Executive Summary

Introduction

The main Project concept aims to reclaim and develop an integrated petroleum hub and maritime industrial park which is situated off Tanjung Piai and is within the jurisdiction of Mukim Serkat, District of Pontian, State of Johor. The project proponent is a joint venture between the State Government of Johor Darul Ta'zim and the State Secretary, Johor (Incorporated) and the Spektrum Budi Sdn. Bhd (hereafter referred to as the Proponent). As a part of the approval process for the development of this project, the Department of Environment (DOE) has requested to undertake a Quantitative Risk Assessment (QRA) for the proposed project which forms part of the Detail Environmental Impact Assessment (DEIA) for this project. The reclamation will cover a total area of approximately 3,485 acres and is located 500 m from the mainland shoreline. The Proponent has commissioned DHI Water and Environment (M) Sdn. Bhd. to undertake the QRA of the project.

Project Background

The proposed project will be an integrated petroleum hub and maritime industrial park, which will include:

- Logistic and Strategic oil storage terminal; and
- Ancillary facilities (such as utilities, amenity and security areas).

Purpose of the QRA

The objectives of the QRA study are to identify and quantify the probability and consequences of the possible accidents that may escalate from the proposed project to the surrounding offsite areas; to calculate the level of risk; and to suggest measures to reduce the level of risk if higher than the allowable level in compliance with DOE's risk criteria stipulated in the Environmental Impact Assessment Guidelines for Risk Assessment, December 2004, EG 1/04.

Salient Findings of the QRA

Hazardous substances are defined as flammable, explosive or toxic substances. The hazardous materials and their associated major hazards identified in this QRA study are:

Table S1: Hazardous Materials and Associated Major Hazards

Hazardous Material	Characterization
Crude Oil	**Flammable**
Gasoline(considered for Clean product)	**Flammable**

The extent of all consequences assessed are limited within the industrial developments surrounding the project, which is in compliance with DOE's risk acceptance criteria.

- IR Contours:
    - The 1 x 10^{-5} per year IR contour of the proposed Project remains within the established industrial development, i.e. Tanjung Piai Industrial Park only; and

- The 1 x 10^{-6} per year IR contour of the proposed Project does not encompass involuntary recipients of industrial risks such as residential areas, schools, hospitals, and places of continuous occupancy, etc.

The above results are in compliance of the requirements stipulated by the DOE risk criteria.

Table S-2: Risk Contour Findings Summary

IR Contours	Max Distance to Contour (m)	Confirmation
1 × 10^{-5} per year	**510**	**The contour remains within the established industrial developments i.e. Tanjung Piai Industrial Park.**
1 × 10^{-6} per year	**630**	**The contour does not encompass the sensitive receptor area.**

It is noted that the risks have been assessed on a conservative basis, both in terms of consequences (e.g. use of the maximum inventories of hazardous substances in vessels, worst case process conditions, releases are modelled based on initial maximum (rather than average) release rates, no account taken of site drainage/ emergency spill containment systems to limit the spread of liquid releases etc. using published computer models that are inherently conservative), and frequency – i.e. no account has been taken of project site safety systems (e.g. isolation valves, detectors), operator intervention to prevent or minimise releases and no credit has been taken to account for the site Safety Management System.

A worst case scenario (WCS) is a scenario with the furthest consequence distance. Where else, a worst case credible scenario (WCCS) is a credible scenario (with event frequencies $\geq$ 1 × 10^{-6} per year) with furthest consequence distance. The WCS and WCCS for the proposed project is explained in detail below.

- The worst case scenarios are those scenarios which entail the farthest consequence distance amongst all the scenarios irrespective of the frequency. For the specified condition, the worst case scenario is envisaged to be the thermal radiation arising from the iso-sections 13 and 14 each. However it must be noted that from each of these scenarios, the impact does not potentially affect the identified sensitive receptor areas (as identified in Section 1.2.1.1). Thus, the worst case scenarios henceforth identified are those with hole diameter 100mm and which are in closer proximity to potentially affect the sensitive receptor areas. These have been mentioned in the **Table S-3** below. The impact representation has been attached under **Appendix 1-D**. For the representation on bund allocation and the respective iso-sections, refer to **Figure 1-4**.

Table S-3: Worst Case Scenarios Identified

Worst Case Scenario	Heat radiation Flux (kW/m^2)	Distance (m)
Iso-section 1 :	4 (Fatality rate: 3%)	280.7
100mm hole size	12.5 (Fatality rate: 50%)	176.5
Release rate – 67.1kg/s	37.5 (Fatality rate: 100%)	0
Iso-section 6 :	4 (Fatality rate: 3%)	279

100mm hole size Release rate – 67.1kg/s	12.5 (Fatality rate: 50%)	175.3
	37.5 (Fatality rate: 100%)	0
Iso-section 7: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	248.2
	12.5 (Fatality rate: 50%)	153.5
	37.5 (Fatality rate: 100%)	0
Iso-section 31: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	227.7
	12.5 (Fatality rate: 50%)	139.3
	37.5 (Fatality rate: 100%)	0
Iso-section 38: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	178
	12.5 (Fatality rate: 50%)	105.7
	37.5 (Fatality rate: 100%)	0
Iso-section 39: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	178
	12.5 (Fatality rate: 50%)	105.7
	37.5 (Fatality rate: 100%)	0

The above scenarios are bund fires reflecting various bund sizes due to the difference in the number of tanks in each bund. Hence, different bund sizes have resulted in the above-mentioned consequence distances.

- On filtering out the frequencies $\geq 1 \times 10^{-6}$ per year, the Worst Case Credible Scenarios for the proposed development area i.e. the furthest distance has been potentially inferred to arise from the Iso-sections 13 and 14 each as its source with a leak hole diameter of 100mm. The associated distances for each criteria of thermal heat radiation is provided below. The impact representation has been attached under **Appendix 1-D.**

Table S-4: Worst Case Credible Scenarios Identified

Worst Case Scenario	Heat radiation Flux (kW/m^2)	Distance (m)	Frequency (per year)
Iso-section 13: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	630	5.8×10^{-5}
	12.5 (Fatality rate: 50%)	423	
	37.5 (Fatality rate: 100%)	276	
Iso-section 14: 100m hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	630	8.19×10^{-5}
	12.5 (Fatality rate: 50%)	423	
	37.5 (Fatality rate: 100%)	276	

The above scenarios are bund fires reflecting various bund sizes due to the difference in the number of tanks in each bund. Hence, different bund sizes have resulted in the above-mentioned consequence distances.

General Recommendations

The following measures are recommended based on the findings of the study. Applying certain or all of these recommendations will ensure that risk is reduced to a level as low as reasonably practicable (ALARP) and adherent to the DOE Guidelines, December 2004.

Further Studies

- Prepare an emergency response plan (ERP) to include possible emergency scenarios due to the operation of the proposed tank farms;

- Engineering design for the tank shall ensure that sufficient reliability, redundancy and basic process control system along with the independent emergency shutdown system (ESD) is accounted for, to prevent tank overfilling, potential loss of containment which may eventually lead to a vapor cloud explosion scenario. This can be achieved by conducting Health Safety Environment (HSE) Engineering studies like Risk Assessment, Firewater Demand Calculation, QRA, Safety Integrity Level (SIL), Hazard and Operability Study (HAZOP), Hazard Identification (HAZID), etc. with adequately required design information and data;

- Depending on the composition of the crude oil, the need for draining water from the bottom of the storage tank to prevent potential boil over scenario shall also be assessed;

- During the design phase, scenarios of tank rim seal fire and full tank surface fire should be assessed along with the identification of neighboring tanks potentially impacted by thermal radiation from the tank on fire. Radiation shields can be recommended to fight fire if deemed necessary based on the outcome of consequence analysis. The firewater demand calculations in the design phase must account for sufficient supplementary firewater and its application rates for cooling the tanks in the above-mentioned scenario;

- The capacity of the bunds shall be designed to comply with NFPA 30 standard and the bunds should be leak-tight and fire-resistant; and

- All the emergency shutdown valves (ESDV) provided shall be fire-proofed for adequate time duration and the remotely operated shut down valves can be considered to be provided to prevent escalation of fire.

Procedural: Operation

- Ensure only fully trained and competent personnel are employed for the proposed tank farm;

- Enforce safety procedures to ensure authorized access only to the tank farm and further restrictions are in place for limiting storage tank farm access to approved persons only;

- Ensure that the tanks in operation have enough headspace margin for the intake to be closed off in time;

- Ensure that all the protection systems are thoroughly inspected, maintained and tested periodically;

- Perform regular emergency response drills (including desktop exercises) as well as feedback and review sessions with the local fire and rescue services for handling and controlling the worst case scenario.

Maintenance

- Undertake regular maintenance of the process equipment i.e. tanks, piping, pumps and process vessels in accordance with manufacturers guidance. This will ensure that the integrity of these equipment will be maintained, hence minimizing any leaks/releases due to mechanical failure.

Fire Fighting System

- Conduct routine inspections of fire safety requirements (fire blankets, fire extinguishers, smoke detectors, sprinklers, emergency lighting and fire-rated doors).

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ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
DOE	Department of Environment
ERP	Emergency Response Plan
ESD	Emergency Shutdown
ESDV	Emergency Shutdown Valve
HAZOP	Hazard and Operability Study
HAZID	Hazard Identification
HSE	Health Safety Environment
IDPT	Independent Deep Water Terminal
IR	Individual Risk
LEL	Lower Explosive Limit
LFL	Lower Flammability Limit
DEIA	Detail Environmental Impact Assessment
PPE	Personal Protective Equipment
QRA	Quantitative Risk Assessment
SIL	Safety Integrity Level
UEL	Upper Explosive Limit
UFL	Upper Flammability Limit
WCCS	Worst Case Credible Scenario
WCS	Worst Case Scenario

1.0 Quantitative Risk Assessment

1.1 Introduction

1.1.1 Background

The main Project concept aims to reclaim and develop an integrated petroleum hub and maritime industrial park which is situated off Tanjung Piai and is within the jurisdiction of Mukim Serkat, District of Pontian, State of Johor. The project proponent is a joint venture between the State Government of Johor Darul Ta'zim and the State Secretary, Johor (Incorporated) and the Spektrum Budi Sdn. Bhd (hereafter referred to as the Proponent). As a part of the approval process for the development of this project, the Department of Environment (DOE) has requested to undertake a Quantitative Risk Assessment (QRA) for the proposed project which forms part of the Detail Environmental Impact Assessment (DEIA) for this project. The reclamation will cover a total area of approximately 3,485 acres and is located 500m from the mainland shoreline. The Proponent has commissioned DHI Water and Environment (M) Sdn. Bhd. to undertake the QRA of the project.

This Quantitative Risk Assessment (QRA) specifically addressed the risk arising to the potential sensitive receptors due to the proposed Tankfarms areas for Phase I, II and III and its associated facilities in the Tanjung Piai Industrial Park (hereafter referred to as "the proposed project").

1.1.2 Objectives

The objectives of the QRA study are to identify and quantify the probability and consequences of the possible accidents that may escalate from the proposed project to the surrounding offsite areas; to calculate the level of risk; and to suggest measures to reduce the level of risk if higher than the allowable level in compliance with DOE's risk criteria stipulated in the Environmental Impact Assessment Guidelines for Risk Assessment, December 2004, EG 1/04.

1.1.3 Scope of Work

The scope of work for this study comprises of the following:

- Hazard Identification – Qualitative review of possible accidents that may occur (based on previous accident experience or professional judgement where necessary) for the proposed project;
- Determination of failure scenarios;
- Determination of probability of occurrence for each failure scenario;
- Determination of consequences hazard distances of each identified hazard scenario;
- Combination of failure frequencies and all consequences in order to determine the individual risk levels posed by the operation of the proposed facility; and
- Comparison of the risk results against DOE risk criteria.

1.1.4 Report Structure

The report is structured as:

Section 1.0	Background and scope of the Quantitative Risk Assessment (QRA)
Section 2.0	Introduction and description of the project and local demography
Section 3.0	QRA methodology, including definitions, key QRA components and DOE risk criteria
Section 4.0	Hazard identification and scenario selection
Section 5.0	Frequency analysis
Section 6.0	Consequence analysis
Section 7.0	Risk Summation
Section 8.0	Conclusion
Section 9.0	Recommendations
Section 10.0	References
Section 11.0	Appendices

1.2 Project background

1.2.1 Site Location

The project is located at the western part of the State of Johor. It is situated off Tanjung Piai, which is the southern-most point of Peninsular Malaysia. Administratively, the project is within Mukim Serkat, District of Pontian. The project site lies 8 km south of the Tanjung Bin Power station and 3 km east of Serkat town, while both the international borders namely the Continental Shelf Boundary and The Malaysia-Singapore Boundary lie within 6-7km from the project site.

The reclamation will cover a total area of approximately 3,485 ac. (1,410 ha) and extends at its farthest point approximately 3 km out to sea. At its nearest point, the reclamation lies approximately 500 m from the mainland shoreline to limit the consequence impact of impingement to the sensitive receptor areas . The proposed site access will be following the existing road which connects Pontian town with Tanjung. Piai. **Figure 1-1** shows the Project location and its key features. **Figure 1-2** provides a detailed overview of the project boundary point locations, the reclamation and the dredging area**.**

Figure 1-1: Location

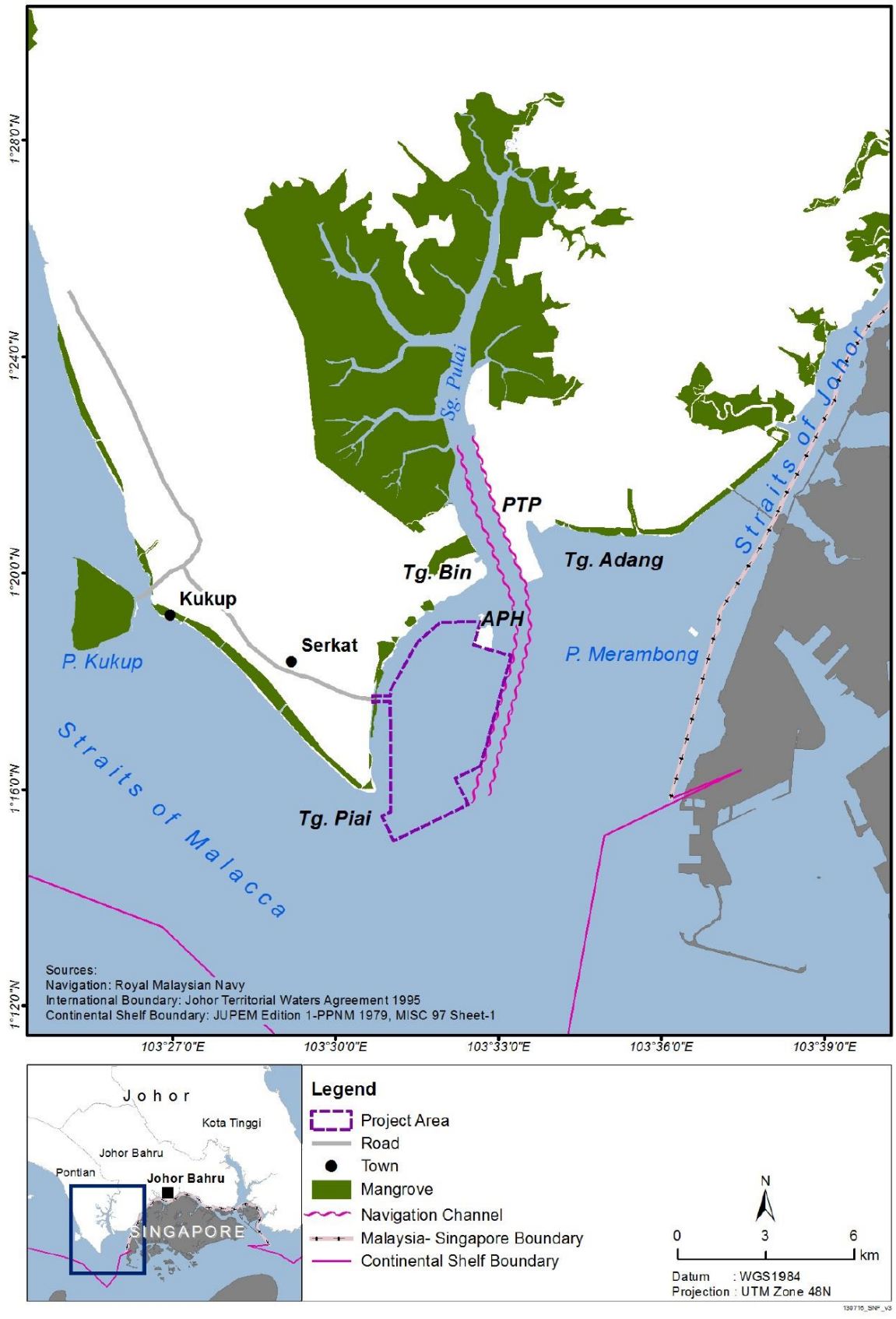
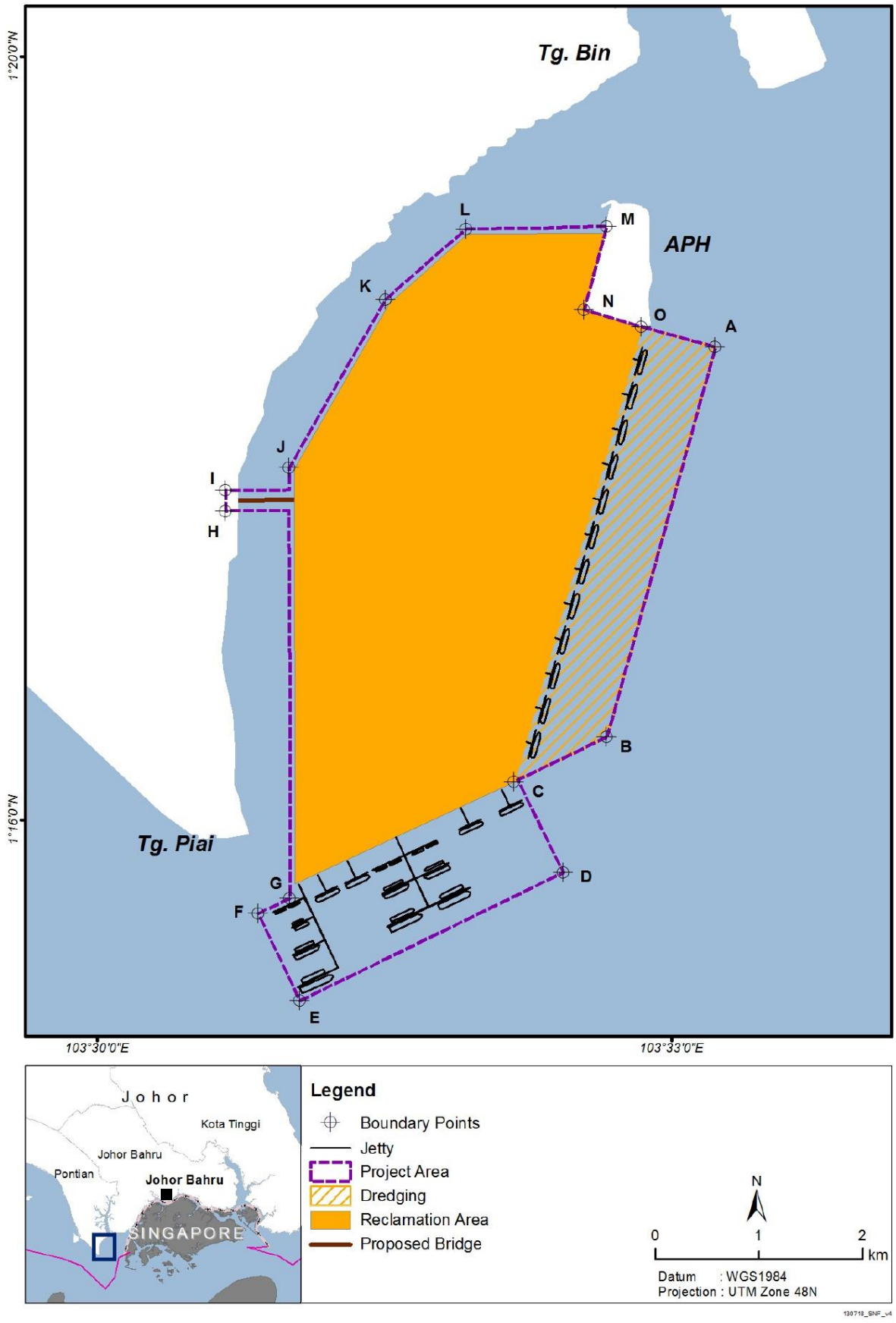


Figure 1-2 : Project and Boundary point locations



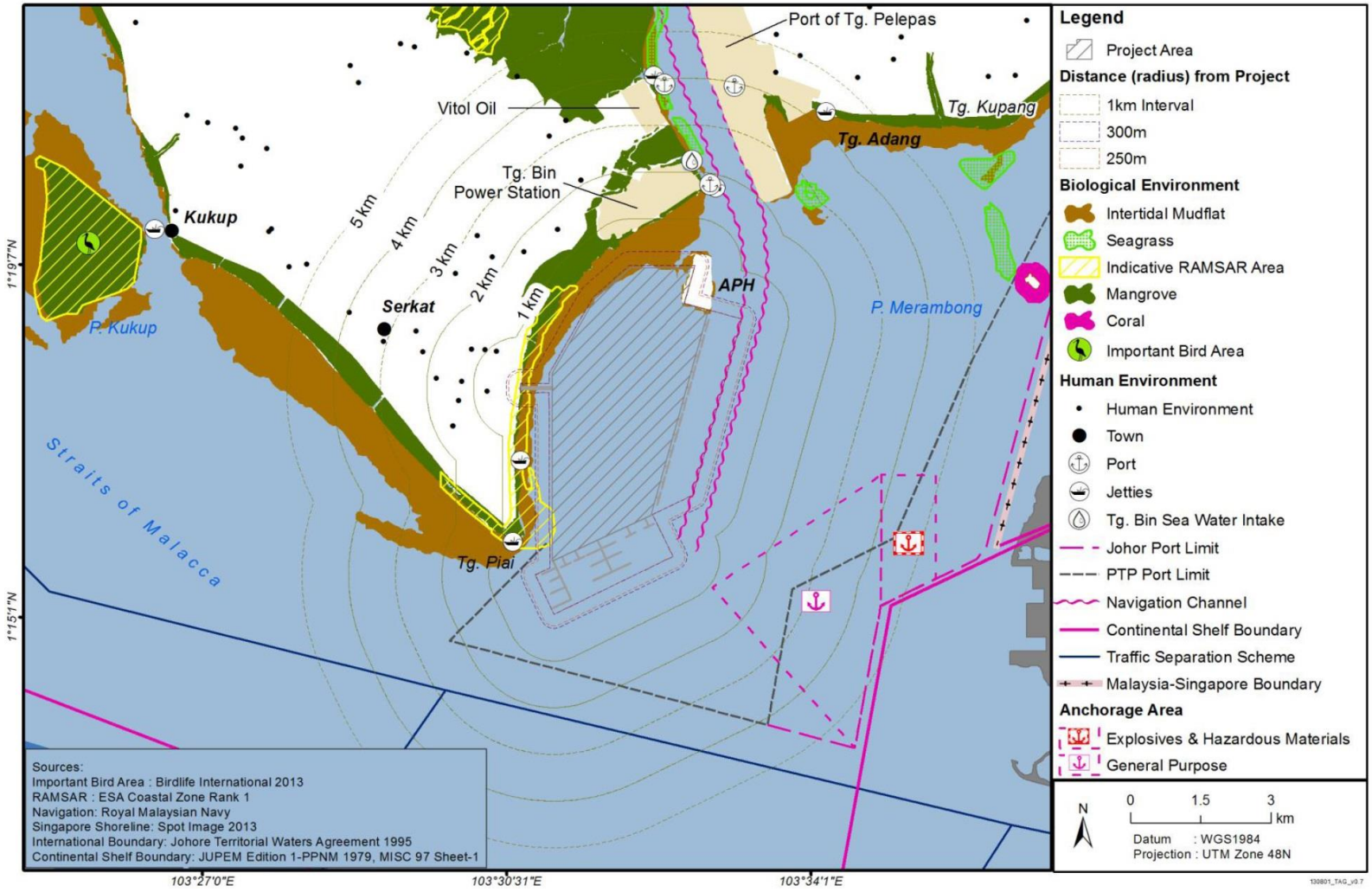
1.2.1.1 Site Sensitive Receptors

Site sensitive receptor is an area that needs to be given special attention or proper consideration prior to a development within the area or adjacent areas. It can be categorised into physical, biological, socio-economic and aesthetic.

The proposed project site vicinity comprises of a mixture of residential area, fishing and mudflat areas with mangroves. There are few site sensitive receptors within 1 km of the proposed project site. The residential lots are located on the western side are Kg. Serong Laut and Kg. Perpat Pasir. The other sensitive receptor areas include the Mangrove at the Tg. Piai State Park, Intertidal Mudflats and the Ramsar sites near the impact area. Apart from that, fishing may also occur within the proposed area and the navigation channel for access also needs to be reviewed.

Refer to **Figure 1-3** for the site sensitive receptor layout.

Figure 1-3 Site Sensitive Receptor Layout



1.2.2 Layout of Project Site

The proposed project will comprise of:

- Logistic terminal Tank Areas for Phase 1,2, and 3;
- Amenity Centre;
- Utility Centre; and
- Jetties of Phase 1, 2 and 3.

The cumulative effects of the flammable hazards from tankage area handling flammable inventory and its supporting facilities like loading pipeline and berth are considered and its impact to the surrounding region shall be assessed and mitigations will be proposed in the remaining sections of this report.

1.2.3 Process Description

The proposed project will be an integrated petroleum hub and maritime industrial park, which will include:

- Logistic and Strategic oil storage terminal; and
- Ancillary facilities (such as utilities, amenity and security areas).

The project is planned to cater for a total of 15 million m^3 storage capacity, with additional facilities for solids and gaseous materials.

The project involves island reclamation of approximately 3,485 acres (1,410 hectares) and the construction of jetties for liquid product import and export. These jetties will be located to the south of the reclamation (for ships up to 300,000 DWT) and to the east of the reclamation (for ships up to 120,000 DWT).

The construction stage will entail dredging, coastal protection, construction of onshore oil terminal facilities and industrial park facilities and infrastructure, and the construction of the jetties and marine facilities. The infrastructure, utilities and supporting amenities will include roads, drains, pipe corridor, sewage treatment, electricity substation, security and safety control center, fire-fighting and emergency response and others.

1.2.4 Meteorological Data

The follow sections present the meteorological data used for the consequence analysis (modeling) of the Quantitative Risk Assessment.

1.2.4.1 Annual Mean Air Temperature

The annual mean air temperature was assumed as 33°C in the consequence modeling.

1.2.4.2 Annual Mean % Humidity

The annual mean percentage humidity was assumed as 85%.

1.2.4.3 Atmospheric Pressure

The atmospheric pressure for Tanjung Piai area was assumed at sea level.

1.2.4.4 Wind Speed (which wind station)

As per DOE risk criteria, the following meteorological conditions has been referenced for conducting consequence analysis. Wind speed affects radiation distances hence different wind speeds have been identified for consequence modeling purposes. Based on the Semakau wind direction data (from year 2010 to 2012) obtained from the Semakau Meteorological Station, the following wind data were applied in the QRA model.

Table 1-1: Semakau Meteorological Data (2010 – 2012)

Speed (m/s)	Annual (Percentage of Occurrence)							
	N	NE	E	SE	S	SW	W	NW
0 - 2	2.30	3.45	1.71	1.87	2.37	1.40	1.22	1.24
2 - 4	6.80	9.72	4.67	5.44	8.41	4.94	3.60	3.13
4 - 6	5.28	5.74	1.99	2.13	4.92	4.44	2.42	2.13
6 - 8	1.37	1.04	0.37	0.36	1.02	1.47	0.82	0.57
8 - 10	0.20	0.05	0.03	0.03	0.11	0.35	0.21	0.18
10 - 12	0.04	0.02	0.00	0.00	0.02	0.12	0.07	0.07
12 - 14	0.01	0.00	0.00	0.00	0.01	0.04	0.02	0.02
14 - 16	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
16 - 18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	16.01	20.02	8.77	9.84	16.87	12.77	8.37	7.35

1.2.4.5 Atmospheric Stability Classification

Generally, the prevailing wind speeds are within the range of 1 m/s and 3 m/s. The corresponding atmospheric stability class for the most prevailing wind speeds is defined as A, B and C in the Pasquill-Turner Atmospheric Stability Classification scheme, which is shown in **Table 1-2**

Table 1-2: Pasquill-Turner Atmospheric Stability Classification

Atmospheric Stability Categories					
Surface Wind Speed (elevation of 10 meters) (m/s)	Day			Night	
	Incoming Solar Radiation			Thinly Overcast or > ½ Cloud Cover	< ½ Cloud Cover
	Strong	Moderate	Slight		
< 2	A	A – B	B	—	—
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	C	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	D

1.3 QRA Methodology

1.3.1 Definitions

The risk assessment of the proposed project have been conducted in accordance with the elements described in the following sections. The main stages of the QRA study are as follows:

- **Stage 1-** Hazard Identification: Identification of initiating release events and major hazards that require further evaluation;
- **Stage 2-** Frequency Analysis: Determination of the frequency of initiating events and the frequency of hazardous event outcomes;
- **Stage 3-** Consequence Analysis: Determination of the consequences of hazardous events;
- **Stage 4-** Event Tree Analysis: Representation of how the initiating event may develop and the resulting likelihood of the hazardous outcome;
- **Stage 5-** Risk Summation: Calculation and evaluation of individual risk level and as well as comparison against the risk criteria established for the study; and
- **Stage 6-** Risk Mitigation: Recommendation of risk mitigation measures, as required.

The methodology adopted for the study is further discussed in the following sections.

1.3.2 Hazard Identification

The first step in the QRA involves identifying physical situations (failure modes or initiating events) that may lead to a major accident with the potential for personnel injury or fatality, such as fire, explosion or the release of a dangerous substance. A representative set of discrete initiating events was short listed after a full review of the process and hazardous substances present onsite. The consequences of these scenarios were further evaluated and their risk was quantified in the study.

1.3.3 Frequency Analysis

Frequency analysis involves estimating the likelihood of each of the representative release events highlighted in the hazard identification exercise. Frequency analysis involves the following steps:

- Quantification of the frequency of initiating events (such as vessel rupture, leakage, etc.) based on historical data; and
- Quantification of the frequency of various hazardous outcomes (such as fire, explosion) through Event Tree Analysis, which is used to describe and analyse how, an initiating event can lead to various outcomes, depending upon the nature and type of the release.

1.3.4 Consequence Analysis

This stage of the QRA involves the determination of the impact of each of the identified hazardous outcomes on the surrounding population. **Section 1.6** of this report summarizes the hazard zones and the potential outcomes with respect to the release consequences. The hazardous outcomes that was evaluated in this study are Pool Fire and Jet Fire and this shall be explained in detail under **Section 1.6.2**.

The software used for the consequence analysis is CasQade Version 2.05.

1.3.5 Event Tree Analysis

Event tree analysis involves taking each initiating event through a defined sequence of events to determine the likelihood that an associated hazardous outcome will occur. Such event trees will take into account the necessary conditions for the hazardous outcome to occur, such as ignition.

By assigning probabilities to each branch of the event tree, the final frequency of each outcome can then be established. The frequency of occurrence and probabilities of the initiating events develops to that outcome. The consequences associated with each of the hazardous outcomes can then be evaluated.

1.3.6 Risk Summation

Risk summation involves combining the frequency of a given event outcome with its associated consequences to determine the individual risk levels associated with the facility.

For the purpose of this study, risks evaluated are reported in terms of Individual Risk (IR). Individual risk may be defined as the frequency of fatality per individual per year due to the realization of specified hazards.

1.3.7 Risk Mitigation Measures

Based on the risk assessment results, risk mitigation measures will be identified, as required, to reduce the risks to levels that are As Low As Reasonably Practicable (ALARP).

1.3.8 Risk Criteria

This section presents the risk tolerability criteria used in this study as stated in the Risk Assessment Guidelines from DOE.

- The 1 x 10^{-5} fatalities/ person per year individual risk contour should not extend beyond industrial developments; and

- The 1 x 10^{-6} fatalities/ person per year individual risk contour should not encompass involuntary recipients of industrial risks such as residential areas, schools, hospitals and places of continuous occupancy.

1.4 Hazard Identification and Scenario Selection

1.4.1 General

The identification of possible major accident hazard in the proposed project is based on the physical and chemical properties (i.e. flash point, boiling point, heat of combustion) of substances stored in this project site. Other than that, the design parameter of the vessels which store the hazardous substance has also been considered as one of the factor in deciding the possible scenario of major accident hazard.

1.4.2 Occupational Health Hazards

The impact of other hazards, such as occupational hazards which are limited to personnel working within the proposed project site and external hazards (earthquake, air plane crash etc.) have not been reported as these hazards are not within the scope of this QRA.

1.4.3 Hazardous Substances

The substances that subjected to this QRA study are Crude Oil and Gasoline. The materials are chosen based on high mass percentage in each unit (equipment) and its physical and chemical properties (explosive and flammability).

Information on the characterization for each hazardous substance is summarized in the following tables in subsequent pages. It should be noted that maximum quantities/ inventories and worst case operating/ processing conditions are used in the QRA to ensure conservatism. Gasoline has been used as the representative material to model all fire consequences associated with clean products in this project.

Table 1-3: Characterization of Hazardous Material

Hazardous Material	Characterization
Crude Oil	**Flammable**
Gasoline(considered for Clean product)	**Flammable**

1.4.4 Physical and Chemical Properties of Hazardous Substances

Crude Oil

Crude oil is a thick light yellow to dark black coloured liquid and has petroleum hydrocarbon odour. It is classified as highly flammable liquid. **Table 1-4** shows the physical and chemical properties of Crude Oil [1].

Table 1-4: Physical and Chemical Properties of Crude Oil

Boiling Point (°C)	<=35
Flash Point (°C)	<23
Auto-ignition Temperature (°C)	260
Vapour Pressure (mmHg)	0.5 to 14000 at 20 ^{o}C

Lower Explosive Limit (LEL) (% vol)	0.8
Upper Explosive Limit (UEL) (% vol)	44.0

Gasoline (Clean Product)

Gasoline is a light straw to red clear liquid with characteristic strong odour of Gasoline. It is classified as flammable liquid. **Table 1-5** shows the physical and chemical properties of Gasoline [2].

Table 1-5: Physical and Chemical Properties of Gasoline

Boiling Point (°C)	26.7 to 226.7
Flash Point (°C)	-40
Auto-ignition Temperature (°C)	> 260
Vapour Pressure (kPa)	60.8 to 101.3 at 20 °C
Lower Explosive Limit (LEL) (% vol)	1.3
Upper Explosive Limit (UEL) (% vol)	7.1

1.4.5 Representative Release Scenarios

Leaks can range in size from a pinhole leak to a catastrophic failure. In general smaller leaks have higher accident likelihood but lower consequence distances. On the other hand larger releases have lower accident likelihood but longer consequence distance. The representative scenarios considered in this study are:

Atmospheric Tank [3];

- Small leak (15 mm);
- Medium leak (50 mm);
- Large leak (100 mm);

Pipeline [3];

- Small leak (15 mm);
- Medium leak (50 mm);
- Catastrophic rupture;

Loading arm [4];

- Small leak (10 mm);
- Medium leak (50 mm);

- Catastrophic rupture;

The events identified for further analysis in this study has been divided into isolatable sections (which represent sections of the process that have various hold up inventory, pressure and temperature) as tabulated in below table. Please refer to **Figure 1-4** for the bunds allocation.

Table 1-6: Listing of Release and Outcome Events for Consequence Analysis

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS01_CRUDE_BUND1.1_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 1.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS02_GASOLINE_BUND2_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 2 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS03_GASOLINE_BUND3.1_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 3.1 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS04_GASOLINE_BUND4_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 4 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS05_CRUDE_BUND5.1_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 5.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS06_CRUDE_BUND6.1_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 6.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS07_CRUDE_BUND7_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 7 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS08_CRUDE_BUND8_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 8 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS09_CRUDE_BUND9.1_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 9.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS10_CRUDE_BUND10.1_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 10.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS11_CRUDE_BUND11.1_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 11.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS12_CRUDE_BUND12_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 12 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire..	15 mm	Pool Fire
		50 mm	
		80 mm	
IS13_GASOLINE_BUND13_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 13 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS14_GASOLINE_BUND14_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 14 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS15_GASOLINE_BUND15_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 15 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS16_GASOLINE_BUND16_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 16 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS17_CRUDE_BUND17.1_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 17.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS18_CRUDE_BUND18_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 18 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire	15 mm	Pool Fire
		50 mm	
		100 mm	
IS19_CRUDE_BUND19_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 19 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS20_CRUDE_BUND20_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 20 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS21_CRUDE_BUND21_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 21 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS22_CRUDE_BUND22_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 22 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS23_CRUDE_BUND23.1_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 23.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS24_CRUDE_BUND24.1_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 24.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS25_CRUDE_BUND25.1_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 25.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS26_GASOLINE_BUND26.1_	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 26.1 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS27_GASOLINE_BUND27_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 27 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS28_GASOLINE_BUND28_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 28 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS29_GASOLINE_BUND29_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 29 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

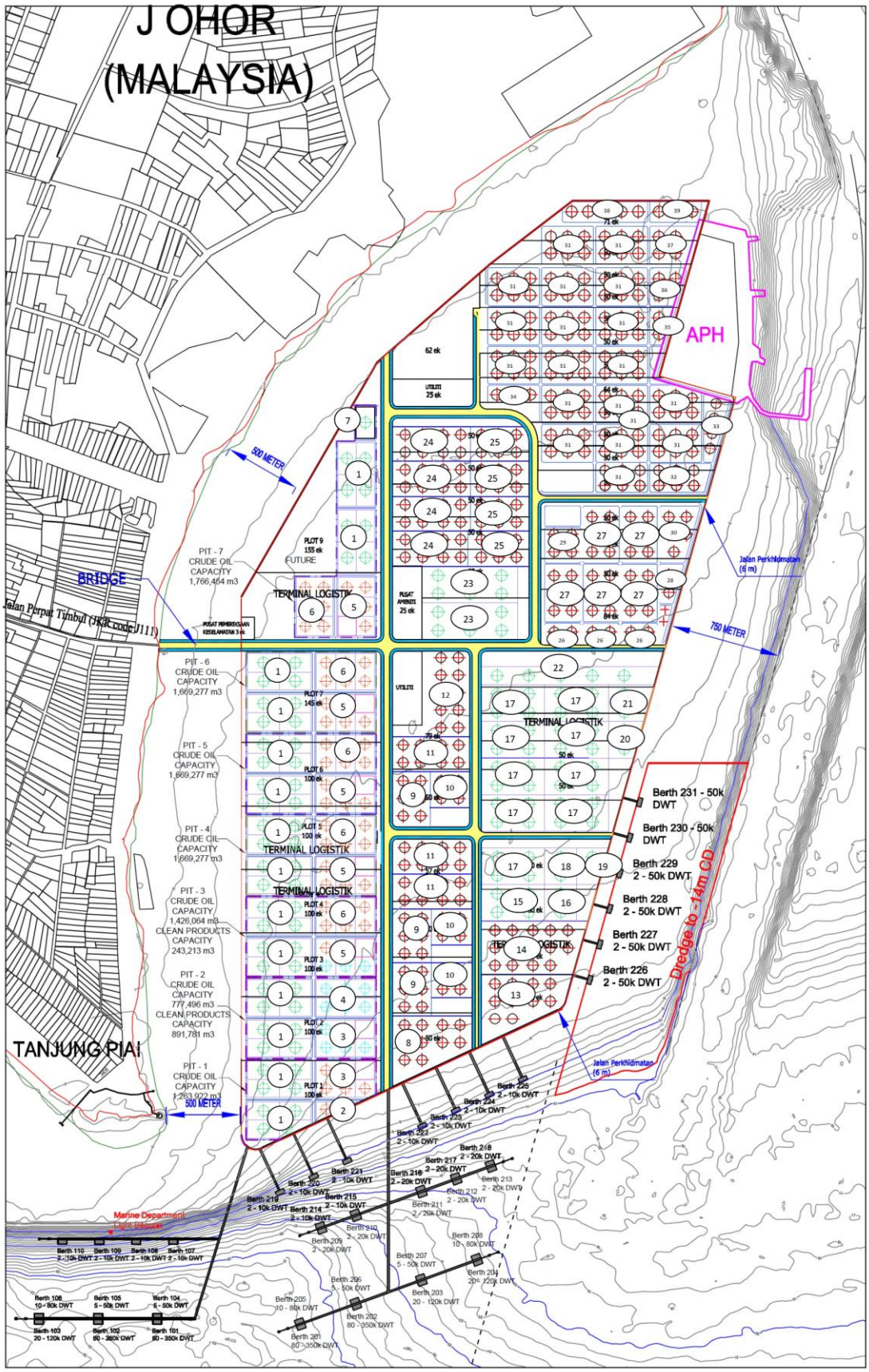
Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS30_GASOLINE_BUND30_L	Release of Gasoline due to leak/catastrophic failure of Tank in Bund 30 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS31_CRUDE_BUND31_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 31 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS32_CRUDE_BUND32_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 32 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS33_CRUDE_BUND33_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 33 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS34_CRUDE_BUND34_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 34 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS35_CRUDE_BUND35_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 35 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS36_CRUDE_BUND36_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 36 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS37_CRUDE_BUND37_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 37 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS38_CRUDE_BUND38_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 38 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	
IS39_CRUDE_BUND39_L	Release of Crude Oil due to leak/catastrophic failure of Tank in Bund 39 and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Pool Fire.	15 mm	Pool Fire
		50 mm	
		100 mm	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS40_CRUDE_LOADARM1_L	Release of Crude Oil due to leak/catastrophic failure of loading arm and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	
IS41_CRUDE_LOADARM3_L	Release of Crude Oil due to leak/catastrophic failure of loading arm and associated fittings/pipings. The immediate and delay outcome of the released Crude Oil will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	
IS42_GASOLINE_LOADARM1_L	Release of Gasoline due to leak/catastrophic failure of loading arm and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	
IS43_CRUDE_PIPELINE1_L	Release of Crude due to leak/catastrophic failure of pipeline 1 and associated fittings/pipings. The immediate and delay outcome of the released Crude will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	
IS44_CRUDE_PIPELINE2_L	Release of Crude due to leak/catastrophic failure of pipeline 2 and associated fittings/pipings. The immediate and delay outcome of the released Crude will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	

Isolatable Sub-section ID	Description	Representative Release Size	Possible Outcomes
IS45_CRUDE_PIPELINE3_L	Release of Crude due to leak/catastrophic failure of pipeline 3 and associated fittings/pipings. The immediate and delay outcome of the released Crude will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	
IS46_GASOLINE_PIPELINE1_L	Release of Gasoline due to leak/catastrophic failure of pipeline 1 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	
IS47_GASOLINE_PIPELINE2_L	Release of Gasoline due to leak/catastrophic failure of pipeline 2 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	
IS48_GASOLINE_PIPELINE3_L	Release of Gasoline due to leak/catastrophic failure of pipeline 3 and associated fittings/pipings. The immediate and delay outcome of the released Gasoline will result in Jet Fire and Pool Fire.	15 mm	Jet Fire, Pool Fire
		50 mm	
		Catastrophic rupture	

Figure 1-4 : Bunds Allocation



1.5 Frequency Analysis

1.5.1 Release Frequencies

1.5.1.1 Equipment Failure Rate

Generic failure rate data for equipment item have been taken from Offshore Hydrocarbon Release Database [3] and COVO 1982 [4]. The table below summarizes the generic equipment failure data used in this study.

Table 1-7: Historical Onshore Equipment Failure Rates

Equipment Item	Failure Size	Failure Frequency
Storage Tank - (> 3 ft) [3]	Small	1.10 x 10^{-3} per tank per year
	Medium	6.46 x 10^{-4} per tank per year
	Large	7.31x 10^{-5} per tank per year
Piping, Steel (D>11 inch) [3] -	Small	3.73 x 10^{-6} per meter per year
	Medium	2.61 x 10^{-6} per meter per year
	Catastrophic	5.52 x 10^{-7} per meter per year
Actuated Valve - (D >11") [3]	Small	6.52 x 10^{-5} per valve per year
	Medium	4.57 x 10^{-5} per valve per year
	Catastrophic	9.65 x 10^{-6} per valve per year
Flange- (D >11) [3]	Small	1.45 x 10^{-5} per flange per year
	Medium	1.01 x 10^{-5} per flange per year
	Catastrophic	2.14 x 10^{-6} per flange per year
Loading arm – (450mm)[4]	Small	6.64 x 10^{-3} per meter per year
	Medium	2.12 x 10^{-3} per meter per year
	Catastrophic	8.76 x 10^{-5} per meter per year
Loading arm - (600mm)[4]	Small	6.61 x 10^{-3} per meter per year
	Medium	2.15 x 10^{-3} per meter per year
	Catastrophic	8.76 x 10^{-5} per meter per year

It should be noted that the equipment listed above are not subject to any lifting operations once installed at the proposed project. Hence the possibility of failures due to lifting operations are deemed not credible.

These generic failure data were derived from statistical analysis of historical accident data from the chemical industry as a whole and take no account of the current safety engineering standards which are generally higher than the historical average. Furthermore, no account was taken of clients' engineering design standards nor safety management systems. The data can be considered as conservative for the purposes of assessment.

1.5.2 Ignition Probabilities

The probability of ignition depends on the availability of a flammable mixture, the flammable mixture reaching an ignition source, and the type of ignition source (energy, etc). The possible ignition sources on the facility include:

- Hot work;
- Faults in electrical equipment;
- Faults in rotating equipment;
- Ignition caused by combustion engines/ hot surfaces;
- Automatic ignition in the event of a fracture/ rupture;
- Static electricity; and
- Lighting.

According to Cox, Lees and Ang [5] (also contained in Frank P. Lee's Loss Prevention in the Process Industries), generic ignition probabilities are given as below:

Table 1-8: Generic Ignition Probabilities

Scenario	Probabilities of Ignition for Release Rate Categories		
	0.1 to 1.0 kg/s	1.0 to 50 kg/s	> 50 kg/s
Gas Leak	0.01	0.07	0.3
Oil/ Condensate Leak	0.01	0.03	0.08

Depending on the time of ignition after release, the ignition can be "immediate ignition" or "delayed ignition". The following assumptions have been made for distribution of overall ignition probability into immediate and delayed ignition:

Table 1-9: Immediate and Delayed Ignition Probability Distribution

Release Rate (kg/s)	Immediate Ignition	Delayed Ignition
0.1 to 1.0	0.1	0.9
1.0 to 50	0.5	0.5
> 50	0.6	0.4

The probability of explosion depends on factors such as location of leak source, gas concentrations (presence of vapour clouds), location and energy of ignition sources, area geometry, and ventilation of the area and equipment congestion. Cox, Lees and Ang [5] provides probabilities for explosion used in the assessment in lieu of the detailed information required for estimation.

Table 1-10: Probability of Explosion Given Gas Cloud Ignition

Release Rate (kg/s)	Probability of Explosion (Given Ignition)
0.1 to 1.0	0.04
1.0 to 50	0.12
> 50	0.3

1.5.3 Event Tree Analysis

The event frequencies can be obtained by applying the ignition probabilities above to event tree as shown in the figures below.

Figure 1-5: Event Tree Model for Release of Flammable Liquid < 2 bar

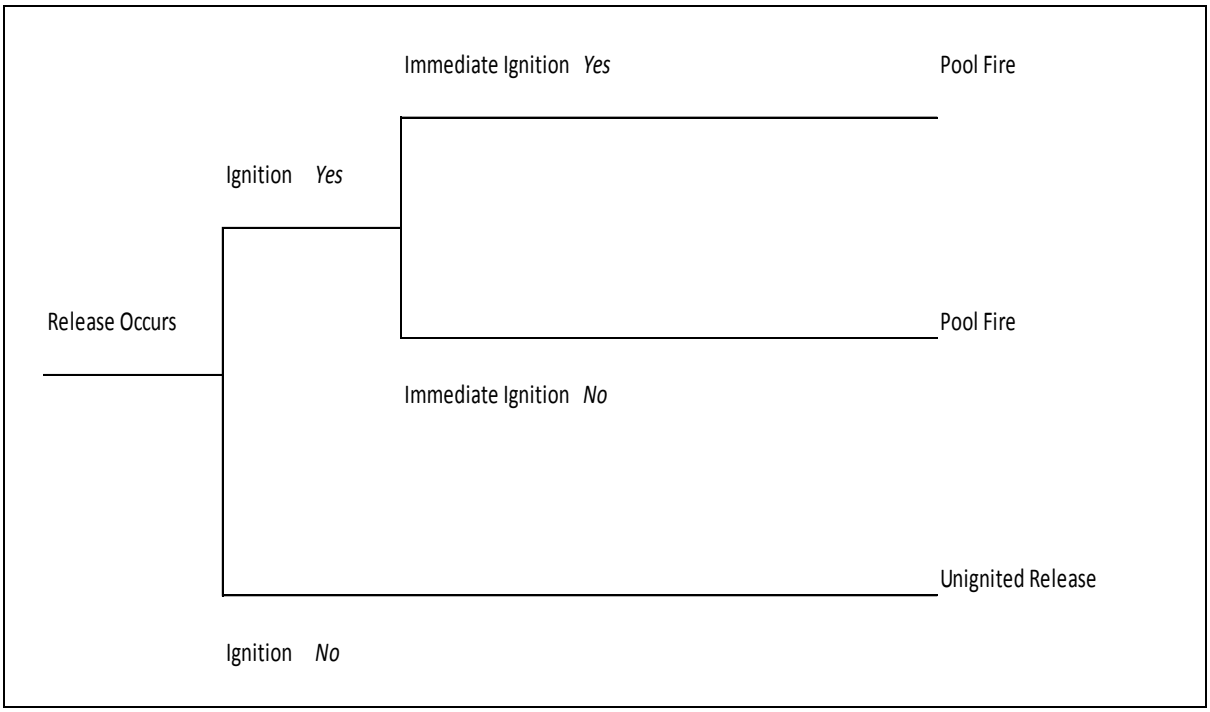


Figure 1-6: Event Tree Model for Small and Medium Release of Flammable Liquid > 2 bar

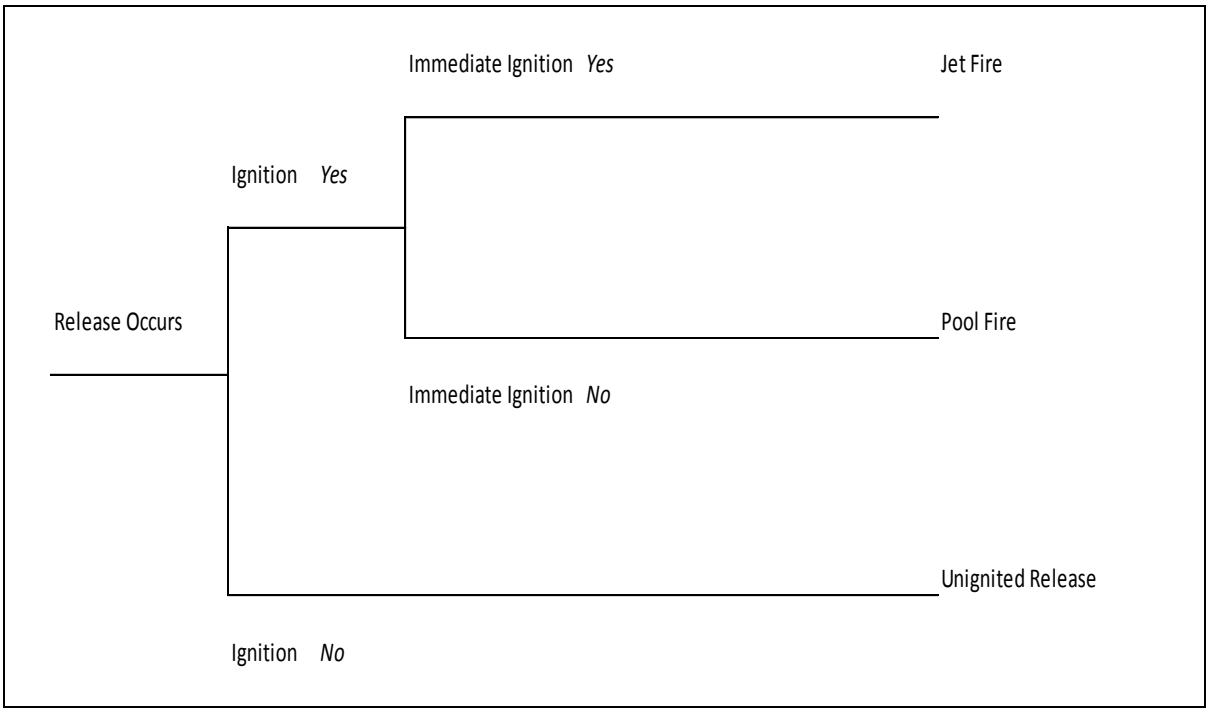
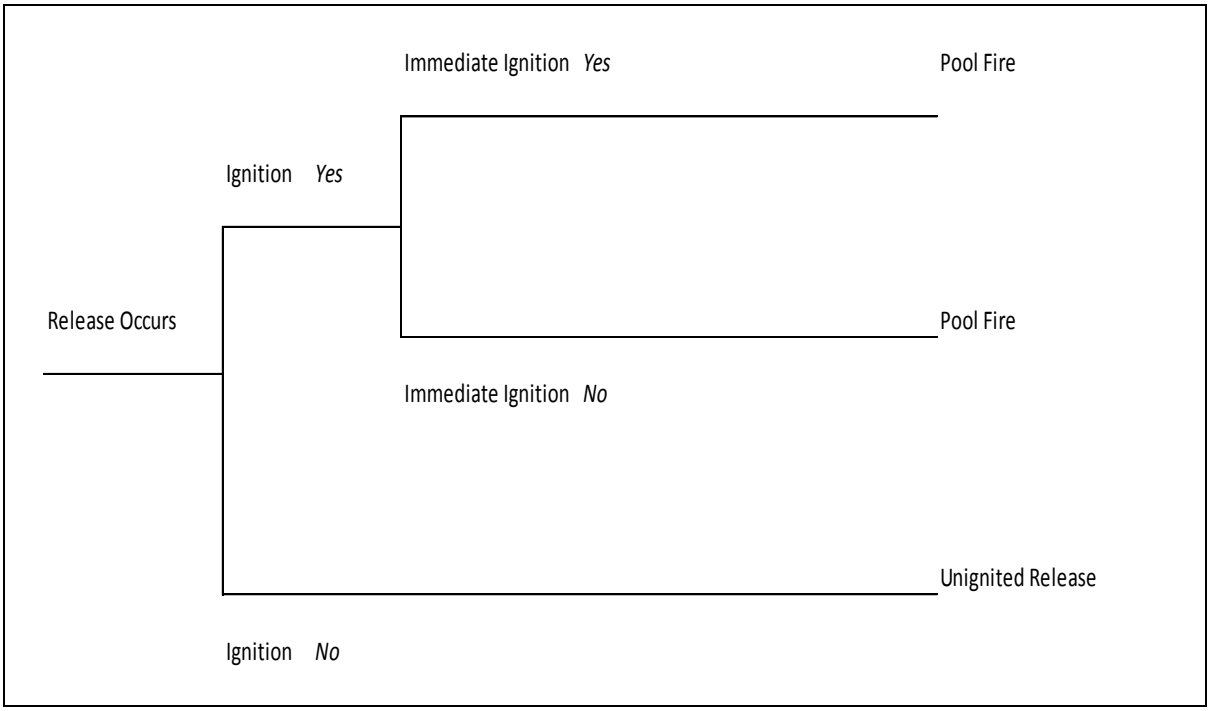


Figure 1-7: Event Tree Model for Catastrophic Release of Flammable Liquid > 2 bar



1.6 Consequence Analysis

1.6.1 Hazard Zones

The following hazard zones have been analyzed via consequence modeling. The criteria for each hazard zone are as follows:

Table 1-11: Hazard Zones Criteria

Hazard	Criteria
Thermal (Fire)	37.5 kW/m^2 – This radiation level may result in up to 100% fatalities in the total population exposed and cause significant damage to process equipment
	12.5 kW/m^2 – This radiation level may result in up to 50% fatalities in the total population exposed and cause damage to process equipment
	4 kW/m^2 – This radiation level may result in up to 3% fatalities in the total population exposed, but below which no injuries or damage would be expected

1.6.2 Models Used

Software package CasQade has been used for the calculation of consequence effects for all events.

Consequence analysis was carried out for identified outcome events, including release rates, characterizing flames and thermal radiation ranges and estimate dispersion distances.

Events

Fire events have been considered for further evaluation. Jet fire scenarios (due to immediate ignition) have been modelled (deemed to give greater consequence distance regardless of the total mass released), as a pressurized release may be ignited and hence the consequence of a fire event in this particular scenario is deemed more likely to take place within the confined area of the project site.

The consequence modelling is performed on a conservative basis to ensure risk are not underestimated. For example, the maximum inventories of hazardous substances in vessels, are used together with worst case process conditions, and releases are modelled based on initial maximum (rather than average) release rates; no account taken of site drainage/ emergency spill containment systems to limit the spread of liquid releases etc, using published computer models that are inherently conservative.

Pool Fire

Pool fires are a result from the ignition of flammable liquid spills. Upon spillage, the liquid draws energy from the ground and surrounding air, to form a flammable vapour/ air layer close to the liquid surface. The thickness of this vapour/ air layer is dependent on the flash point of the spilt liquid.

If the spill releases insufficient fuel to fill the bund area or the spill is unbunded, the pool will spread with gravitational forces pushing down on it and forcing it outwards at the edges. Spreading will stop when equilibrium is reached between the gravitational forces, frictional forces and surface tension forces acting on the spreading liquid (the latter two forces resisting pool spread). The pool thickness and hence surface area are therefore dependent on the point at which this equilibrium is reached. For pools that fill the bund

or containment area, the pool surface area is fixed, with the depth of liquid varying according to the volume of liquid spilled.

Upon ignition, it is the vapor layer above the liquid pool that burn, generating heat that in turn causes further evaporation of liquid (i.e. the fire becomes self-generating). Since burning only occurs at the surface of the pool, the radiant heat effect of a pool fire is dependent on the volume of fuel spilt, the size of the bund/ containment area and the burning rate of the fuel. Hazards arising from pool fires are primarily due to thermal radiation.

Jet Fire

In the event of a continuous pressurized release of either gas or liquid or two-phase fluid, a jet of fluid will form. A jet or spray fire is a turbulent diffusion flame resulting from the combustion of a fuel continuously released with some significant momentum in a particular direction or directions. Jet fires can arise from releases of gaseous, flashing liquid (two phase) and pure liquid inventories.

The primary concern for jet fires is that of engulfment and high thermal radiation flux. Normally jet fires should be distinguished as being either horizontal or vertical jets. Horizontal jets have the possibility of impacting upon other structures and being deflected. This process gives rise to a loss of momentum and substantial entrainment which enhances the formation of a flammable cloud and hence the potential for an unconfined explosion.

The properties of jet fires depend on the fuel composition, release conditions, release rate, release geometry, direction and ambient wind conditions. Low velocity two-phase releases of condensate material can produce ‘lazy’, wind affected buoyant, sooty and highly radiative flames similar to pool ffires.

1.6.3 Tabulation of Consequence and Frequency of All Possible Accident Scenarios

This section presents the results of the consequence modelling performed for the failure cases identified in the hazard identification. All consequence results can be found in **Appendix 1-A** while the frequency results can be found in **Appendix 1-B**.

1.7 Risk Summation

The results of risk summation are presented in terms of Individual Risk which, in the context of the DOE Risk Guidelines, is defined as the risk of fatality to a person in the vicinity of a hazard. This includes the nature of the fatality to the individual, the likelihood of the fatality occurring, and the period of time over which the fatality might occur. The individual is assumed to be unprotected and to be present during the total time of exposure (i.e. 24 hours a day, every day of the year). The individual risk value, $R_{i,}$ at a particular distance, *i,* due to the occurrence of a particular event outcome, *j,* is calculated by the following equation:

$$R_i = \sum f_{eo,j} . P_{fat,i,j} . P_{weather,j}$$, where:

$f_{eo,j}$ is the frequency of event outcome *j* obtained from event tree analysis and historical data;

$P_{fat,i,j}$ is the probability of fatality at distance *i* produced by event outcome *j* from consequence analysis; and

$P_{weather,j}$ is the probability of the weather conditions required to produce the event outcome at *j* (from meteorological data, 1 for weather independent event outcomes).

The individual risk (IR) profile for the site under study is calculated with the Consultant's in-house spreadsheet based on the above equation. It is represented as a function of distance from the source of potential risk upon the surrounding environment. Risk summation involves combining the frequency of a given event outcome *j* with its associated consequences to determine the individual risk levels associated with the site.

The worst case findings can be summarized as follows:

Table 1-12: Individual Risk (IR) Contour Findings Summary

IR Contours	Max Distance to Contour (m)
$1x10^{-5}$ per year	**510**
$1x10^{-6}$ per year	**630**

The representation of IR contours of various iso-sections for the proposed Project is attached in **Appendix 1-C.**

1.8 Conclusion

1.8.1 Salient findings of the QRA study

The extent of all consequences assessed are limited within the industrial developments surrounding the project, which is in compliance with DOE's risk acceptance criteria.

- IR Contours:
    - The 1 x 10^{-5} per year IR contour of the proposed Project remains within the established industrial development, i.e. Tanjung Piai Industrial Park only; and
    - The 1 x 10^{-6} per year IR contour of the proposed Project does not encompass involuntary recipients of industrial risks such as residential areas, schools, hospitals, and places of continuous occupancy, etc.

The above results are in compliance of the requirements stipulated by the DOE risk criteria.

Table 1-13: Risk Contour Findings Summary

IR Contours	Max Distance to Contour (m)	Confirmation
1 × 10^{-5} per year	**510**	**The contour remains within the established industrial developments i.e. Tanjung Piai Industrial Park.**
1 × 10^{-6} per year	**630**	**The contour does not encompass the sensitive receptor area.**

It is noted that the risks have been assessed on a conservative basis, both in terms of consequences (e.g. use of the maximum inventories of hazardous substances in vessels, worst case process conditions, releases are modelled based on initial maximum (rather than average) release rates, no account taken of site drainage/ emergency spill containment systems to limit the spread of liquid releases etc. using published computer models that are inherently conservative), and frequency – i.e. no account has been taken of project site safety systems (e.g. isolation valves, detectors), operator intervention to prevent or minimise releases and no credit has been taken to account for the site Safety Management System.

A worst case scenario (WCS) is a scenario with the furthest consequence distance. Where else, a worst case credible scenario (WCCS) is a credible scenario (with event frequencies $\geq$ 1 × 10^{-6} per year) with furthest consequence distance. The WCS and WCCS for the proposed project are explained in detail below.

- The WCS are those scenarios which entail the farthest consequence distance amongst all the scenarios irrespective of the frequency. For the specified condition, the WCS is envisaged to be the thermal radiation arising from the iso-sections 13 and 14 each. However it must be noted that from each of these scenarios, the impact does not potentially affect the identified sensitive receptor areas (as identified in Section 1.2.1.1). Thus, the worst case scenarios henceforth identified are those with hole diameter 100 mm and which are in closer proximity to potentially affect the sensitive receptor areas. These have been mentioned in the **Table 1-14** below. The impact representation has been attached under **Appendix 1-D**. For the representation on bund allocation and the respective iso-sections, refer to **Figure 1-4**.

Table 1-14: Worst Case Scenarios Identified

Worst Case Scenario	Heat radiation Flux (kW/m^2)	Distance (m)
Iso-section 1 : 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	280.7
	12.5 (Fatality rate: 50%)	176.5
	37.5 (Fatality rate: 100%)	0
Iso-section 6 : 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	279
	12.5 (Fatality rate: 50%)	175.3
	37.5 (Fatality rate: 100%)	0
Iso-section 7: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	248.2
	12.5 (Fatality rate: 50%)	153.5
	37.5 (Fatality rate: 100%)	0
Iso-section 31: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	227.7
	12.5 (Fatality rate: 50%)	139.3
	37.5 (Fatality rate: 100%)	0
Iso-section 38: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	178
	12.5 (Fatality rate: 50%)	105.7
	37.5 (Fatality rate: 100%)	0
Iso-section 39: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	178
	12.5 (Fatality rate: 50%)	105.7
	37.5 (Fatality rate: 100%)	0

The above scenarios are bund fires reflecting various bund sizes due to the difference in the number of tanks in each bund. Hence, different bund sizes have resulted in the above-mentioned consequence distances.

- On filtering out the frequencies $\geq 1 \times 10^{-6}$ per year, the WCCS for the proposed development area i.e. the furthest distance has been potentially inferred to arise from the Iso-sections 13 and 14 each as its source with a leak hole diameter of 100mm. The associated distances for each criteria of thermal heat radiation is provided below. The impact representation has been attached under **Appendix 1-D.**

Table 1-15: Worst Case Credible Scenarios Identified

Worst Case Scenario	Heat radiation Flux (kW/m^2)	Distance (m)	Frequency (per year)
Iso-section 13: 100mm hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	630	5.8×10^{-5}
	12.5 (Fatality rate: 50%)	423	
	37.5 (Fatality rate: 100%)	276	
Iso-section 14: 100m hole size Release rate – 67.1kg/s	4 (Fatality rate: 3%)	630	8.19×10^{-5}
	12.5 (Fatality rate: 50%)	423	
	37.5 (Fatality rate: 100%)	276	

The above scenarios are bund fires reflecting various bund sizes due to the difference in the number of tanks in each bund. Hence, different bund sizes have resulted in the above-mentioned consequence distances.

1.9 Recommendations

The following measures are recommended based on the findings of the study. Applying certain or all of these recommendations will ensure that risk is reduced to a level as low as reasonably practicable (ALARP) and adherent to the DOE Guidelines, December 2004.

Further Studies

- Prepare an emergency response plan (ERP) to include possible emergency scenarios due to the operation of the proposed tank farms;
- Engineering design for the tank shall ensure that sufficient reliability, redundancy and basic process control system along with the independent Emergency Shutdown System (ESD) is accounted for, to prevent tank overfilling, potential loss of containment which may eventually lead to a vapor cloud explosion scenario. This can be achieved by conducting Health Safety Environment (HSE) Engineering studies like Risk Assessment, Firewater Demand Calculation, QRA, Safety Integrity Level (SIL), Hazard and Operability Study (HAZOP), Hazard Identification (HAZID), etc. with adequately required design information and data;
- Depending on the composition of the crude oil, the need for draining water from the bottom of the storage tank to prevent potential boil over scenario shall also be assessed;
- During the design phase, scenarios of tank rim seal fire and full tank surface fire should be assessed along with the identification of neighboring tanks potentially impacted by thermal radiation from the tank on fire. Radiation shields can be recommended to fight fire if deemed necessary based on the outcome of consequence analysis. The firewater demand calculations in the design phase must account for sufficient supplementary firewater and its application rates for cooling the tanks in the above-mentioned scenario;
- The capacity of the bunds shall be designed to comply with NFPA 30 standard and the bunds should be leak-tight and fire-resistant; and

- All the emergency shutdown valves (ESDV) provided shall be fire-proofed for adequate time duration and the remotely operated shut down valves can be considered to be provided to prevent escalation of fire.

Procedural: Operation

- Ensure only fully trained and competent personnel are employed for the proposed tank farm;
- Enforce safety procedures to ensure authorized access only to the tank farm and further restrictions are in place for limiting storage tank farm access to approved persons only;
- Ensure that the tanks in operation have enough headspace margin for the intake to be closed off in time;
- Ensure that all the protection systems are thoroughly inspected, maintained and tested periodically;
- Perform regular emergency response drills (including desktop exercises) as well as feedback and review sessions with the local fire and rescue services for handling and controlling the worst case scenario.

Maintenance

- Undertake regular maintenance of the process equipment i.e. tanks, piping, pumps and process vessels in accordance with manufacturers guidance. This will ensure that the integrity of these equipment will be maintained, hence minimizing any leaks/releases due to mechanical failure.

Fire Fighting System

- Conduct routine inspections of fire safety requirements (fire blankets, fire extinguishers, smoke detectors, sprinklers, emergency lighting and fire-rated doors).

1.10 References

[1] Crude Oil Material Safety Data Sheet, Retrieved on 10th July 2014, Website <http://www.encana.com/pdf/business/contractors/msds/crude-sour.pdf>.

[2] Gasoline Material Safety Data Sheet, Retrieved on 10th July 2014, Website < http://www.valero.com/v_msds/002%20-%20unleaded%20gasoline%20rev%202.pdf>.

[3] Offshore Hydrocarbon Release Data, HSE OSD, 2011, from HSE on-line database, https://www.hse.gov.uk/hcr3/.

[4] Rijnmond Public Authority, “A Risk Analysis of Six Potentially Hazardous Industrial Objects in the Rijnmond Area - A Pilot Study”, COVO, D. Reidel Publishing Co., Dordrecht, 1982.

[5] Cox, Lee and Ang, *Classification of Hazardous Location, 1990.*

APPENDIX 1-A

CONSEQUENCE MODELLING RESULT

Pool Fire Small – 15 mm hole diameter

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
1	IS01_CRUDE_BUND1.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS01_CRUDE_BUND1.1_L_PF_S_0.5	0.50	84.10	106.50	135.20
	IS01_CRUDE_BUND1.1_L_PF_S_0.03	0.03	148.20	184.20	223.70
2	IS02_GASOLINE_BUND2_L_PF_S_1	1.00	98.60	124.60	151.20
	IS02_GASOLINE_BUND2_L_PF_S_0.5	0.50	155.90	194.80	237.20
	IS02_GASOLINE_BUND2_L_PF_S_0.03	0.03	280.00	325.10	352.50
3	IS03_GASOLINE_BUND3.1_L_PF_S_1	1.00	91.90	116.60	142.60
	IS03_GASOLINE_BUND3.1_L_PF_S_0.5	0.50	146.20	184.10	223.90
	IS03_GASOLINE_BUND3.1_L_PF_S_0.03	0.03	363.60	370.60	330.30
4	IS04_GASOLINE_BUND4_L_PF_S_1	1.00	91.90	116.60	142.60
	IS04_GASOLINE_BUND4_L_PF_S_0.5	0.50	146.20	184.10	223.90
	IS04_GASOLINE_BUND4_L_PF_S_0.03	0.03	363.60	370.60	330.30
5	IS05_CRUDE_BUND5.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS05_CRUDE_BUND5.1_L_PF_S_0.5	0.50	87.80	110.50	139.70
	IS05_CRUDE_BUND5.1_L_PF_S_0.03	0.03	154.20	187.80	231.70
6	IS06_CRUDE_BUND6.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS06_CRUDE_BUND6.1_L_PF_S_0.5	0.50	87.80	110.50	139.70
	IS06_CRUDE_BUND6.1_L_PF_S_0.03	0.03	154.20	187.80	231.60
7	IS07_CRUDE_BUND7_L_PF_S_1	1.00	0.00	0.00	0.00
	IS07_CRUDE_BUND7_L_PF_S_0.5	0.50	143.60	169.30	200.60

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS07_CRUDE_BUND7_L_PF_S_0.03	0.03	241.00	266.70	335.40
8	IS08_CRUDE_BUND8_L_PF_S_1	1.00	0.00	0.00	0.00
	IS08_CRUDE_BUND8_L_PF_S_0.5	0.50	90.70	113.50	143.20
	IS08_CRUDE_BUND8_L_PF_S_0.03	0.03	158.90	190.10	237.70
9	IS09_CRUDE_BUND9.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS09_CRUDE_BUND9.1_L_PF_S_0.5	0.50	89.10	111.80	141.20
	IS09_CRUDE_BUND9.1_L_PF_S_0.03	0.03	156.20	188.90	234.30
10	IS10_CRUDE_BUND10.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS10_CRUDE_BUND10.1_L_PF_S_0.5	0.50	92.20	115.00	144.90
	IS10_CRUDE_BUND10.1_L_PF_S_0.03	0.03	161.20	191.80	240.70
11	IS11_CRUDE_BUND11.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS11_CRUDE_BUND11.1_L_PF_S_0.5	0.50	90.60	113.40	143.00
	IS11_CRUDE_BUND11.1_L_PF_S_0.03	0.03	158.70	190.10	237.40
12	IS12_CRUDE_BUND12_L_PF_S_1	1.00	0.00	0.00	0.00
	IS12_CRUDE_BUND12_L_PF_S_0.5	0.50	170.70	130.50	162.80
	IS12_CRUDE_BUND12_L_PF_S_0.03	0.03	185.70	280.60	271.70
13	IS13_GASOLINE_BUND13_L_PF_S_1	1.00	101.20	127.80	150.60
	IS13_GASOLINE_BUND13_L_PF_S_0.5	0.50	159.70	198.70	242.40
	IS13_GASOLINE_BUND13_L_PF_S_0.03	0.03	286.40	331.70	361.20
14	IS14_GASOLINE_BUND14_L_PF_S_1	1.00	100.30	126.70	153.40
	IS14_GASOLINE_BUND14_L_PF_S_0.5	0.50	158.40	197.40	240.60
	IS14_GASOLINE_BUND14_L_PF_S_0.03	0.03	284.20	329.40	358.20

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
15	IS15_GASOLINE_BUND15_L_PF_S_1	1.00	142.40	177.60	204.70
	IS15_GASOLINE_BUND15_L_PF_S_0.5	0.50	217.60	252.90	319.20
	IS15_GASOLINE_BUND15_L_PF_S_0.03	0.03	378.80	414.00	489.80
16	IS16_GASOLINE_BUND16_L_PF_S_1	1.00	142.90	178.30	205.40
	IS16_GASOLINE_BUND16_L_PF_S_0.5	0.50	218.30	253.70	320.30
	IS16_GASOLINE_BUND16_L_PF_S_0.03	0.03	379.90	415.20	491.40
17	IS17_CRUDE_BUND17.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS17_CRUDE_BUND17.1_L_PF_S_0.5	0.50	143.00	168.70	200.00
	IS17_CRUDE_BUND17.1_L_PF_S_0.03	0.03	240.10	265.80	334.40
18	IS18_CRUDE_BUND18_L_PF_S_1	1.00	0.00	0.00	0.00
	IS18_CRUDE_BUND18_L_PF_S_0.5	0.50	143.60	169.30	200.60
	IS18_CRUDE_BUND18_L_PF_S_0.03	0.03	241.00	266.70	335.40
19	IS19_CRUDE_BUND19_L_PF_S_1	1.00	0.00	0.00	0.00
	IS19_CRUDE_BUND19_L_PF_S_0.5	0.50	143.20	168.90	200.20
	IS19_CRUDE_BUND19_L_PF_S_0.03	0.03	240.40	266.10	334.70
20	IS20_CRUDE_BUND20_L_PF_S_1	1.00	0.00	0.00	0.00
	IS20_CRUDE_BUND20_L_PF_S_0.5	0.50	142.10	167.70	199.10
	IS20_CRUDE_BUND20_L_PF_S_0.03	0.03	238.70	274.30	332.90
21	IS21_CRUDE_BUND21_L_PF_S_1	1.00	0.00	0.00	0.00
	IS21_CRUDE_BUND21_L_PF_S_0.5	0.50	143.20	168.80	200.20
	IS21_CRUDE_BUND21_L_PF_S_0.03	0.03	240.30	266.00	334.60
22	IS22_CRUDE_BUND22_L_PF_S_1	1.00	0.00	0.00	0.00

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS22_CRUDE_BUND22_L_PF_S_0.5	0.50	101.00	124.00	155.30
	IS22_CRUDE_BUND22_L_PF_S_0.03	0.03	175.20	202.80	258.60
23	IS23_CRUDE_BUND23.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS23_CRUDE_BUND23.1_L_PF_S_0.5	0.50	143.60	169.30	200.60
	IS23_CRUDE_BUND23.1_L_PF_S_0.03	0.03	241.00	266.70	335.40
24	IS24_CRUDE_BUND24.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS24_CRUDE_BUND24.1_L_PF_S_0.5	0.50	92.50	115.50	145.40
	IS24_CRUDE_BUND24.1_L_PF_S_0.03	0.03	161.80	192.40	241.50
25	IS25_CRUDE_BUND25.1_L_PF_S_1	1.00	0.00	0.00	0.00
	IS25_CRUDE_BUND25.1_L_PF_S_0.5	0.50	92.70	115.70	145.60
	IS25_CRUDE_BUND25.1_L_PF_S_0.03	0.03	162.10	192.70	241.90
26	IS26_GASOLINE_BUND26.1_L_PF_S_1	1.00	103.50	130.50	157.50
	IS26_GASOLINE_BUND26.1_L_PF_S_0.5	0.50	163.10	202.10	246.90
	IS26_GASOLINE_BUND26.1_L_PF_S_0.03	0.03	292.00	337.20	368.90
27	IS27_GASOLINE_BUND27_L_PF_S_1	1.00	92.30	117.00	143.10
	IS27_GASOLINE_BUND27_L_PF_S_0.5	0.50	146.70	184.80	224.70
	IS27_GASOLINE_BUND27_L_PF_S_0.03	0.03	264.50	308.60	331.60
28	IS28_GASOLINE_BUND28_L_PF_S_1	1.00	111.50	140.00	167.60
	IS28_GASOLINE_BUND28_L_PF_S_0.5	0.50	174.60	212.00	261.90
	IS28_GASOLINE_BUND28_L_PF_S_0.03	0.03	310.90	353.50	394.80
29	IS29_GASOLINE_BUND29_L_PF_S_1	1.00	86.60	110.20	135.70
	IS29_GASOLINE_BUND29_L_PF_S_0.5	0.50	138.40	175.20	213.00

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS29_GASOLINE_BUND29_L_PF_S_0.03	0.03	250.30	292.70	312.40
30	IS30_GASOLINE_BUND30_L_PF_S_1	1.00	95.50	120.80	147.20
	IS30_GASOLINE_BUND30_L_PF_S_0.5	0.50	151.30	189.90	231.00
	IS30_GASOLINE_BUND30_L_PF_S_0.03	0.03	272.30	317.00	342.10
31	IS31_CRUDE_BUND31_L_PF_S_1	1.00	0.00	0.00	0.00
	IS31_CRUDE_BUND31_L_PF_S_0.5	0.50	79.20	100.80	128.50
	IS31_CRUDE_BUND31_L_PF_S_0.03	0.03	140.00	177.90	212.10
32	IS32_CRUDE_BUND32_L_PF_S_1	1.00	0.00	0.00	0.00
	IS32_CRUDE_BUND32_L_PF_S_0.5	0.50	94.00	117.00	147.10
	IS32_CRUDE_BUND32_L_PF_S_0.03	0.03	164.10	194.40	244.50
33	IS33_CRUDE_BUND33_L_PF_S_1	1.00	0.00	0.00	0.00
	IS33_CRUDE_BUND33_L_PF_S_0.5	0.50	74.30	95.40	121.70
	IS33_CRUDE_BUND33_L_PF_S_0.03	0.03	131.70	170.70	200.10
34	IS34_CRUDE_BUND34_L_PF_S_1	1.00	0.00	0.00	0.00
	IS34_CRUDE_BUND34_L_PF_S_0.5	0.50	78.40	99.80	127.50
	IS34_CRUDE_BUND34_L_PF_S_0.03	0.03	138.70	176.80	210.20
35	IS35_CRUDE_BUND35_L_PF_S_1	1.00	0.00	0.00	0.00
	IS35_CRUDE_BUND35_L_PF_S_0.5	0.50	108.90	131.90	164.20
	IS35_CRUDE_BUND35_L_PF_S_0.03	0.03	187.70	210.60	274.10
36	IS36_CRUDE_BUND36_L_PF_S_1	1.00	0.00	0.00	0.00
	IS36_CRUDE_BUND36_L_PF_S_0.5	0.50	86.60	109.20	138.30
	IS36_CRUDE_BUND36_L_PF_S_0.03	0.03	152.30	186.70	229.20

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
37	IS37_CRUDE_BUND37_L_PF_S_1	1.00	0.00	0.00	0.00
	IS37_CRUDE_BUND37_L_PF_S_0.5	0.50	106.40	129.10	161.40
	IS37_CRUDE_BUND37_L_PF_S_0.03	0.03	183.80	206.50	239.30
38	IS38_CRUDE_BUND38_L_PF_S_1	1.00	0.00	0.00	0.00
	IS38_CRUDE_BUND38_L_PF_S_0.5	0.50	97.70	120.80	151.50
	IS38_CRUDE_BUND38_L_PF_S_0.03	0.03	170.10	199.40	252.10
39	IS39_CRUDE_BUND39_L_PF_S_1	1.00	0.00	0.00	0.00
	IS39_CRUDE_BUND39_L_PF_S_0.5	0.50	97.70	120.80	151.50
	IS39_CRUDE_BUND39_L_PF_S_0.03	0.03	170.10	199.40	252.10
40	IS40_CRUDE_LOADARM1_L_PF_S_1	1.00	7.00	11.60	13.40
	IS40_CRUDE_LOADARM1_L_PF_S_0.5	0.50	11.90	16.30	16.30
	IS40_CRUDE_LOADARM1_L_PF_S_0.03	0.03	21.30	21.50	22.20
41	IS41_CRUDE_LOADARM3_L_PF_S_1	1.00	7.00	11.60	13.40
	IS41_CRUDE_LOADARM3_L_PF_S_0.5	0.50	11.90	16.30	16.30
	IS41_CRUDE_LOADARM3_L_PF_S_0.03	0.03	21.30	21.50	22.20
42	IS42_GASOLINE_LOADARM1_L_PF_S_1	1.00	7.90	12.90	14.50
	IS42_GASOLINE_LOADARM1_L_PF_S_0.5	0.50	13.40	17.70	17.30
	IS42_GASOLINE_LOADARM1_L_PF_S_0.03	0.03	23.60	23.50	23.00
43	IS43_CRUDE_PIPELINE1_L_PF_S_1	1.00	6.10	9.90	11.30
	IS43_CRUDE_PIPELINE1_L_PF_S_0.5	0.50	10.50	13.30	13.20
	IS43_CRUDE_PIPELINE1_L_PF_S_0.03	0.03	18.20	17.20	17.50
44	IS44_CRUDE_PIPELINE2_L_PF_S_1	1.00	6.10	9.90	11.30

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS44_CRUDE_PIPELINE2_L_PF_S_0.5	0.50	10.50	13.30	13.20
	IS44_CRUDE_PIPELINE2_L_PF_S_0.03	0.03	18.20	17.20	17.50
45	IS45_CRUDE_PIPELINE3_L_PF_S_1	1.00	6.10	9.90	11.30
	IS45_CRUDE_PIPELINE3_L_PF_S_0.5	0.50	10.50	13.30	13.20
	IS45_CRUDE_PIPELINE3_L_PF_S_0.03	0.03	18.20	17.20	17.50
46	IS46_GASOLINE_PIPELINE1_L_PF_S_1	1.00	6.10	8.80	9.80
	IS46_GASOLINE_PIPELINE1_L_PF_S_0.5	0.50	9.90	12.00	11.60
	IS46_GASOLINE_PIPELINE1_L_PF_S_0.03	0.03	16.40	15.80	14.30
47	IS47_GASOLINE_PIPELINE2_L_PF_S_1	1.00	6.10	8.80	9.80
	IS47_GASOLINE_PIPELINE2_L_PF_S_0.5	0.50	9.90	12.00	11.60
	IS47_GASOLINE_PIPELINE2_L_PF_S_0.03	0.03	16.40	15.80	14.30
48	IS48_GASOLINE_PIPELINE3_L_PF_S_1	1.00	6.10	8.80	9.80
	IS48_GASOLINE_PIPELINE3_L_PF_S_0.5	0.50	9.90	12.00	11.60
	IS48_GASOLINE_PIPELINE3_L_PF_S_0.03	0.03	16.40	15.80	14.30

Pool Fire Medium – 50 mm hole diameter

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
1	IS01_CRUDE_BUND1.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS01_CRUDE_BUND1.1_L_PF_M_0.5	0.50	165.80	192.80	221.90
	IS01_CRUDE_BUND1.1_L_PF_M_0.03	0.03	274.20	301.10	369.50
2	IS02_GASOLINE_BUND2_L_PF_M_1	1.00	98.60	124.60	151.20
	IS02_GASOLINE_BUND2_L_PF_M_0.5	0.50	155.90	194.80	237.20
	IS02_GASOLINE_BUND2_L_PF_M_0.03	0.03	280.00	325.10	352.50
3	IS03_GASOLINE_BUND3.1_L_PF_M_1	1.00	162.70	201.70	231.60
	IS03_GASOLINE_BUND3.1_L_PF_M_0.5	0.50	244.70	283.70	358.90
	IS03_GASOLINE_BUND3.1_L_PF_M_0.03	0.03	427.80	466.80	544.90
4	IS04_GASOLINE_BUND4_L_PF_M_1	1.00	162.70	201.70	231.60
	IS04_GASOLINE_BUND4_L_PF_M_0.5	0.50	244.70	283.70	358.90
	IS04_GASOLINE_BUND4_L_PF_M_0.03	0.03	427.80	466.80	544.90
5	IS05_CRUDE_BUND5.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS05_CRUDE_BUND5.1_L_PF_M_0.5	0.50	164.70	191.50	220.80
	IS05_CRUDE_BUND5.1_L_PF_M_0.03	0.03	272.50	299.30	367.80
6	IS06_CRUDE_BUND6.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS06_CRUDE_BUND6.1_L_PF_M_0.5	0.50	164.70	191.50	220.80
	IS06_CRUDE_BUND6.1_L_PF_M_0.03	0.03	272.50	299.30	367.80
7	IS07_CRUDE_BUND7_L_PF_M_1	1.00	0.00	0.00	0.00
	IS07_CRUDE_BUND7_L_PF_M_0.5	0.50	143.60	169.30	200.60

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS07_CRUDE_BUND7_L_PF_M_0.03	0.03	241.00	266.70	335.40
8	IS08_CRUDE_BUND8_L_PF_M_1	1.00	0.00	0.00	0.00
	IS08_CRUDE_BUND8_L_PF_M_0.5	0.50	179.30	206.80	237.20
	IS08_CRUDE_BUND8_L_PF_M_0.03	0.03	293.90	321.50	388.30
9	IS09_CRUDE_BUND9.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS09_CRUDE_BUND9.1_L_PF_M_0.5	0.50	175.80	203.20	233.30
	IS09_CRUDE_BUND9.1_L_PF_M_0.03	0.03	288.90	316.30	383.60
10	IS10_CRUDE_BUND10.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS10_CRUDE_BUND10.1_L_PF_M_0.5	0.50	182.00	209.60	240.40
	IS10_CRUDE_BUND10.1_L_PF_M_0.03	0.03	297.90	325.50	391.90
11	IS11_CRUDE_BUND11.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS11_CRUDE_BUND11.1_L_PF_M_0.5	0.50	178.90	206.40	236.90
	IS11_CRUDE_BUND11.1_L_PF_M_0.03	0.03	293.40	320.90	387.80
12	IS12_CRUDE_BUND12_L_PF_M_1	1.00	0.00	0.00	0.00
	IS12_CRUDE_BUND12_L_PF_M_0.5	0.50	195.80	223.90	256.30
	IS12_CRUDE_BUND12_L_PF_M_0.03	0.03	317.90	346.10	416.60
13	IS13_GASOLINE_BUND13_L_PF_M_1	1.00	199.00	242.00	276.30
	IS13_GASOLINE_BUND13_L_PF_M_0.5	0.50	290.80	333.70	423.00
	IS13_GASOLINE_BUND13_L_PF_M_0.03	0.03	514.10	557.10	629.90
14	IS14_GASOLINE_BUND14_L_PF_M_1	1.00	199.00	242.00	276.30
	IS14_GASOLINE_BUND14_L_PF_M_0.5	0.50	290.80	333.70	423.00
	IS14_GASOLINE_BUND14_L_PF_M_0.03	0.03	514.10	557.10	629.90

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
15	IS15_GASOLINE_BUND15_L_PF_M_1	1.00	162.70	201.70	231.60
	IS15_GASOLINE_BUND15_L_PF_M_0.5	0.50	244.70	283.70	358.90
	IS15_GASOLINE_BUND15_L_PF_M_0.03	0.03	427.80	466.80	554.90
16	IS16_GASOLINE_BUND16_L_PF_M_1	1.00	162.70	201.70	231.60
	IS16_GASOLINE_BUND16_L_PF_M_0.5	0.50	244.70	283.70	358.90
	IS16_GASOLINE_BUND16_L_PF_M_0.03	0.03	427.80	466.80	554.90
17	IS17_CRUDE_BUND17.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS17_CRUDE_BUND17.1_L_PF_M_0.5	0.50	164.70	191.50	220.80
	IS17_CRUDE_BUND17.1_L_PF_M_0.03	0.03	272.50	299.30	367.80
18	IS18_CRUDE_BUND18_L_PF_M_1	1.00	0.00	0.00	0.00
	IS18_CRUDE_BUND18_L_PF_M_0.5	0.50	164.70	191.50	220.80
	IS18_CRUDE_BUND18_L_PF_M_0.03	0.03	272.50	299.30	367.80
19	IS19_CRUDE_BUND19_L_PF_M_1	1.00	0.00	0.00	0.00
	IS19_CRUDE_BUND19_L_PF_M_0.5	0.50	143.20	168.90	200.20
	IS19_CRUDE_BUND19_L_PF_M_0.03	0.03	240.40	266.10	334.70
20	IS20_CRUDE_BUND20_L_PF_M_1	1.00	0.00	0.00	0.00
	IS20_CRUDE_BUND20_L_PF_M_0.5	0.50	165.90	192.90	221.90
	IS20_CRUDE_BUND20_L_PF_M_0.03	0.03	274.30	301.20	369.60
21	IS21_CRUDE_BUND21_L_PF_M_1	1.00	0.00	0.00	0.00
	IS21_CRUDE_BUND21_L_PF_M_0.5	0.50	195.80	223.90	256.30
	IS21_CRUDE_BUND21_L_PF_M_0.03	0.03	317.90	346.10	416.60
22	IS22_CRUDE_BUND22_L_PF_M_1	1.00	0.00	0.00	0.00

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS22_CRUDE_BUND22_L_PF_M_0.5	0.50	101.00	124.00	155.30
	IS22_CRUDE_BUND22_L_PF_M_0.03	0.03	175.20	202.80	258.60
23	IS23_CRUDE_BUND23.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS23_CRUDE_BUND23.1_L_PF_M_0.5	0.50	195.80	223.90	256.30
	IS23_CRUDE_BUND23.1_L_PF_M_0.03	0.03	317.90	346.10	416.60
24	IS24_CRUDE_BUND24.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS24_CRUDE_BUND24.1_L_PF_M_0.5	0.50	168.30	195.30	224.60
	IS24_CRUDE_BUND24.1_L_PF_M_0.03	0.03	277.80	307.80	373.00
25	IS25_CRUDE_BUND25.1_L_PF_M_1	1.00	0.00	0.00	0.00
	IS25_CRUDE_BUND25.1_L_PF_M_0.5	0.50	158.40	185.00	215.00
	IS25_CRUDE_BUND25.1_L_PF_M_0.03	0.03	263.20	289.80	358.60
26	IS26_GASOLINE_BUND26.1_L_PF_M_1	1.00	103.50	130.50	157.50
	IS26_GASOLINE_BUND26.1_L_PF_M_0.5	0.50	163.10	202.10	246.90
	IS26_GASOLINE_BUND26.1_L_PF_M_0.03	0.03	292.00	337.20	368.90
27	IS27_GASOLINE_BUND27_L_PF_M_1	1.00	160.00	198.70	228.20
	IS27_GASOLINE_BUND27_L_PF_M_0.5	0.50	241.20	279.90	353.90
	IS27_GASOLINE_BUND27_L_PF_M_0.03	0.03	421.30	459.90	538.10
28	IS28_GASOLINE_BUND28_L_PF_M_1	1.00	111.50	140.00	167.60
	IS28_GASOLINE_BUND28_L_PF_M_0.5	0.50	174.60	212.00	261.90
	IS28_GASOLINE_BUND28_L_PF_M_0.03	0.03	310.90	353.50	394.80
29	IS29_GASOLINE_BUND29_L_PF_M_1	1.00	176.20	216.80	248.30
	IS29_GASOLINE_BUND29_L_PF_M_0.5	0.50	262.10	302.60	383.10

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS29_GASOLINE_BUND29_L_PF_M_0.03	0.03	460.20	500.70	577.70
30	IS30_GASOLINE_BUND30_L_PF_M_1	1.00	178.60	219.40	251.30
	IS30_GASOLINE_BUND30_L_PF_M_0.5	0.50	265.10	305.90	387.40
	IS30_GASOLINE_BUND30_L_PF_M_0.03	0.03	465.90	506.70	583.30
31	IS31_CRUDE_BUND31_L_PF_M_1	1.00	0.00	0.00	0.00
	IS31_CRUDE_BUND31_L_PF_M_0.5	0.50	129.90	150.70	186.80
	IS31_CRUDE_BUND31_L_PF_M_0.03	0.03	220.20	245.00	312.40
32	IS32_CRUDE_BUND32_L_PF_M_1	1.00	0.00	0.00	0.00
	IS32_CRUDE_BUND32_L_PF_M_0.5	0.50	139.90	165.30	196.90
	IS32_CRUDE_BUND32_L_PF_M_0.03	0.03	235.30	260.80	329.20
33	IS33_CRUDE_BUND33_L_PF_M_1	1.00	0.00	0.00	0.00
	IS33_CRUDE_BUND33_L_PF_M_0.5	0.50	74.30	95.40	121.70
	IS33_CRUDE_BUND33_L_PF_M_0.03	0.03	131.70	170.70	200.10
34	IS34_CRUDE_BUND34_L_PF_M_1	1.00	0.00	0.00	0.00
	IS34_CRUDE_BUND34_L_PF_M_0.5	0.50	78.40	99.80	127.50
	IS34_CRUDE_BUND34_L_PF_M_0.03	0.03	138.70	176.80	210.20
35	IS35_CRUDE_BUND35_L_PF_M_1	1.00	0.00	0.00	0.00
	IS35_CRUDE_BUND35_L_PF_M_0.5	0.50	108.90	131.90	164.20
	IS35_CRUDE_BUND35_L_PF_M_0.03	0.03	187.70	210.60	274.10
36	IS36_CRUDE_BUND36_L_PF_M_1	1.00	0.00	0.00	0.00
	IS36_CRUDE_BUND36_L_PF_M_0.5	0.50	170.80	198.00	227.60
	IS36_CRUDE_BUND36_L_PF_M_0.03	0.03	281.50	308.70	376.70

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
37	IS37_CRUDE_BUND37_L_PF_M_1	1.00	0.00	0.00	0.00
	IS37_CRUDE_BUND37_L_PF_M_0.5	0.50	195.80	223.90	256.30
	IS37_CRUDE_BUND37_L_PF_M_0.03	0.03	317.90	346.10	416.60
38	IS38_CRUDE_BUND38_L_PF_M_1	1.00	0.00	0.00	0.00
	IS38_CRUDE_BUND38_L_PF_M_0.5	0.50	97.70	120.80	151.50
	IS38_CRUDE_BUND38_L_PF_M_0.03	0.03	170.10	199.40	252.10
39	IS39_CRUDE_BUND39_L_PF_M_1	1.00	0.00	0.00	0.00
	IS39_CRUDE_BUND39_L_PF_M_0.5	0.50	97.70	120.80	151.50
	IS39_CRUDE_BUND39_L_PF_M_0.03	0.03	170.10	199.40	252.10
40	IS40_CRUDE_LOADARM1_L_PF_M_1	1.00	14.00	19.70	22.50
	IS40_CRUDE_LOADARM1_L_PF_M_0.5	0.50	22.40	35.20	38.80
	IS40_CRUDE_LOADARM1_L_PF_M_0.03	0.03	40.90	52.90	53.60
41	IS41_CRUDE_LOADARM3_L_PF_M_1	1.00	14.00	19.70	22.50
	IS41_CRUDE_LOADARM3_L_PF_M_0.5	0.50	22.40	35.20	38.80
	IS41_CRUDE_LOADARM3_L_PF_M_0.03	0.03	40.90	52.90	53.60
42	IS42_GASOLINE_LOADARM1_L_PF_M_1	1.00	16.60	27.30	31.80
	IS42_GASOLINE_LOADARM1_L_PF_M_0.5	0.50	29.50	41.50	44.30
	IS42_GASOLINE_LOADARM1_L_PF_M_0.03	0.03	53.10	61.60	62.70
43	IS43_CRUDE_PIPELINE1_L_PF_M_1	1.00	10.90	17.30	20.40
	IS43_CRUDE_PIPELINE1_L_PF_M_0.5	0.50	18.30	28.60	30.90
	IS43_CRUDE_PIPELINE1_L_PF_M_0.03	0.03	35.40	42.60	43.40
44	IS44_CRUDE_PIPELINE2_L_PF_M_1	1.00	10.90	17.30	20.40

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS44_CRUDE_PIPELINE2_L_PF_M_0.5	0.50	18.30	28.60	30.90
	IS44_CRUDE_PIPELINE2_L_PF_M_0.03	0.03	35.40	42.60	43.40
45	IS45_CRUDE_PIPELINE3_L_PF_M_1	1.00	10.90	17.30	20.40
	IS45_CRUDE_PIPELINE3_L_PF_M_0.5	0.50	18.30	28.60	30.90
	IS45_CRUDE_PIPELINE3_L_PF_M_0.03	0.03	35.40	42.60	43.40
46	IS46_GASOLINE_PIPELINE1_L_PF_M_1	1.00	11.50	20.00	23.50
	IS46_GASOLINE_PIPELINE1_L_PF_M_0.5	0.50	20.90	28.20	29.80
	IS46_GASOLINE_PIPELINE1_L_PF_M_0.03	0.03	36.10	41.00	41.90
47	IS47_GASOLINE_PIPELINE2_L_PF_M_1	1.00	11.50	20.00	23.50
	IS47_GASOLINE_PIPELINE2_L_PF_M_0.5	0.50	20.90	28.20	29.80
	IS47_GASOLINE_PIPELINE2_L_PF_M_0.03	0.03	36.10	41.00	41.90
48	IS48_GASOLINE_PIPELINE3_L_PF_M_1	1.00	11.50	20.00	23.50
	IS48_GASOLINE_PIPELINE3_L_PF_M_0.5	0.50	20.90	28.20	29.80
	IS48_GASOLINE_PIPELINE3_L_PF_M_0.03	0.03	36.10	41.00	41.90

Pool Fire Large – 100mm hole diameter

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
1	IS01_CRUDE_BUND1.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS01_CRUDE_BUND1.1_L_PF_L_0.5	0.50	165.80	192.80	221.90
	IS01_CRUDE_BUND1.1_L_PF_L_0.03	0.03	274.20	301.10	369.50
2	IS02_GASOLINE_BUND2_L_PF_L_1	1.00	98.60	124.60	151.20
	IS02_GASOLINE_BUND2_L_PF_L_0.5	0.50	155.90	194.80	237.20
	IS02_GASOLINE_BUND2_L_PF_L_0.03	0.03	280.00	325.10	352.50
3	IS03_GASOLINE_BUND3.1_L_PF_L_1	1.00	162.70	201.70	231.60
	IS03_GASOLINE_BUND3.1_L_PF_L_0.5	0.50	244.70	283.70	358.90
	IS03_GASOLINE_BUND3.1_L_PF_L_0.03	0.03	427.80	466.80	544.90
4	IS04_GASOLINE_BUND4_L_PF_L_1	1.00	162.70	201.70	231.60
	IS04_GASOLINE_BUND4_L_PF_L_0.5	0.50	244.70	283.70	358.90
	IS04_GASOLINE_BUND4_L_PF_L_0.03	0.03	427.80	466.80	544.90
5	IS05_CRUDE_BUND5.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS05_CRUDE_BUND5.1_L_PF_L_0.5	0.50	164.70	191.50	220.80
	IS05_CRUDE_BUND5.1_L_PF_L_0.03	0.03	272.50	299.30	367.80
6	IS06_CRUDE_BUND6.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS06_CRUDE_BUND6.1_L_PF_L_0.5	0.50	164.70	191.50	220.80
	IS06_CRUDE_BUND6.1_L_PF_L_0.03	0.03	272.50	299.30	367.80
7	IS07_CRUDE_BUND7_L_PF_L_1	1.00	0.00	0.00	0.00
	IS07_CRUDE_BUND7_L_PF_L_0.5	0.50	143.60	169.30	200.60

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS07_CRUDE_BUND7_L_PF_L_0.03	0.03	241.00	266.70	335.40
8	IS08_CRUDE_BUND8_L_PF_L_1	1.00	0.00	0.00	0.00
	IS08_CRUDE_BUND8_L_PF_L_0.5	0.50	179.30	206.80	237.20
	IS08_CRUDE_BUND8_L_PF_L_0.03	0.03	293.90	321.50	388.30
9	IS09_CRUDE_BUND9.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS09_CRUDE_BUND9.1_L_PF_L_0.5	0.50	175.80	203.20	233.30
	IS09_CRUDE_BUND9.1_L_PF_L_0.03	0.03	288.90	316.30	383.60
10	IS10_CRUDE_BUND10.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS10_CRUDE_BUND10.1_L_PF_L_0.5	0.50	182.00	209.60	240.40
	IS10_CRUDE_BUND10.1_L_PF_L_0.03	0.03	297.90	325.50	391.90
11	IS11_CRUDE_BUND11.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS11_CRUDE_BUND11.1_L_PF_L_0.5	0.50	178.90	206.40	236.90
	IS11_CRUDE_BUND11.1_L_PF_L_0.03	0.03	293.40	320.90	387.80
12	IS12_CRUDE_BUND12_L_PF_L_1	1.00	0.00	0.00	0.00
	IS12_CRUDE_BUND12_L_PF_L_0.5	0.50	195.80	223.90	256.30
	IS12_CRUDE_BUND12_L_PF_L_0.03	0.03	317.90	346.10	416.60
13	IS13_GASOLINE_BUND13_L_PF_L_1	1.00	199.00	242.00	276.30
	IS13_GASOLINE_BUND13_L_PF_L_0.5	0.50	290.80	333.70	423.00
	IS13_GASOLINE_BUND13_L_PF_L_0.03	0.03	514.10	557.10	629.90
14	IS14_GASOLINE_BUND14_L_PF_L_1	1.00	199.00	242.00	276.30
	IS14_GASOLINE_BUND14_L_PF_L_0.5	0.50	290.80	333.70	423.00
	IS14_GASOLINE_BUND14_L_PF_L_0.03	0.03	514.10	557.10	629.90

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
15	IS15_GASOLINE_BUND15_L_PF_L_1	1.00	162.70	201.70	231.60
	IS15_GASOLINE_BUND15_L_PF_L_0.5	0.50	244.70	283.70	358.90
	IS15_GASOLINE_BUND15_L_PF_L_0.03	0.03	427.80	466.80	554.90
16	IS16_GASOLINE_BUND16_L_PF_L_1	1.00	162.70	201.70	231.60
	IS16_GASOLINE_BUND16_L_PF_L_0.5	0.50	244.70	283.70	358.90
	IS16_GASOLINE_BUND16_L_PF_L_0.03	0.03	427.80	466.80	554.90
17	IS17_CRUDE_BUND17.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS17_CRUDE_BUND17.1_L_PF_L_0.5	0.50	164.70	191.50	220.80
	IS17_CRUDE_BUND17.1_L_PF_L_0.03	0.03	272.50	299.30	367.80
18	IS18_CRUDE_BUND18_L_PF_L_1	1.00	0.00	0.00	0.00
	IS18_CRUDE_BUND18_L_PF_L_0.5	0.50	164.70	191.50	220.80
	IS18_CRUDE_BUND18_L_PF_L_0.03	0.03	272.50	299.30	367.80
19	IS19_CRUDE_BUND19_L_PF_L_1	1.00	0.00	0.00	0.00
	IS19_CRUDE_BUND19_L_PF_L_0.5	0.50	143.20	168.90	200.20
	IS19_CRUDE_BUND19_L_PF_L_0.03	0.03	240.40	266.10	334.70
20	IS20_CRUDE_BUND20_L_PF_L_1	1.00	0.00	0.00	0.00
	IS20_CRUDE_BUND20_L_PF_L_0.5	0.50	165.90	192.90	221.90
	IS20_CRUDE_BUND20_L_PF_L_0.03	0.03	274.30	301.20	369.60
21	IS21_CRUDE_BUND21_L_PF_L_1	1.00	0.00	0.00	0.00
	IS21_CRUDE_BUND21_L_PF_L_0.5	0.50	195.80	223.90	256.30
	IS21_CRUDE_BUND21_L_PF_L_0.03	0.03	317.90	346.10	416.60
22	IS22_CRUDE_BUND22_L_PF_L_1	1.00	0.00	0.00	0.00

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS22_CRUDE_BUND22_L_PF_L_0.5	0.50	101.00	124.00	155.30
	IS22_CRUDE_BUND22_L_PF_L_0.03	0.03	175.20	202.80	258.60
23	IS23_CRUDE_BUND23.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS23_CRUDE_BUND23.1_L_PF_L_0.5	0.50	195.80	223.90	256.30
	IS23_CRUDE_BUND23.1_L_PF_L_0.03	0.03	317.90	346.10	416.60
24	IS24_CRUDE_BUND24.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS24_CRUDE_BUND24.1_L_PF_L_0.5	0.50	168.30	195.30	224.60
	IS24_CRUDE_BUND24.1_L_PF_L_0.03	0.03	277.80	307.80	373.00
25	IS25_CRUDE_BUND25.1_L_PF_L_1	1.00	0.00	0.00	0.00
	IS25_CRUDE_BUND25.1_L_PF_L_0.5	0.50	158.40	185.00	215.00
	IS25_CRUDE_BUND25.1_L_PF_L_0.03	0.03	263.20	289.80	358.60
26	IS26_GASOLINE_BUND26.1_L_PF_L_1	1.00	103.50	130.50	157.50
	IS26_GASOLINE_BUND26.1_L_PF_L_0.5	0.50	163.10	202.10	246.90
	IS26_GASOLINE_BUND26.1_L_PF_L_0.03	0.03	292.00	337.20	368.90
27	IS27_GASOLINE_BUND27_L_PF_L_1	1.00	160.00	198.70	228.20
	IS27_GASOLINE_BUND27_L_PF_L_0.5	0.50	241.20	279.90	353.90
	IS27_GASOLINE_BUND27_L_PF_L_0.03	0.03	421.30	459.90	538.10
28	IS28_GASOLINE_BUND28_L_PF_L_1	1.00	111.50	140.00	167.60
	IS28_GASOLINE_BUND28_L_PF_L_0.5	0.50	174.60	212.00	261.90
	IS28_GASOLINE_BUND28_L_PF_L_0.03	0.03	310.90	353.50	394.80
29	IS29_GASOLINE_BUND29_L_PF_L_1	1.00	176.20	216.80	248.30
	IS29_GASOLINE_BUND29_L_PF_L_0.5	0.50	262.10	302.60	383.10

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS29_GASOLINE_BUND29_L_PF_L_0.03	0.03	460.20	500.70	577.70
30	IS30_GASOLINE_BUND30_L_PF_L_1	1.00	178.60	219.40	251.30
	IS30_GASOLINE_BUND30_L_PF_L_0.5	0.50	265.10	305.90	387.40
	IS30_GASOLINE_BUND30_L_PF_L_0.03	0.03	465.90	506.70	583.30
31	IS31_CRUDE_BUND31_L_PF_L_1	1.00	0.00	0.00	0.00
	IS31_CRUDE_BUND31_L_PF_L_0.5	0.50	129.90	150.70	186.80
	IS31_CRUDE_BUND31_L_PF_L_0.03	0.03	220.20	245.00	312.40
32	IS32_CRUDE_BUND32_L_PF_L_1	1.00	0.00	0.00	0.00
	IS32_CRUDE_BUND32_L_PF_L_0.5	0.50	139.90	165.30	196.90
	IS32_CRUDE_BUND32_L_PF_L_0.03	0.03	235.30	260.80	329.20
33	IS33_CRUDE_BUND33_L_PF_L_1	1.00	0.00	0.00	0.00
	IS33_CRUDE_BUND33_L_PF_L_0.5	0.50	74.30	95.40	121.70
	IS33_CRUDE_BUND33_L_PF_L_0.03	0.03	131.70	170.70	200.10
34	IS34_CRUDE_BUND34_L_PF_L_1	1.00	0.00	0.00	0.00
	IS34_CRUDE_BUND34_L_PF_L_0.5	0.50	78.40	99.80	127.50
	IS34_CRUDE_BUND34_L_PF_L_0.03	0.03	138.70	176.80	210.20
35	IS35_CRUDE_BUND35_L_PF_L_1	1.00	0.00	0.00	0.00
	IS35_CRUDE_BUND35_L_PF_L_0.5	0.50	108.90	131.90	164.20
	IS35_CRUDE_BUND35_L_PF_L_0.03	0.03	187.70	210.60	274.10
36	IS36_CRUDE_BUND36_L_PF_L_1	1.00	0.00	0.00	0.00
	IS36_CRUDE_BUND36_L_PF_L_0.5	0.50	170.80	198.00	227.60
	IS36_CRUDE_BUND36_L_PF_L_0.03	0.03	281.50	308.70	376.70

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
37	IS37_CRUDE_BUND37_L_PF_L_1	1.00	0.00	0.00	0.00
	IS37_CRUDE_BUND37_L_PF_L_0.5	0.50	195.80	223.90	256.30
	IS37_CRUDE_BUND37_L_PF_L_0.03	0.03	317.90	346.10	416.60
38	IS38_CRUDE_BUND38_L_PF_L_1	1.00	0.00	0.00	0.00
	IS38_CRUDE_BUND38_L_PF_L_0.5	0.50	97.70	120.80	151.50
	IS38_CRUDE_BUND38_L_PF_L_0.03	0.03	170.10	199.40	252.10
39	IS39_CRUDE_BUND39_L_PF_L_1	1.00	0.00	0.00	0.00
	IS39_CRUDE_BUND39_L_PF_L_0.5	0.50	97.70	120.80	151.50
	IS39_CRUDE_BUND39_L_PF_L_0.03	0.03	170.10	199.40	252.10

Pool Fire Catastrophic - Rupture

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
40	IS40_CRUDE_LOADARM1_L_PF_C_1	1.00	40.00	40.00	40.00
	IS40_CRUDE_LOADARM1_L_PF_C_0.5	0.50	56.90	79.60	97.90
	IS40_CRUDE_LOADARM1_L_PF_C_0.03	0.03	103.30	139.10	155.80
41	IS41_CRUDE_LOADARM3_L_PF_C_1	1.00	40.00	40.00	40.00
	IS41_CRUDE_LOADARM3_L_PF_C_0.5	0.50	56.90	79.60	97.90
	IS41_CRUDE_LOADARM3_L_PF_C_0.03	0.03	103.30	139.10	155.80
42	IS42_GASOLINE_LOADARM1_L_PF_C_1	1.00	51.90	72.70	88.10
	IS42_GASOLINE_LOADARM1_L_PF_C_0.5	0.50	86.00	119.30	134.60

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS42_GASOLINE_LOADARM1_L_PF_C_0.03	0.03	157.00	182.20	189.30
43	IS43_CRUDE_PIPELINE1_L_PF_C_1	1.00	40.00	40.00	40.00
	IS43_CRUDE_PIPELINE1_L_PF_C_0.5	0.50	55.30	77.80	95.80
	IS43_CRUDE_PIPELINE1_L_PF_C_0.03	0.03	101.10	135.90	151.60
44	IS44_CRUDE_PIPELINE2_L_PF_C_1	1.00	40.00	40.00	40.00
	IS44_CRUDE_PIPELINE2_L_PF_C_0.5	0.50	59.40	82.70	101.20
	IS44_CRUDE_PIPELINE2_L_PF_C_0.03	0.03	106.60	144.10	162.20
45	IS45_CRUDE_PIPELINE3_L_PF_C_1	1.00	40.00	40.00	40.00
	IS45_CRUDE_PIPELINE3_L_PF_C_0.5	0.50	58.20	81.40	99.60
	IS45_CRUDE_PIPELINE3_L_PF_C_0.03	0.03	105.00	141.70	159.10
46	IS46_GASOLINE_PIPELINE1_L_PF_C_1	1.00	28.20	44.20	53.00
	IS46_GASOLINE_PIPELINE1_L_PF_C_0.5	0.50	49.70	68.70	76.70
	IS46_GASOLINE_PIPELINE1_L_PF_C_0.03	0.03	85.90	105.90	107.10
47	IS47_GASOLINE_PIPELINE2_L_PF_C_1	1.00	29.90	46.60	56.20
	IS47_GASOLINE_PIPELINE2_L_PF_C_0.5	0.50	52.50	73.30	80.80
	IS47_GASOLINE_PIPELINE2_L_PF_C_0.03	0.03	92.20	112.40	113.70
48	IS48_GASOLINE_PIPELINE3_L_PF_C_1	1.00	29.40	45.90	55.20
	IS48_GASOLINE_PIPELINE3_L_PF_C_0.5	0.50	51.70	71.90	79.60
	IS48_GASOLINE_PIPELINE3_L_PF_C_0.03	0.03	90.30	111.50	111.70

Jet Fire Small – 15mm hole diameter

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
40	IS40_CRUDE_LOADARM1_L_JF_S_1	1.00	18.30	16.80	15.90
	IS40_CRUDE_LOADARM1_L_JF_S_0.5	0.50	19.50	18.00	17.50
	IS40_CRUDE_LOADARM1_L_JF_S_0.03	0.03	23.50	22.50	21.70
41	IS41_CRUDE_LOADARM3_L_JF_S_1	1.00	18.30	16.80	15.90
	IS41_CRUDE_LOADARM3_L_JF_S_0.5	0.50	19.50	18.00	17.50
	IS41_CRUDE_LOADARM3_L_JF_S_0.03	0.03	23.50	22.50	21.70
42	IS42_GASOLINE_LOADARM1_L_JF_S_1	1.00	16.90	15.60	14.70
	IS42_GASOLINE_LOADARM1_L_JF_S_0.5	0.50	19.30	17.90	17.10
	IS42_GASOLINE_LOADARM1_L_JF_S_0.03	0.03	23.30	22.30	21.60
43	IS43_CRUDE_PIPELINE1_L_JF_S_1	1.00	13.80	12.80	11.60
	IS43_CRUDE_PIPELINE1_L_JF_S_0.5	0.50	15.10	14.30	13.80
	IS43_CRUDE_PIPELINE1_L_JF_S_0.03	0.03	18.60	17.70	16.90
44	IS44_CRUDE_PIPELINE2_L_JF_S_1	1.00	13.80	12.80	11.60
	IS44_CRUDE_PIPELINE2_L_JF_S_0.5	0.50	15.10	14.30	13.80
	IS44_CRUDE_PIPELINE2_L_JF_S_0.03	0.03	18.60	17.70	16.90
45	IS45_CRUDE_PIPELINE3_L_JF_S_1	1.00	13.80	12.80	11.60
	IS45_CRUDE_PIPELINE3_L_JF_S_0.5	0.50	15.10	14.30	13.80
	IS45_CRUDE_PIPELINE3_L_JF_S_0.03	0.03	18.60	17.70	16.90
46	IS46_GASOLINE_PIPELINE1_L_JF_S_1	1.00	10.00	9.70	8.90
	IS46_GASOLINE_PIPELINE1_L_JF_S_0.5	0.50	12.40	11.60	11.20

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS46_GASOLINE_PIPELINE1_L_JF_S_0.03	0.03	15.40	14.40	13.90
47	IS47_GASOLINE_PIPELINE2_L_JF_S_1	1.00	10.00	9.70	8.90
	IS47_GASOLINE_PIPELINE2_L_JF_S_0.5	0.50	12.40	11.60	11.20
	IS47_GASOLINE_PIPELINE2_L_JF_S_0.03	0.03	15.40	14.40	13.90
48	IS48_GASOLINE_PIPELINE3_L_JF_S_1	1.00	10.00	9.70	8.90
	IS48_GASOLINE_PIPELINE3_L_JF_S_0.5	0.50	12.40	11.60	11.20
	IS48_GASOLINE_PIPELINE3_L_JF_S_0.03	0.03	15.40	14.40	13.90

Jet Fire Medium – 50mm hole diameter

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
40	IS40_CRUDE_LOADARM1_L_JF_M_1	1.00	52.40	47.80	46.10
	IS40_CRUDE_LOADARM1_L_JF_M_0.5	0.50	58.60	54.80	51.60
	IS40_CRUDE_LOADARM1_L_JF_M_0.03	0.03	70.80	68.00	66.20
41	IS41_CRUDE_LOADARM3_L_JF_M_1	1.00	52.40	47.80	46.10
	IS41_CRUDE_LOADARM3_L_JF_M_0.5	0.50	58.60	54.80	51.60
	IS41_CRUDE_LOADARM3_L_JF_M_0.03	0.03	70.80	68.00	66.20
42	IS42_GASOLINE_LOADARM1_L_JF_M_1	1.00	52.10	47.40	45.80
	IS42_GASOLINE_LOADARM1_L_JF_M_0.5	0.50	58.60	54.70	51.60
	IS42_GASOLINE_LOADARM1_L_JF_M_0.03	0.03	70.70	67.90	66.10
43	IS43_CRUDE_PIPELINE1_L_JF_M_1	1.00	41.30	38.10	33.90
	IS43_CRUDE_PIPELINE1_L_JF_M_0.5	0.50	43.90	41.60	40.10
	IS43_CRUDE_PIPELINE1_L_JF_M_0.03	0.03	54.30	51.90	50.20
44	IS44_CRUDE_PIPELINE2_L_JF_M_1	1.00	41.30	38.10	33.90
	IS44_CRUDE_PIPELINE2_L_JF_M_0.5	0.50	43.90	41.60	40.10
	IS44_CRUDE_PIPELINE2_L_JF_M_0.03	0.03	54.30	51.90	50.20
45	IS45_CRUDE_PIPELINE3_L_JF_M_1	1.00	41.30	38.10	33.90
	IS45_CRUDE_PIPELINE3_L_JF_M_0.5	0.50	43.90	41.60	40.10
	IS45_CRUDE_PIPELINE3_L_JF_M_0.03	0.03	54.30	51.90	50.20
46	IS46_GASOLINE_PIPELINE1_L_JF_M_1	1.00	36.60	34.10	30.40
	IS46_GASOLINE_PIPELINE1_L_JF_M_0.5	0.50	39.90	37.00	36.20

Ref.	Scenarios	Fatality Probability	Weather Condition 1F	Weather Condition 3C	Weather Condition 5D
			Downwind Distance	Downwind Distance	Downwind Distance
	IS46_GASOLINE_PIPELINE1_L_JF_M_0.03	0.03	48.40	46.40	44.40
47	IS47_GASOLINE_PIPELINE2_L_JF_M_1	1.00	36.60	34.10	30.40
	IS47_GASOLINE_PIPELINE2_L_JF_M_0.5	0.50	39.90	37.00	36.20
	IS47_GASOLINE_PIPELINE2_L_JF_M_0.03	0.03	48.40	46.40	44.40
48	IS48_GASOLINE_PIPELINE3_L_JF_M_1	1.00	36.60	34.10	30.40
	IS48_GASOLINE_PIPELINE3_L_JF_M_0.5	0.50	39.90	37.00	36.20
	IS48_GASOLINE_PIPELINE3_L_JF_M_0.03	0.03	48.40	46.40	44.40

APPENDIX 1-B

FAILURE FREQUENCIES

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
1	IS01_CRUDE_BUND1.1_L	Small	Pool Fire	6.60E-05	Pool Fire	6.60E-05	1.32E-04
		Medium	Pool Fire	3.88E-05	Pool Fire	3.88E-05	7.75E-05
		Large	Pool Fire	1.40E-05	Pool Fire	9.36E-06	2.34E-05
2	IS02_GASOLINE_BUND2_L	Small	Pool Fire	1.65E-05	Pool Fire	1.65E-05	3.30E-05
		Medium	Pool Fire	9.69E-06	Pool Fire	9.69E-06	1.94E-05
		Large	Pool Fire	3.51E-06	Pool Fire	2.34E-06	5.85E-06
3	IS03_GASOLINE_BUND3.1_L	Small	Pool Fire	8.25E-05	Pool Fire	8.25E-05	1.65E-04
		Medium	Pool Fire	4.85E-05	Pool Fire	4.85E-05	9.69E-05
		Large	Pool Fire	1.75E-05	Pool Fire	1.17E-05	2.92E-05
4	IS04_GASOLINE_BUND4_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
5	IS05_CRUDE_BUND5.1_L	Small	Pool Fire	8.25E-05	Pool Fire	8.25E-05	1.65E-04
		Medium	Pool Fire	4.85E-05	Pool Fire	4.85E-05	9.69E-05
		Large	Pool Fire	1.75E-05	Pool Fire	1.17E-05	2.92E-05
6	IS06_CRUDE_BUND6.1_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
7	IS07_CRUDE_BUND7_L	Small	Pool Fire	1.65E-05	Pool Fire	1.65E-05	3.30E-05
		Medium	Pool Fire	9.69E-06	Pool Fire	9.69E-06	1.94E-05
		Large	Pool Fire	3.51E-06	Pool Fire	2.34E-06	5.85E-06
8	IS08_CRUDE_BUND8_L	Small	Pool Fire	1.65E-04	Pool Fire	1.65E-04	3.30E-04
		Medium	Pool Fire	9.69E-05	Pool Fire	9.69E-05	1.94E-04
		Large	Pool Fire	3.51E-05	Pool Fire	2.34E-05	5.85E-05
9	IS09_CRUDE_BUND9.1_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
10	IS10_CRUDE_BUND10.1_L	Small	Pool Fire	6.60E-05	Pool Fire	6.60E-05	1.32E-04
		Medium	Pool Fire	3.88E-05	Pool Fire	3.88E-05	7.75E-05
		Large	Pool Fire	1.40E-05	Pool Fire	9.36E-06	2.34E-05
11	IS11_CRUDE_BUND11.1_L	Small	Pool Fire	1.32E-04	Pool Fire	1.32E-04	2.64E-04
		Medium	Pool Fire	7.75E-05	Pool Fire	7.75E-05	1.55E-04
		Large	Pool Fire	2.81E-05	Pool Fire	1.87E-05	4.68E-05
12	IS12_CRUDE_BUND12_L	Small	Pool Fire	1.65E-04	Pool Fire	1.65E-04	3.30E-04

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
		Medium	Pool Fire	9.69E-05	Pool Fire	9.69E-05	1.94E-04
		Large	Pool Fire	3.51E-05	Pool Fire	2.34E-05	5.85E-05
13	IS13_GASOLINE_BUND13_L	Small	Pool Fire	1.65E-04	Pool Fire	1.65E-04	3.30E-04
		Medium	Pool Fire	9.69E-05	Pool Fire	9.69E-05	1.94E-04
		Large	Pool Fire	3.51E-05	Pool Fire	2.34E-05	5.85E-05
14	IS14_GASOLINE_BUND14_L	Small	Pool Fire	2.31E-04	Pool Fire	2.31E-04	4.62E-04
		Medium	Pool Fire	1.36E-04	Pool Fire	1.36E-04	2.71E-04
		Large	Pool Fire	4.91E-05	Pool Fire	3.27E-05	8.19E-05
15	IS15_GASOLINE_BUND15_L	Small	Pool Fire	6.60E-05	Pool Fire	6.60E-05	1.32E-04
		Medium	Pool Fire	3.88E-05	Pool Fire	3.88E-05	7.75E-05
		Large	Pool Fire	1.40E-05	Pool Fire	9.36E-06	2.34E-05
16	IS16_GASOLINE_BUND16_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
17	IS17_CRUDE_BUND17.1_L	Small	Pool Fire	6.60E-05	Pool Fire	6.60E-05	1.32E-04
		Medium	Pool Fire	3.88E-05	Pool Fire	3.88E-05	7.75E-05
		Large	Pool Fire	1.40E-05	Pool Fire	9.36E-06	2.34E-05

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
18	IS18_CRUDE_BUND18_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
19	IS19_CRUDE_BUND19_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
20	IS20_CRUDE_BUND20_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
21	IS21_CRUDE_BUND21_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
22	IS22_CRUDE_BUND22_L	Small	Pool Fire	8.25E-05	Pool Fire	8.25E-05	1.65E-04
		Medium	Pool Fire	4.85E-05	Pool Fire	4.85E-05	9.69E-05
		Large	Pool Fire	1.75E-05	Pool Fire	1.17E-05	2.92E-05
23	IS23_CRUDE_BUND23.1_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
24	IS24_CRUDE_BUND24.1_L	Small	Pool Fire	1.32E-04	Pool Fire	1.32E-04	2.64E-04
		Medium	Pool Fire	7.75E-05	Pool Fire	7.75E-05	1.55E-04
		Large	Pool Fire	2.81E-05	Pool Fire	1.87E-05	4.68E-05
25	IS25_CRUDE_BUND25.1_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
26	IS26_GASOLINE_BUND26.1_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
27	IS27_GASOLINE_BUND27_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
28	IS28_GASOLINE_BUND28_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
29	IS29_GASOLINE_BUND29_L	Small	Pool Fire	6.60E-05	Pool Fire	6.60E-05	1.32E-04

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
		Medium	Pool Fire	3.88E-05	Pool Fire	3.88E-05	7.75E-05
		Large	Pool Fire	1.40E-05	Pool Fire	9.36E-06	2.34E-05
30	IS30_GASOLINE_BUND30_L	Small	Pool Fire	8.25E-05	Pool Fire	8.25E-05	1.65E-04
		Medium	Pool Fire	4.85E-05	Pool Fire	4.85E-05	9.69E-05
		Large	Pool Fire	1.75E-05	Pool Fire	1.17E-05	2.92E-05
31	IS31_CRUDE_BUND31_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
32	IS32_CRUDE_BUND32_L	Small	Pool Fire	9.90E-05	Pool Fire	9.90E-05	1.98E-04
		Medium	Pool Fire	5.81E-05	Pool Fire	5.81E-05	1.16E-04
		Large	Pool Fire	2.11E-05	Pool Fire	1.40E-05	3.51E-05
33	IS33_CRUDE_BUND33_L	Small	Pool Fire	6.60E-05	Pool Fire	6.60E-05	1.32E-04
		Medium	Pool Fire	3.88E-05	Pool Fire	3.88E-05	7.75E-05
		Large	Pool Fire	1.40E-05	Pool Fire	9.36E-06	2.34E-05
34	IS34_CRUDE_BUND34_L	Small	Pool Fire	4.95E-05	Pool Fire	4.95E-05	9.90E-05
		Medium	Pool Fire	2.91E-05	Pool Fire	2.91E-05	5.81E-05
		Large	Pool Fire	1.05E-05	Pool Fire	7.02E-06	1.75E-05

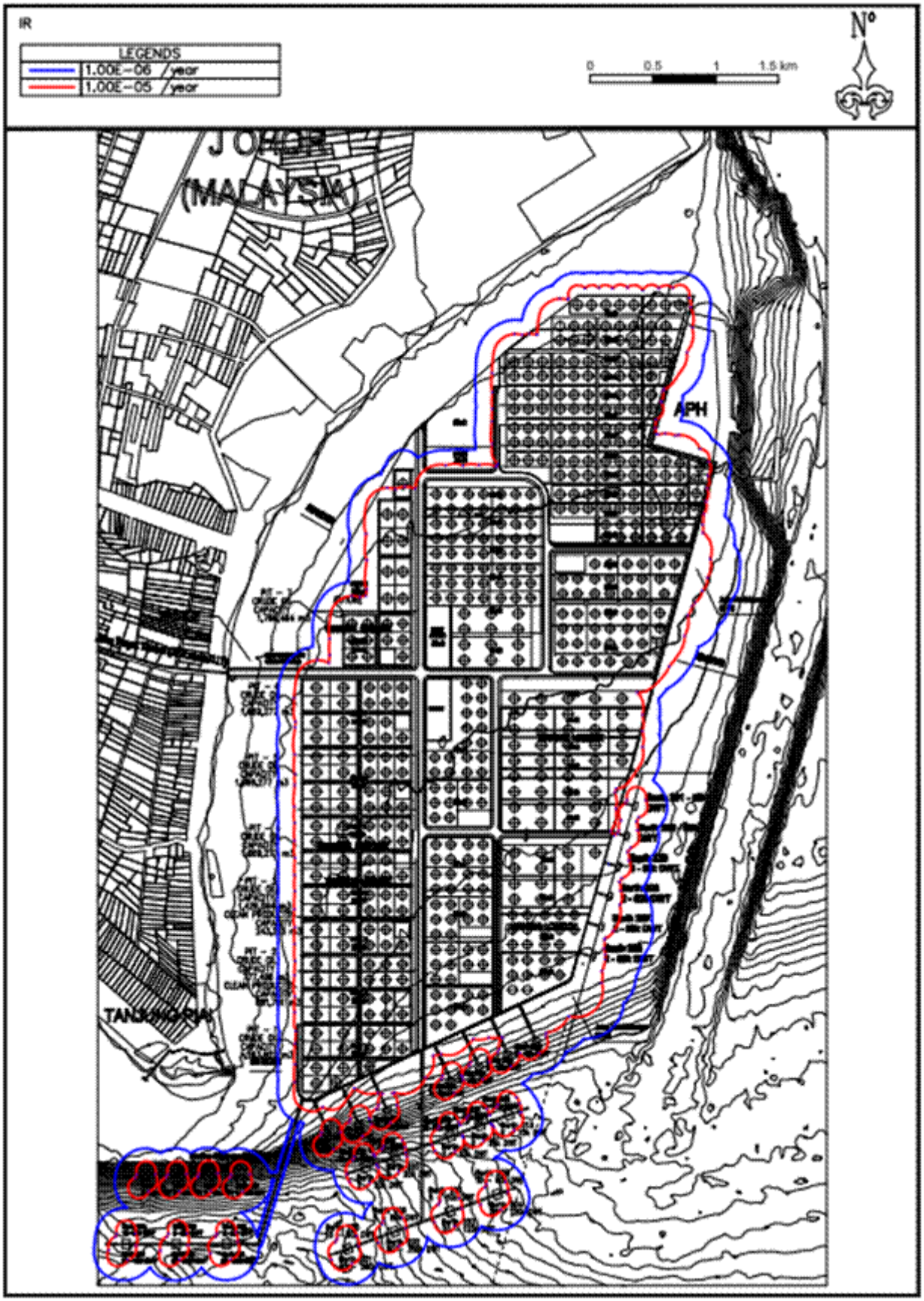
No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
35	IS35_CRUDE_BUND35_L	Small	Pool Fire	3.30E-05	Pool Fire	3.30E-05	6.60E-05
		Medium	Pool Fire	1.94E-05	Pool Fire	1.94E-05	3.88E-05
		Large	Pool Fire	7.02E-06	Pool Fire	4.68E-06	1.17E-05
36	IS36_CRUDE_BUND36_L	Small	Pool Fire	4.95E-05	Pool Fire	4.95E-05	9.90E-05
		Medium	Pool Fire	2.91E-05	Pool Fire	2.91E-05	5.81E-05
		Large	Pool Fire	1.05E-05	Pool Fire	7.02E-06	1.75E-05
37	IS37_CRUDE_BUND37_L	Small	Pool Fire	6.60E-05	Pool Fire	6.60E-05	1.32E-04
		Medium	Pool Fire	3.88E-05	Pool Fire	3.88E-05	7.75E-05
		Large	Pool Fire	1.40E-05	Pool Fire	9.36E-06	2.34E-05
38	IS38_CRUDE_BUND38_L	Small	Pool Fire	8.25E-05	Pool Fire	8.25E-05	1.65E-04
		Medium	Pool Fire	4.85E-05	Pool Fire	4.85E-05	9.69E-05
		Large	Pool Fire	1.75E-05	Pool Fire	1.17E-05	2.92E-05
39	IS39_CRUDE_BUND39_L	Small	Pool Fire	8.25E-05	Pool Fire	8.25E-05	1.65E-04
		Medium	Pool Fire	4.85E-05	Pool Fire	4.85E-05	9.69E-05
		Large	Pool Fire	1.75E-05	Pool Fire	1.17E-05	2.92E-05
40	IS40_CRUDE_LOADARM1_L	Small	Jet Fire	6.61E-05	Pool Fire	5.95E-04	-/-
		Medium	Jet Fire	3.22E-04	Pool Fire	3.22E-04	-/-

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
		Catastrophic	Pool Fire	4.20E-05	Pool Fire	2.80E-05	7.01E-05
41	IS41_CRUDE_LOADARM3_L	Small	Jet Fire	1.98E-04	Pool Fire	1.79E-03	-/-
		Medium	Jet Fire	9.65E-04	Pool Fire	9.65E-04	-/-
		Catastrophic	Pool Fire	1.26E-04	Pool Fire	8.41E-05	2.10E-04
42	IS42_GASOLINE_LOADARM1_L	Small	Jet Fire	6.64E-05	Pool Fire	5.97E-04	-/-
		Medium	Jet Fire	3.19E-04	Pool Fire	3.19E-04	-/-
		Catastrophic	Pool Fire	4.20E-05	Pool Fire	2.80E-05	7.01E-05
43	IS43_CRUDE_PIPELINE1_L	Small	Jet Fire	1.24E-07	Pool Fire	1.12E-06	-/-
		Medium	Jet Fire	1.30E-06	Pool Fire	1.30E-06	-/-
		Catastrophic	Pool Fire	8.80E-07	Pool Fire	5.87E-07	1.47E-06
44	IS44_CRUDE_PIPELINE2_L	Small	Jet Fire	1.15E-07	Pool Fire	1.04E-06	-/-
		Medium	Jet Fire	1.21E-06	Pool Fire	1.21E-06	-/-
		Catastrophic	Pool Fire	8.19E-07	Pool Fire	5.46E-07	1.37E-06
45	IS45_CRUDE_PIPELINE3_L	Small	Jet Fire	1.18E-07	Pool Fire	1.06E-06	-/-
		Medium	Jet Fire	1.23E-06	Pool Fire	1.23E-06	-/-
		Catastrophic	Pool Fire	8.35E-07	Pool Fire	5.57E-07	1.39E-06
46	IS46_GASOLINE_PIPELINE1_L	Small	Jet Fire	1.24E-07	Pool Fire	1.12E-06	-/-

No.	Section ID	Hole Size	Immediate Ignition Event	Immediate Ignition Frequency (Event Frequency / Year)	Delayed Ignition 1 Event	Delayed Ignition 1 Frequency (Event Frequency / Year)	Pool Fire + Pool Fire (Event Frequency / Year)
		Medium	Jet Fire	1.30E-06	Pool Fire	1.30E-06	-/-
		Catastrophic	Pool Fire	2.75E-07	Pool Fire	2.75E-07	5.50E-07
47	IS47_GASOLINE_PIPELINE2_L	Small	Jet Fire	1.15E-07	Pool Fire	1.04E-06	-/-
		Medium	Jet Fire	1.21E-06	Pool Fire	1.21E-06	-/-
		Catastrophic	Pool Fire	8.19E-07	Pool Fire	5.46E-07	1.37E-06
48	IS48_GASOLINE_PIPELINE3_L	Small	Jet Fire	1.18E-07	Pool Fire	1.06E-06	-/-
		Medium	Jet Fire	1.23E-06	Pool Fire	1.23E-06	-/-
		Catastrophic	Pool Fire	8.35E-07	Pool Fire	5.57E-07	1.39E-06

APPENDIX 1-C

INDIVIDUAL RISK (IR) CONTOUR


IR
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1.00E-05 /year
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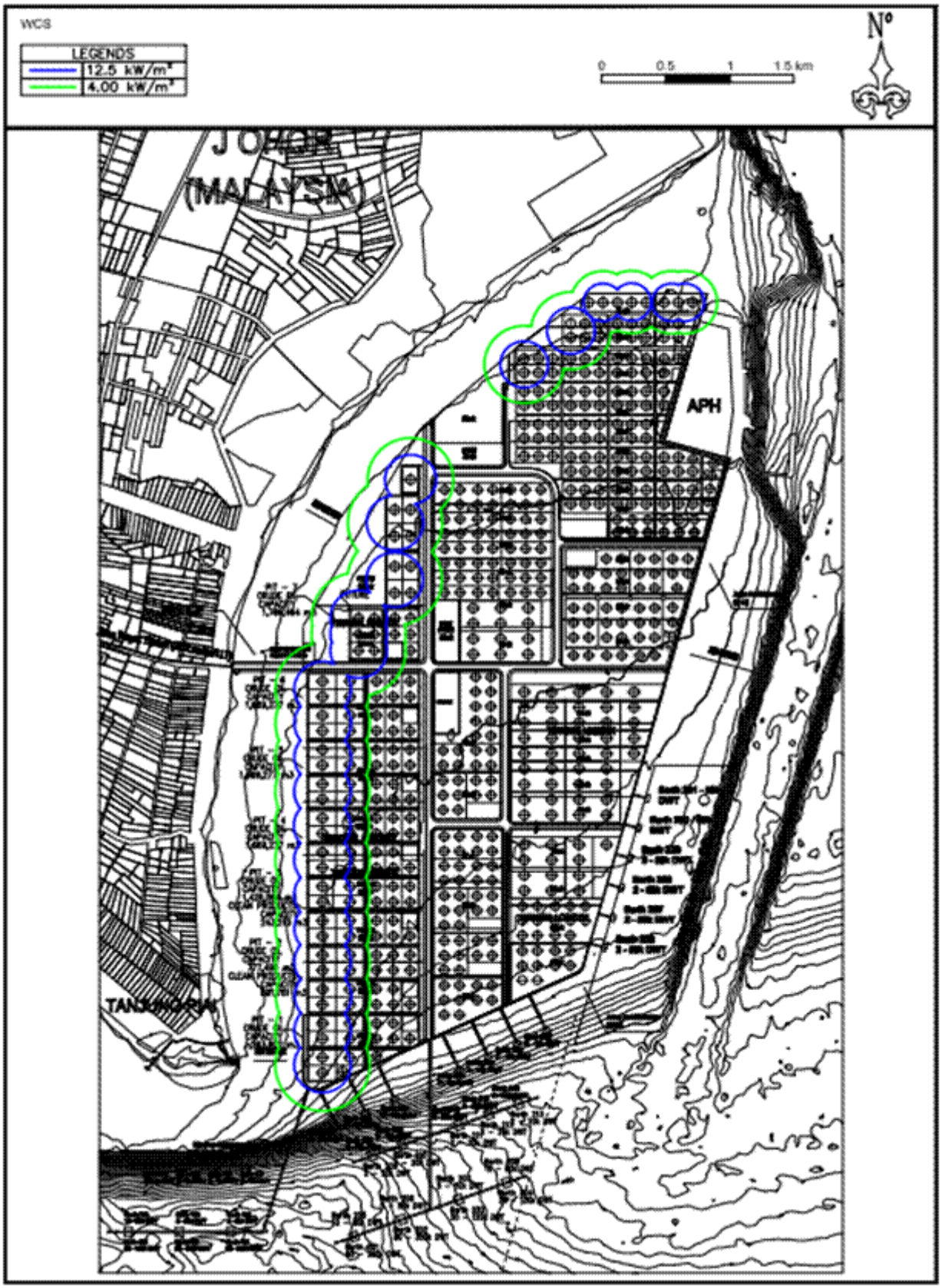
JOHOR
(MALAYSIA)
APH
TANJUNG PIAI

APPENDIX 1-D

WORST CASE SCENARIO AND WORST CASE CREDIBLE SCENARIO

FIRE EVENT

WORST CASE SCENARIO



WORST CASE CREDIBLE SCENARIO