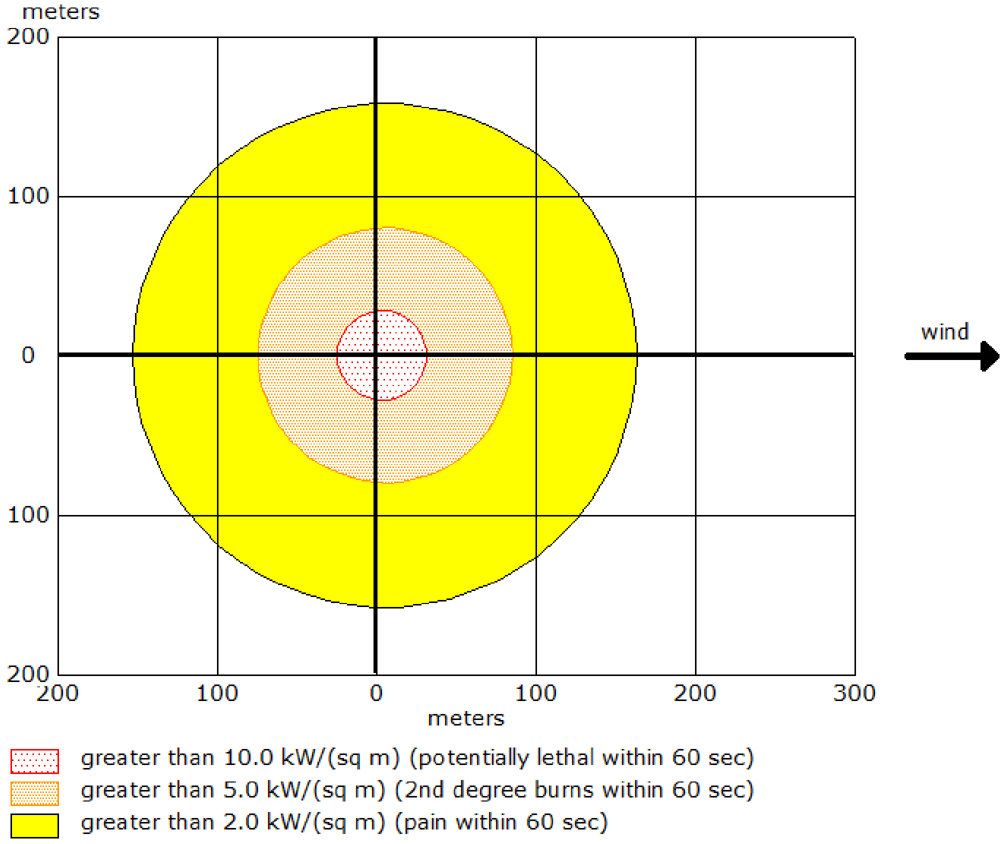
Yellow: 85 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of LNG from the storage tank -2 leak (100mm) will be experienced to a maximum radial distance of 19m from the source with potential lethal effects within 1 minute.

Scenario 4: LNG Storage Tank-2 Leak (200mm dia)

The jet fire threat zone plot for release and ignition of LNG from storage tank-2 leak of 200mm dia (worst case) at the terminal is represented in ***Figure 1.10*** below.

Figure 1.10 Threat Zone Plot –LNG Storage Tank-2 Leak (200mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 32 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 85 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

Yellow: 163 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of LNG from the storage tank-2 leak (200mm) will be experienced to a maximum radial distance of 32m from the source with potential lethal effects within 1 minute.

For calculating the risk significance of FSRU-1 LNG tank, the likelihood ranking is considered to be "2" as the probability of catastrophic failure historically for refrigerated pressurised vessels computed to be ~>1x10^{-6} per km per year; whereas the consequence ranking has been identified to be as "3" as given for a worst case scenario (200mm leak) lethal effects is likely to be experienced within a radius of ~ 32m. Considering there is no major settlement in the near vicinity and also taking into account the risk contour distances, no major consequences/concerns is anticipated beyond the terminal boundary.

Risk Ranking –LNG Tank Leakage (Worst Case Scenario)

Likelihood ranking	**2**	**Consequence ranking**	**3**
Risk Ranking & Significance = 6 i.e. "Low" i.e. Risk is Low and can be managed by well-established controls and routine processes/procedures			

Hence it can be concluded that any major risk like fatalities that may arise under any worst case scenarios associated with the LNG tanks are likely to be limited within site itself and need to be managed through installation and operation of appropriate design safety controls.

Consequence Analysis – Oil Spill

Properties of Spilled Oil

The main properties which affect the fate of spilled oil at river are:

- specific gravity
- distillation characteristics (its volatility)
- viscosity (its resistance to flow)
- pour point (the temperature below which it will not flow).

In addition, the wax and asphaltene content influence the likelihood that the oil will mix with water to form a water-in-oil emulsion. Oils which form stable water-in-oil emulsions persist longer on the water surface.

For the purpose of the risk assessment, High Speed Diesel has been considered for modelling as it will be serving as fuel source for the LNG carriers. The diesel oil properties fall within the range of specified values i.e. density: 0.82-0.86 g/cm^3, kinematic viscosity: 2-5 cSt, distillation percent recovered and are in compliance with IS 1460:2005. Further the product to be simulated (HSD) is a refined product and it is generally accepted that refined oils will not form stable emulsions due to their low asphaltene and resin content. The characteristics of HSD have been presented in ***Table 1.11*** below.

Table 1.11 Summary of Oil Characterization Data

Oil Type	API Gravity	Density (g/cm^3)	Viscosity (cP)	Surface Tension (dyne/cm)	Maximum Water Content
HSD	38.7	0.831	2.76	18.0	0%

Fate of Spilled Oil

When oil is spilled at river it normally spreads out and moves on the surface with wind and current while undergoing a number of chemical and physical changes. These processes are collectively termed weathering and determine the fate of the oil. Some of these processes, like natural dispersion of the oil into the water, lead to the removal of the oil from the surface, and facilitate its natural breakdown in the marine environment. Others, particularly the formation of water-in-oil emulsions, cause the oil to become more persistent, and remain at river or on the shoreline for prolonged periods of time.

The speed and relative importance of the processes depend on factors such as the quantity spilled, the oil's initial physical and chemical characteristics, weather and river conditions and whether the oil remains at surface or is washed ashore. Ultimately, the marine environment usually eliminates spilled oil through the long-term process of biodegradation.

Modelling of Oil Spill Weathering

The weathering of the hypothetical spill volumes of HSD resulting from the proposed project during berthing and/or vessel collision has been modelled using *ADIOS (Automated Data Inquiry for Oil Spills)* online tool. This is an oil weathering model developed by National Oceanographic and Atmospheric Administration (NOAA) and asks for information on the spill itself, environmental conditions, and the planned cleanup strategy.

The ADIOS database includes estimates of the physical properties of oils and products. It then uses this information and mathematical equations to predict *changes* in those properties once the oil has been released. Such properties include the density, viscosity, and water content of oil or refined product; and the rates at which it evaporates from the surface, disperses into the water column, and forms oil droplets that become emulsified, or suspended, in the water. The database was compiled from a variety of sources, including Environment Canada, the U.S. Department of Energy, and industry.
The program includes models to estimate the effects of common cleanup techniques, such as chemically dispersing, skimming, or burning the oil, and it now accounts for environmental processes, such as sedimentation.

Based on the proposed project operations, the following HSD spill volumes including the study area climatological data, wave conditions and water properties have been considered as input for modeling the weathering of oil spills (Refer ***Table 1.12***). The model has not taken into account use of any external oil spill control agents like dispersants etc.

Table 1.12 Oil Spill Weathering Model Inputs

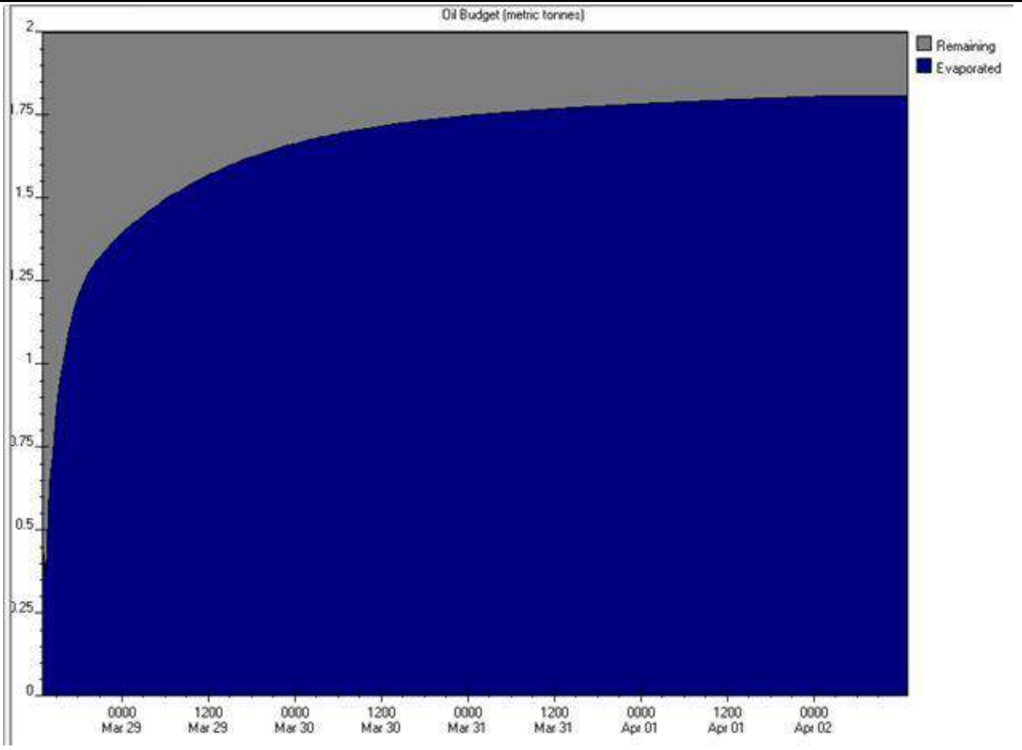
Sl. No.	Parameter	Value/Remarks
A	**Spill Details**	
1	Fuel Type	High Speed Diesel
2	Release type	Instantaneous
3	Release volume (metric tonnes)	2 MT; and 200 MT
B	**Climatology, Wave and Water Properties**	
4	Wind Velocity	1 m/s (average)

Sl. No.	Parameter	Value/Remarks
5	Wind Direction	180 degrees (predominant)
6	Water Temperature	35°C
7	Salinity	<5 ppt
8	Sediment load (TSS)	326 g/m^3

Source: Secondary Literature

The model output for the aforesaid release scenarios has been presented in ***Figure 1.11*** and ***Figure 1.12*** below.

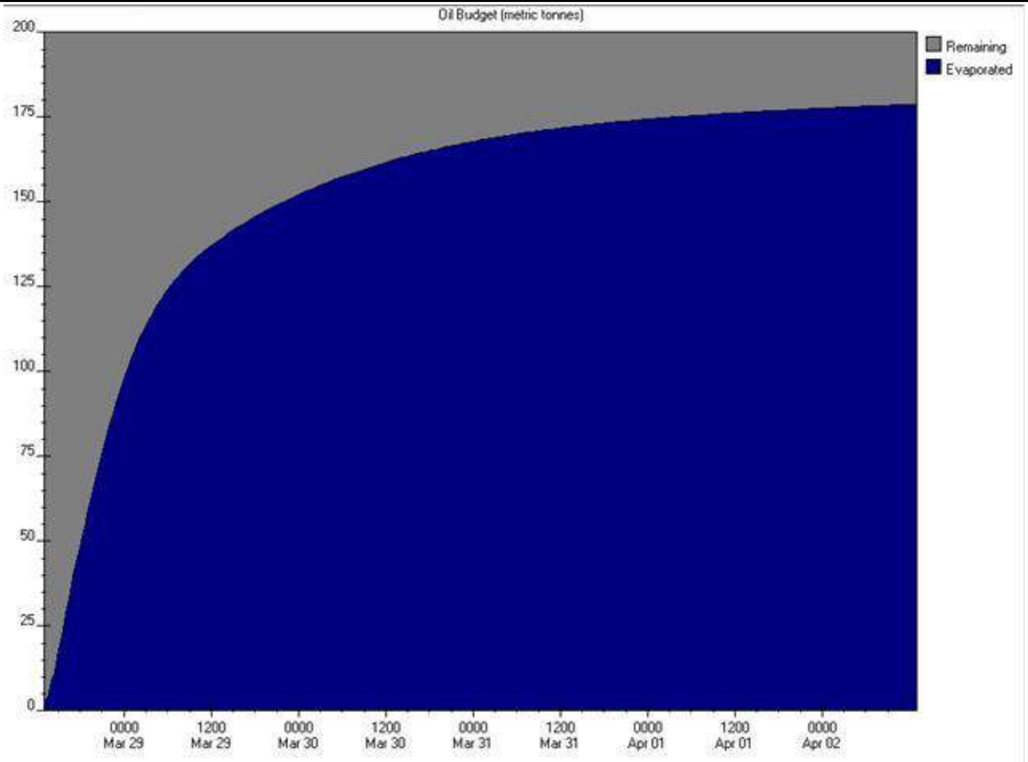
Figure 1.11 Oil Weather Model – Instantaneous HSD Spill of 2MT



Source: ADIOS Model

Interpretation of the ADIOS model output for a 2MT release (***Figure 1.11***) indicates that nearly 54% of the oil volume will be lost through evaporation within 4 hours of its release. This is primarily attributed to the fact that diesel being less persistent in the environment compared to heavy crude. About 90% of the spilled oil (2MT) is modeled to be lost through evaporation following 90 hours of release. Depending on the properties of diesel oil, the model indicates loss only through evaporation.

Figure 1.12 Oil Weather Model – Instantaneous HSD Spill of 200 MT



Source: ADIOS Model

Interpretation of the ADIOS model output for a 200MT release of diesel (***Figure 1.12***) indicates that nearly 50% of the oil volume will be lost through evaporation within 12 hours of its release. The model reveals that loss through evaporation gradually reduces with only 1-4% loss predicted over a time period between 24 to 90 hours from release. About 89% of the spilled oil (200MT) is modeled to be lost through evaporation following 120 hours of its release. Evaporation remains the only fate of spilled oil for such high volume releases as compared to other processes viz. dissolution, dispersion, emulsification, sedimentation, photo-oxidation, biodegradation.

Oil Spill Scenarios

Stochastic and worst-case deterministic simulations were performed for each of the three potential spill scenarios using the Online Oil Spill Advisory System (OOSA) developed by the Indian National Centre of Ocean Information Services (INCOIS). All scenarios originated at 88° 09' 20.92" East, 21 ° 59′ 39.78″ North in the Hooghly estuary. High Speed Diesel fuel (HSD) was spilled in all scenarios (Refer ***Table 1.13***)

The two spill volumes simulated were:

- 2MT, representing the lower end of a significant accidental spill that may result from leakage of refueling hose/pipeline;
- 200 MT, considered the largest instantaneous volume that would be spilled in the event of a side-on collision resulting in the complete loss of diesel from the fuel tank of the LNG carrier/supply vessel.

In no case the volume of spill is likely to be greater than 200 MT, given that it is the maximum fuel holding tank capacity of a supply vessel to be used for refuelling operations. Based on IMO guidelines, an oil spill up to 700 MTs is considered as the Tier-I oil spill; hence taking into account the maximum spill volume 200 MT for this project which is likely to be released under a worst case scenario, will be mediating a Tier-1 response which will be managed in coordination with BCPL and Indian Coast Guard.

Table 1.13 *Oil Spill Release Scenarios*

Scenario	Oil Type	Season	Release Duration	Release Hours	Volume Released (MT)
1	High Speed Diesel	Monsoon	Instantaneous	4 hours	2
2	High Speed Diesel	Monsoon	Instantaneous	36 hours	200

As per the Indian Coast Guard Circular dated 1 May 2015, the OOSA has been developed for use by the Indian Coast Guard and other statutory authorities and combat agencies involved in spill cleanup and control measures in the event of a spill. On submission of necessary information like location of the spill, date, time, pollutant type and its quantity, the trajectory prediction set up is triggered in the background, along with forecasted forcing parameters such as wind and currents. OOSA immediately delivers the trajectory prediction of the spilled oil for the next forty eight to ninety hours, thereby enabling planning of clean-up activity. The system provided trajectory prediction for continuous and instantaneous spills. The circular requires registration of all concerned and their adequate familiarization with the OOSA software as an immediate next step in enhancing preparedness and ensuring proficient use of the software in the event of an oil spill contingency.

The spill modelled using OOSA for monsoon was extrapolated on an integrated web GIS maps and presented in ***Figure 7.13*** and ***Figure 7.14*** below.

Figure 1.13 Oil Spill Trajectory during Monsoon – Instantaneous HSD Spill of 2MT

Source: OOSA

Figure 1.14 Oil Spill Trajectory during Monsoon – Instantaneous HSD Spill of 200MT

Source: OOSA

Interpretation of the model indicates, during the monsoon the 2MT spill trajectory is observed towards south-east i.e. opposite to the proposed project coastline i.e towards east and west depending upon the tidal action; however shoreline impact has not been predicted by the model for such small spill volumes.

Interpretation of the model indicates that during monsoon a 200MT diesel oil spill is likely to travel towards east/north-east (approximately 1.3 km from spill location) based on predominant wind direction and tidal currents. The spill is predicted to reach the shoreline within 24 hours of its release. Approximately~6.34km of the shoreline is likely to be impacted from volume of oil spilled within 36 hours of its release. Based on the direction and area of impact, no sensitive ecological habitat viz. mangroves are likely to be affected for the spill modelled.

Further, BCPL as part of its Emergency Plan will adopt appropriate oil spill response measures in the form of use of spill control equipment and coordination with oil spill response groups/agencies viz. coast guard, port authorities to prevent the spread of the spill. Considering the above discussion, the impact is not likely to be significant.

Risk Ranking – Oil Spill Release (Worst Case Scenario)

Likelihood ranking	**3**	**Consequence ranking**	**3**
Risk Ranking & Significance = 9 i.e. "Low" i.e. Risk is Acceptable and can be managed through use of existing controls with the option for installation of additional controls, if necessary.			

1.1.7 *Emergency Preparedness and Response Plan*

Purpose

This section outlines the procedure for the management of emergencies and evacuation plans during the operations phase. The main objective of the Emergency Response Plan (ERP) is to ensure that activities are carried out to the following priorities:

- Safeguard lives;
- Protect the Environment;
- Safeguard existing activities at the project location;
- Provide response to emergency situations using an effective communication network and organized procedures;
- Protect the company or Third Party assets;
- Maintain the company image/reputation;
- Resume normal activities.

Personnel involved in dealing with emergency situations shall follow these priorities while making decisions and developing strategies.

Scope

The ERP covers the emergency response that needs to be applied to both onshore and offshore elements of the project.

Emergency Response Team Composition

The emergency response onsite will be mediated by BCPL through two dedicated team's *viz*. the First Intervention Team (FIT) and Emergency Response Team (ERT). The roles and responsibilities of key team members have been outlined below.

Incident Controller

The shift operation supervisor is the incident controller and will be leading the response team until the emergency is totally brought under control. The incident controller takes control of an incident and manages directly or appoints personnel to positions. He assumes control of the organization and maintains command with site personnel.

- Assess the situation;
- Appoint, brief and task personnel;
- Establish Incident control point (ICP);
- Initiate Incident action plan (IAP);
- Manage emergency operations at the incident site;
- Plan, execute, review and re-assess fire-fighting operations continuously;
- Maintain safe environment; and
- Record actions taken during course of incident control

Field Operators

Shift Field Operators are part of the First Intervention team (FIT) and will act in emergency response operations as per instructions of the incident controller. They will act in ensuring

- Timely alert;
- Isolation of release;
- Evacuation of personnel;
- Rescue and relief work; and
- Fire-fighting operations, where instructed

Panel Operator

The Panel Operator also has a role on the FIT with the responsibility to maintain:

- Prompt isolation of effected area of terminal;
- Maintaining internal communication with emergency site, Duty Manager, port control room etc.; and
- Acting on incident controller's instructions

In case of an emergency, the Shift Security supervisor will report to the Shift Operation supervisor immediately together with the Shift Security guards, as an Auxiliary Support Team.

Emergency Response Team

In case of prolonged or serious emergencies, BCPL shall have a strong back up team. The ERT will be assisting the FIT in the following areas:

- Handle communication both Internal/External;
- Devise strategies to control the emergency situation - plan, organise, implement via incident controller and evaluate the results;
- Read drawings, issue guidelines to incident controller;
- Arrange logistics; identify potential needs, suppliers of service, material. Secure agreements, resource hiring etc.;
- Food, transport, replacement of site personnel, alternate duty roster in case of prolonged emergencies;
- Handling of journalists, media, public (in line with protocol with the BCPL);
- Implement the plan jointly as supporting team, external aid arrangements;
- Maintain a log of events and recording the sequence of actions taken; and
- Inform and Coordinate with Country Crisis Management Team (CCMT)

The minimum composition of the ERT is at least one manager, one discipline engineer (duty engineer), one technician from all disciplines and one administration co-coordinator. The following functions are the responsibility of the ERT:

- *Planning/Intelligence*: Gathers all information regarding the incident, any impact on other parts of the process and possible evolution
- *Incident Operation*: Manages the practical aspects of incident control, implements the action plan, provides a practical input to it, establishes a structure of actors, identifies additional practical resources, relays current information regarding the incident back to the Incident Manager
- *Safety Advice*: Evaluates the adequacy of response to incident, advises the Incident Controller about response strategy and tactics.
- *Logistics support*: Provides and maintains personnel, materials, facilities and services as and when requested by Incident Controller.

Responsibilities of LNG Carriers crew

The shift pilots, teams at LNG Carriers with the support of district administration and human resources from onshore will be responsible for executing emergency plan in the event of emergency situation.

Public Relations and Emergency Coordination with Local Government

BCPL shall have designated and trained site personnel who will interact with press, public, govt. and media briefing during any emergency. No employee or contractor would interact directly with above agencies without permission of Emergency Response Controller (ERC).

Country Crisis Management Team (CCMT)

Country crisis management team of BCPL will also provide support to ERT at site.

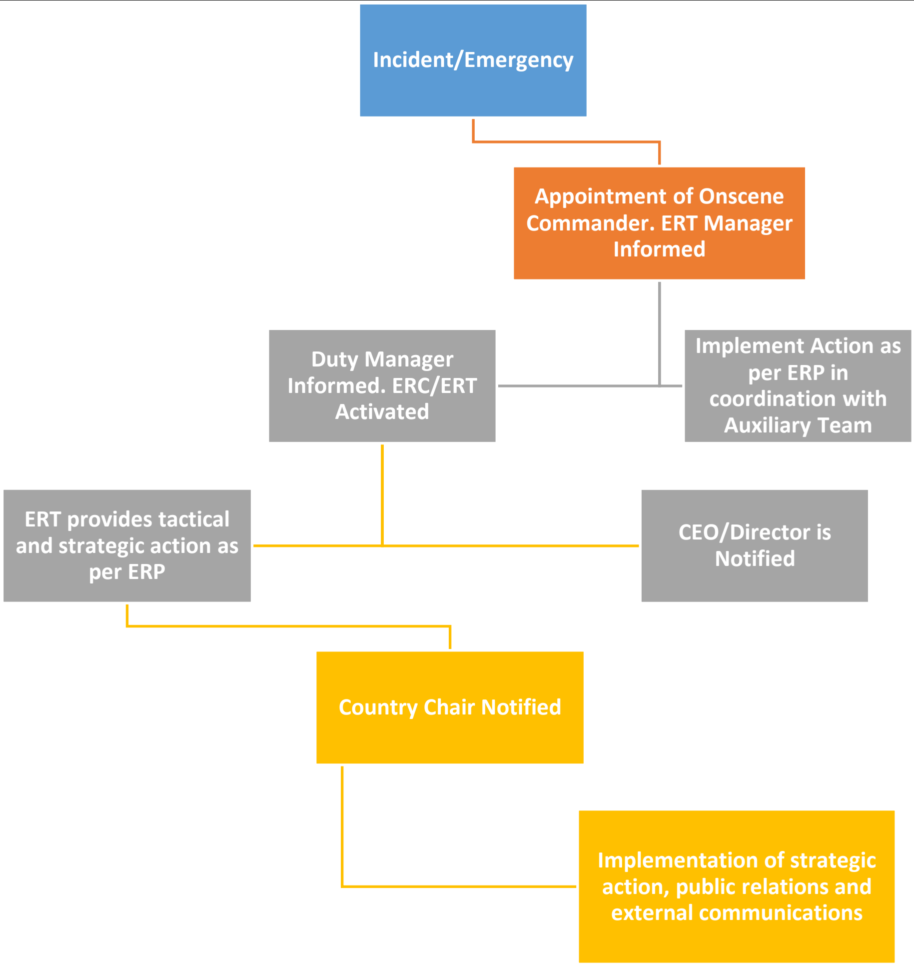
Mutual Aid / External Help Arrangements

As part of mutual aid scheme, BCPL plans to enter in agreements with neighboring industries in the region to share emergency resources and equipment in case of serious crisis. However, the decision of seeking external assistance will be taken by duty manager on advice of ERT and CCMT.

Emergency Alert Process

For an alert or emergency, the list of all authorities/ parties and resources to be immediately informed (including the Control Room at the Company) will be listed. If an alert is initiated by a third party, control room of the Company to be informed and actions coordinated with those serving as experts. The emergency notification and response process has been presented in ***Figure 1.15***.

Figure 1.15 Emergency Notification & Response Process



Emergency Response Actions

LNG Fires & Gas Clouds

It is the responsibility of the emergency site commander to take situational decision. LNG spill is most credible when LNG is being transferred from LNG Carrier to Onland storage tanks by Ship to Shore Transfer technology using hoses/unloading arms. The following actions will be adopted in case of LNG Fire.

- Spot and immediately isolate the leak/spill i.e. source of Hydrocarbon;
- Evacuate the area and rescue people, if any;
- Use water spray on vapour cloud to ensure effective dispersion of vapour cloud;
- Cool the surroundings by water screens. Only water-cooling of surroundings to be maintained to stop secondary fires and structures overheating as in the case of LNG Carriers and Onshore facilities and equipment. The LNG Carriers will have fire water facilities designed as per classification society requirements and the project site will have a separate fire water pump house for any emergency firefighting. Also, the tugs employed at the site for berthing have firefighting capability to stop or control the fire during the emergency.

In order to the regulate/control fires, fire alarms will be adopted in on basis of locations with potential fire scenarios. Gas alarms shall be installed across all the locations with a potential to have a gas leak. The installation of automatic shutdown upon detection by these alarms will be considered, depending upon the reliability of the gas detector and the scenario. An all-clear siren shall be installed for use to indicate all clear after an emergency. Other alarm systems would include the following:

- Onboard emergency alarms;
- Adverse weather / rough sea condition warnings;
- Emergency shut-down ESD alarms

Cyclonic/Thunderstorms Hazards

For cyclonic events, the response actions will be adopted by BCPL in coordination with the District Emergency Response Centre (DERC). The actions to be performed include but not limited to the following activities:

- On receipt of cyclonic/thunderstorm warning, BCPL ERT will take the initiative to evacuate the LNG Carriers from the jetty and personnel with assistance from DERC;
- The workers and personnel to be guided to respective cyclonic shelter as directed by the DERC personnel;
- Also the vessels shall be guided to a safe berthing at jetty in consultation with KoPT;
- Ensure provision of food, drinking water, torches, communication facilities (satellite phones) and emergency supplies at the shelter; and
- Obtain continuous update on the status of the cyclones/thunderstorms.

In order to ensure effective emergency response during such event, efforts will be made by BCPL to improve preparedness of the ERT to deal with such event through participating on demo session on alert warning/early signal, removal, rescue and operation of relief works. The session will emphasise particularly towards guiding the workers and personnel to safety of the shelters with periodic mock drills undertaken by BCPL to this effect.

Medical Emergency onshore

Any medical emergency at the onshore terminal will be managed in accordance with the Medical Emergency Response Plan.

Bomb scare / Terrorist Attack

Any security related incident shall be managed in accordance with the Security Manual. For the LNG Carriers, the Ship Security Plan shall be complied with. In case of onshore attack, a security plan shall be developed, and all personnel shall act in accordance with the instructions of the Terminal Manager.

1.1.8 Oil Spill Management

Objectives

The primary objective of the oil spill response strategy is to;

- Ensure safety of human life;
- Stabilize the situation to preclude it from worsening (e.g., source control, on-water recovery); and
- Minimize adverse environmental and socioeconomic impacts.

Equipment

As discussed in the risk assessment section, any major oil spill in the region has the probability to impact the shoreline. Hence in order to effectively support Indian Coast Guard and KoPT in managing any accidental spills within the project area, BCPL will procure standard oil spill response kit/packages from renowned third party agencies such as Oil Spill Response Limited (OSRL)[2]. Since the actual procurement of the oil spill response packages is to be undertaken prior to project operations with guidance from Indian Coast Guard, the detailed specification of such equipment cannot be furnished at this stage. An indicative list of equipment to be available in the standard shoreline clean-up package supplied by OSRL is presented below:

- 200 meters of shore skirt boom and 50 meters of shore sealing boom including air inflators, tow bridles and a water pump to fill the bottom chambers of the shore-sealing boom. For deploying booms response vessels/trailers of Indian Coast Guard/KoPT will be used;
- Shoreline flushing equipment to flush and remobilize stranded beached oil;

[2] https://www.oilspillresponse.com/services/preparedness-services/equip/shoreline-response/

- A shoreline skimmer device with hydraulic power pack, pump and hoses;
- A 10,000 litre collapsible storage tank for storing recovered oil;
- Absorbent pads and 50 m absorbent boom;
- Shoreline ancillary equipment; and
- Personal protective equipment.

However, the aforesaid list is subject to updation/revision during the actual procurement of the equipment prior to operations based on recommendation of the Indian Coast Guard. BCPL Crisis Management Team (CMT) will be developing a bespoke equipment package in consistent with specific operations, environment, spill risk and regulatory requirements. Cost for purchasing the aforesaid equipment will be finalized prior to commencement of operations.

Action Points in Case of Oil Spill

The action points to be followed in case of a spill are mentioned below:

Case 1: If the oil has not yet reached banks[3]

- Deploy sand bags and absorbent socks down gradient from the oil, or erect temporary barriers such as trenches or mounds to prevent the oil from flowing towards riverbanks.
- If required shoreline booms will also be deployed by Indian Coast Guard with support from BCPL (as may be required), to concentrate the spilled oil in a small area. This creates the optimum condition for the skimmer/pump for recovering the oil.

Case 2: If the oil has reached the river banks

- Trigger Tier I response;
- Deploy floating shoreline booms immediately downstream from the release point;
- Deploy protective booming measures for downstream receptors that may be impacted by the spill.

Details of shoreline response mechanism is mentioned below

Shoreline Oil Spill Response

Introduction

The shoreline oil spill response will be undertaken as per industry best practices and as guided by Indian Coast Guard and KoPT. Standard practices are enumerated below.

[3] For any light distillate oil (HSD) spill that may occur with respect to the proposed project and travelling towards shore, use of marine dispersants has been prohibited as specified in the following document published by the Indian Coast Guard - Policy and Guidelines for use of Oil Spill Dispersants in Indian Waters, Indian Coast Guard. 2009.

Shoreline Response planning and strategy

BCPL along with Indian Coast Guard and KoPT will conduct a damage assessment prior to initial response efforts to evaluate damage which will include the following information:

- Type of shoreline impacted - in this case the shoreline is predominantly muddy
- Characteristics of oil/oily material - tar balls, viscous oil, liquid oil, oiled sand (if any);
- Extent of oiling - upper shore/lower shore, heavy, moderate, patchy, light staining;
- Sketch maps/profile of shore showing extent of oiling;
- Assess volumes of oily materials.

Steps in Shoreline Clean-up Operations

The three main steps in a shoreline clean-up operation that are to be followed for the proposed project are:

Step 1: Assessment

- Indian Coast Guard, KoPT and local experts familiar with the ecology of the coastline will be consulted as to which areas will require immediate "clean-up" attention. A "leave –alone" action could also be considered if the expert/Indian Coast Guard suggests as clean-up mechanism sometimes can lead to more ecosystem damage;
- If clean up mechanism is to be initiated in consultation with the ecological expert/ Indian Coast Guard/KoPT, the degree of clean up required will be assessed in consultation with the ecological expert, Indian Coast Guard and KoPT

Step 2: Clean-up Operations (Specific to muddy shores)

- *Portable skimmers/pumps* - If possible, patches of oil will be removed by surface skimmers adjusted to these special circumstances; in case oils have got collected behind booms and in natural depressions on the shore it will be removed by use of portable skimmers;
- *Manual Sorbent Application* - For removing pools of light, non-sticky oil from the mud shores, sorbents will be applied manually on the contaminated area to soak up oil;
- *Manual removal of oiled materials* - Manual cleaning will be deployed to remove oil from lightly contaminated areas onshore using portable hand tools (non-sparking spades and shovels). Oiled sediments and debris will be removed by hand, shovels, rakes, wheelbarrows, etc.
- *Backhoe Operation* - For oils trapped in steep bank, backhoe will be operated from top of the bank or beach to remove contaminated sediments and load it into trucks. However appropriate care should be taken for use of any heavy machinery, or let people trample over the oiled area;

- *Sump and Pump/Vacuum*: In the event of continuing oil contamination complemented by strong river currents, a sump (60cm X 120cm) will be excavated on the shoreline. The oil will be diverted to this sump using booms and then collected using portable skimmers/pumps.

The activity or combination of shoreline clean-up activities as mentioned above will be selected and implemented by the key response agencies - Indian Coast Guard and KoPT with support from BCPL as may be required. The collection of un-oiled debris, sediments & its separate storage will be minimised at all cases.

Step 3: Termination/Monitoring

- Ongoing assessment of clean-up operations will be conducted;
- Determine compliance to clean-up objectives
- Post-spill monitoring to confirm recovery of shoreline features.

The primary purpose of the post-incident review is to identify actual or potential deficiencies in the Plan and determine the changes required to correct the deficiencies. The post-incident review also is intended to identify which response procedures, equipment, and techniques were effective and which were not and the reason(s) why. Key agency personnel that were involved in the response will be invited to attend the post incident review.

Storage of Oil and Oily Waste

The end result of shoreline clean-up activities is that significant quantities of waste material have to be temporarily stored and transported to be their final disposal sites. A critical factor to consider during disposal operations is to minimize the amount of wastes that must be processed. Also, wastes should be segregated as much as possible to maintain flexibility in the choice of disposal options.

Any form of oily waste generated from oil spills will be identified as hazardous with their storage and handling being governed by the relevant provision of the Hazardous Waste Rules, 2016.

With respect to the proposed project, the shoreline oily waste collected will be stored in dedicated drum/containers of specified capacity (~10,000 litres capacity). The storage area will be covered, lined and placed well above the high tide mark to prevent any contamination of surrounding area or ground wastes. Further, there will be provision of secondary containment and spill kits at the waste storage area to control any accidental spills during storage and handling. The storage drums will also be labelled with type, nature and quantity of waste being stored.

For oil and water mixture removed during the clean-up operations, it will be allowed to separate and the water decanted directly from the storage container. The residual oil will be considered as hazardous waste and stored as mentioned above.

Transport and Disposal of Oil and Oily waste

BCPL will initiate discussion with the West Bengal Waste Management Limited (WBWML), Haldia who maintains an Integrated Hazardous Wastes Transfer Storage and Disposal Facility (TSDF) during the project construction stage. The facility is located at a road distance of ~55km from the project site and can also be accessible by commercial navigational vessels. Necessary authorization for disposal of hazardous wastes will be obtained from West Bengal Pollution Control Board (WBPCB) before commencement of operations.

Secured trucks will be called in from the WBWML facility for transport and disposal of wastes generated from oil spills to the WBWML facility.
Actions and Operations

This section of the plan contains procedures for receiving, identifying and classifying notices of events, which need immediate response and communicating this information for corrective action. Upon notification of an oil spill event, the Incident Controller receiving such notice shall activate the emergency response system according to the procedures specified in the plan starting with First Responder Awareness Level procedures.

Any person whether an employee of the facility, vessel operator, appointed responder or not, can pass any information of any oil spill or a situation that could lead to an oil spill, held or observed by him or her, to any one of the areas to facilitate activation of this plan and initiation of response activity in accordance with the procedures laid down.

Based on the conditions present, the Incident Controller will implement appropriate emergency operations and the command post will be established at the site ECC. Involvement of the District Disaster Management Authority, Haldia Port, Indian Coast Guard (Eastern Region) will be coordinated under a unified command structure with the Incident Controller as discussed under the Emergency Response Plan.
The following response actions to be adopted on notification of a spill:

- Account for all personnel;
- Identify product and estimate quantity or rate of oil released along with wind forecasts;
- Conduct site safety characterization (hazard assessment);
- Identify actual or potential health and safety hazards;
- Secure the spill area (exclusion zone);
- Prepare a Spill/Incident Report Form for initial notification, if necessary Details of spills to be recorded in an Oil Spill Report Form;
- Incident Controller will notify of the spill and recommend level of response required based on initial reports.

- Activate facility Emergency or Spill Response Team based on the emergency tier.
- Activate firefighting systems or resources if needed
- Conduct preliminary incident severity/potential assessment
- Implement other asset-specific response actions
- Emergency response personnel or qualified individual to engage with the Incident Controller to:
    - Authorize funding of response resources.
    - Communicate the response priorities and objectives.
    - Discuss resources available or en-route.
    - Determine what additional resources may be mobilized.
    - Attend the initial incident briefing.
- Continue to coordinate response activities until relieved.
- Advise the Incident Commander on response strategies and progress.
- Attend all team briefings until demobilized.

Situation Reports

During oil spill that reaches the shorelines the Indian Coast Guard office at Haldia would be contacted. The District Collector being the lead agency for the clean-up operations should collect, collate and disseminate Information periodically and send the situation report (SITREP) to the State Environment Ministry and the Coast Guard Operations Centre at Haldia and to other agencies as relevant.

Post Incident Reports

On successful completion of shoreline clean-up, a report is to be sent to the State environment Ministry and Coast Guard by the lead agency, stating the actions taken right from the incident to the shoreline clean-up strategy and methods adopted, challenges encountered, amount spent, resources mobilized, assistance obtained, the level of clean-up activated and the monitoring.

Documentation

BCPL will produce a log of all the shoreline clean-up activities undertaken including the use of clean-up equipment, the amount paid to the volunteers and workers, the transportation and administration cost the cost paid as compensation to the fishermen and other legitimate users of the area, etc.

The visual record of the major response activities are also to be maintained. These may include the following:-

- Notes - make sure all are well marked (location where taken, date, time, description of what is photographed, video-taped, etc.)
- Sketches
- Videos
- Photos - for photos and video, use a reference object to indicate object being photographed or video -taped (e.g., when taking photo of a hole in a vessel, have a person stand next to the hole to show the reference size)

Termination and Completion of operations

Termination and Completion of Operations will be declared by the Incident Controller. Termination of operations is to be declared by Incident Controller post discussions with CMT and is to be undertaken in steps as per the satisfactory completion of each phase. However, advise on termination is also to be sought from Indian Coast Guard.

In the event of shoreline activity being conducted under the authority of local administration, that part of the activity will be declared terminated by the controlling authority.

Completion and Standing down

For declaring termination, the provisions outlined in Operations Manual with regard to assess different parameters especially the Net Environmental Benefits (NEB) are to be taken into account.

While, all phases and activities of operation may be declared terminated on completion, the operations per say are to be declared completed after following activities have been completed;

- Machinery and equipment accounting,
- Ensuring serviceability of equipment,
- Discussions about amendments, revisions, plans and procedures by CMT,
- Completion of actions arising out of final report on conduct of operations,
- Compilation of details with respect to compensations and damages.

Review of Plan and Procedures

Amendments as required to be undertaken to oil spill contingency plan or Operations Manual are to be put up to CMT for review and approval for induction into the contingency plan. Any member associated with response operations in any manner or otherwise may suggest amendments to the plan. The amendments will be undertaken for inclusion into the plan with authorization from Incident Controller.