

PRELIMINARY HAZARD ANALYSIS

PORT KEMBLA BULK LIQUIDS TERMINAL

STAGE 3 DEVELOPMENT

TQ HOLDINGS AUSTRALIA PTY LTD

ENVIRONMENTAL IMPACT STATEMENT

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ABBREVIATIONS

AAT	Australian Amalgamated Terminal
ADG	Australian Dangerous Good
API	American Petroleum Institute
AS	Australian Standard
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
DA	Development Application
DG	Dangerous Good
DPE	Department of Planning & Environment
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESD	Emergency Shutdown
FRNSW	Fire and Rescue New South Wales
FSS	Fire Safety Study
HAZID	Hazard Identification
HIPAP	NSW Hazardous Industry Planning Advisory Paper
IBC	Intermediate Bulk Container
IFR	Internal Floating Roof
LFL	Lower Flammability Limit
MHF	Major Hazard Facility
ML	Mega Litres
MLA	Marine Loading Arm
MOC	Management of Change
NSW	New South Wales
OGP	Oil and Gas Producers
NFPA	National Fire Protection Association
PHA	Preliminary Hazard Analysis
PG	Packaging Group
PKBLT	Port Kembla Bulk Liquids Terminal
PKCT	Port Kembla Coal Terminal
QRA	Quantitative Risk Assessment
SCADA	Supervisory Control and Data Acquisition
SEARs	Secretary's Environment Assessment Requirements
SEPP	State Environmental Planning Policy
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SRS	Safety Requirement Specification

UK HSE	United Kingdom Health and Safety Executive
VCA	Vapour Cloud Assessment
VCE	Vapour Cloud Explosion
VRU	Vapour Recovery Unit
WHS	Work Health Safety

1. SUMMARY

1.1. Project Background

TQ Holdings Australia Pty Ltd (TQ Holdings), previously National Terminals Pty Ltd, is planning to develop a bulk liquids terminal within the New South Wales (NSW) Ports precinct at Port Kembla, Australia. The terminal will have a storage capacity of 288 ML which will be used for combustible and flammable liquids. The proposed development will be located in the vicinity of the Port Kembla Coal Terminal (PKCT), GrainCorp Grain Terminal, Quattro Grain Terminal and Australian Amalgamated Terminal (AAT).

The Port Kembla Bulk Liquid Terminal (PKBLT) will be constructed in three stages:

- Stage 1 – includes:
 - Stage 1A (Approved) – refers to aspects of the Stage 1 project scope items that are covered in the existing Development Application (DA) (MP_08_0083).
 - Stage 1B (Balance) – refers to aspects of the Stage 1 project items that are not covered in the approved DA.
- Stage 2 – intermediate terminal capacity (not covered in the approved DA).
- Stage 3 – future capacity (not covered in the approved DA).

The infrastructure and equipment to be constructed under each of the stages are summarised in Table 2.2. The proposed project consists of the three main development stages which have been separated to fast track the commencement of operations.

TQ Holdings has submitted a new DA to cover all stages of the development. In response to the DA, TQ Holdings has received a set of draft and final Secretary Environmental Assessment Requirements (SEARs). The objective of this report is to address the ‘hazard and risk’ component of the SEARs which are:

- Conducting a preliminary risk screening in accordance with State Environmental Planning Policy (SEPP) 33 analysis.
- Conducting a Preliminary Hazard Analysis (PHA) in accordance with *Hazardous Industry Planning Advisory Paper 6* (HIPAP 6) ‘Guidelines for Hazard Analysis’ and Multi-Level Risk Assessment.
- Identify the hazards associated with the existing site and proposed development, as well as any external hazards (ie natural hazards).
- Address all relevant recommendations arising from the Buncefield accident.
- Demonstrate that the proposed development complies with the criteria set out in *HIPAP No 4 – Risk Criteria for Land Use Safety Planning*.
- Estimate the cumulative impacts from the overall site and the surrounding potentially hazardous developments in the area (if any) and demonstrate that the proposed

development does not increase the cumulative risk of the area to unacceptable levels.

An evaluation of the impacts of the transport of Dangerous Goods (DG) to and from the site is covered in the Traffic Impact Assessment in another section of the Environmental Impact Statement (EIS) and is not covered in this report.

Cardno Limited (Cardno) has been engaged to prepare the EIS for TQ Holdings. Sherpa Consulting Pty Ltd (Sherpa) has been engaged by Cardno to address the Hazard and Risk requirements of the SEARs.

1.2. Study Methodology

The 'Hazards and Risk' requirements of the SEARs were met using the following methodology.

- A SEPP 33 analysis was completed for the site. The analysis involved obtaining the list and quantities of dangerous goods that are proposed to be stored onsite and transported by road tankers and comparing with the threshold quantities to determine whether a PHA and transport risk assessment are required. The SEPP 33 analysis involved assessing the proposed site as a '*potentially hazardous*' installation only. Assessment as '*potentially offensive*' is covered in another section of the EIS.
- Based on the screening, a PHA was conducted in accordance with HIPAP 6 'Guidelines for Hazard Analysis' (Ref.1). PHA is a land use planning tool. The steps in the PHA are:
 - Hazard Identification (HAZID) study – To identify the hazards, causes, consequences and safeguards. The findings allowed identification of hazards associated with the proposed development and hazardous scenarios that have the potential for offsite impact.
 - Consequence Analysis – To determine the impact area of the hazardous scenarios and the resulting extent of injury or fatality effects.
 - Frequency Analysis – To determine the likelihood of each loss of containment and ignition scenario using historical leak frequency data.
 - Risk Analysis and Evaluation – To establish whether the offsite risk levels comply with the risk criteria in the NSW DPE HIPAP 4 'Risk Criteria for Land Use Safety Planning' (Ref.2), which covers:
 - Injury, irritation and fatality risks to offsite land uses, expressed as individual risk
 - Risk of property damage and accident propagation to neighbouring hazardous installations.

- The impact of external hazards on the site was captured in the HAZID and has been considered in the site design through the use of relevant standards.
- The approach adopted to address the recommendations from the Buncefield accident which are relevant to the site are provided in Appendix G.
- Cumulative impacts from the overall site and the surrounding potentially hazardous developments in the area were assessed qualitatively.

1.3. Findings

1.3.1. SEPP33 Analysis

The SEPP33 analysis found that the quantities of Class 3 Packaging Group (PG) II materials, ie gasoline, stored onsite exceeded the threshold quantities stated in the SEPP33 guideline (Ref. 15). The proposed development is '*potentially hazardous*' and a PHA study is required.

The SEPP33 analysis also found that a transport route evaluation study is required as weekly vehicle movements of Class 3 PG II materials are above the SEPP33 transport screening threshold levels. This requirement is addressed in the Traffic Impact Assessment by Cardno in accordance with HIPAP No. 11 guideline.

1.3.2. Preliminary Hazard Analysis

A quantitative PHA was completed for the preliminary design of the site. The PHA included external hazards.

The results of the PHA are compared with the HIPAP 4 criteria in Table 1.1.

Table 1.1: Summary of compliance of HIPAP 4 risk criteria

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Individual fatality risk		
Hospitals, child-care facilities and old age housing (sensitive land use).	5×10^{-7}	Yes
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}	Yes
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}	Yes
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}	Yes
For industrial sites, individual fatality risk level should, as a target, be contained within the boundaries of the site where applicable.	5×10^{-5}	No

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Injury risk – heat radiation exceeding 4.7 kW/m²		
Residential and sensitive use.	5 x 10 ⁻⁵	Yes ^{Note 1}
Injury risk – explosion overpressure exceeding 7 kPa		
Residential and sensitive use.	5 x 10 ⁻⁵	Yes ^{Note 2}
Risk of property damage and accident propagation – 23 kW/m² heat flux		
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5 x 10 ⁻⁵	No
Risk of property damage and accident propagation – 14 kPa explosion overpressure		
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5 x 10 ⁻⁵	Yes ^{Note 2}
<p>Note.</p> <p>1. Injury heat radiation contours do not extend into the nearest residential and sensitive land use areas.</p> <p>2. Explosion overpressures were not evaluated in relation to injury and property damage/propagation risk as they are not generated.</p>		

Figure 1.1 shows the individual fatality risk contours for the PKBLT site. The 5 x 10⁻⁵ per year individual fatality risk contour extends into the Gurungaty waterway east of Site 2 (up to 20 m from site boundary). This does not meet the **target** of retaining the risk contour within the site boundary where applicable. The affected area is a shallow waterway, which precludes ship or boat access, and is within the port area, which restricts public access. Hence it is unlikely people will be present in this area and exposed to the risk.

Figure 1.2 shows the property damage and accident propagation risk contour for the PKBLT site. The 5 x 10⁻⁵ per year property damage and accident propagation risk contour extends into the neighbouring land north of Site 1 (up to 5 m from site boundary). This land is zoned to accommodate potentially hazardous installation. It is noted that there is currently no equipment, structures or dangerous goods located in the area the risk contour extends into.

The main risk contributor scenario to the north of Site 1 is a bund fire in the pump bay. Fire detection and foam suppression systems will be provided in the pump bay as well as hydrocarbon spill detection. These measures were not incorporated in the risk assessment due to the uncertainty in their ability to reduce the immediate impact of the incident. However, it would reduce the severity of the fire.

The PHA is based on a preliminary design of the site. As the detailed design progresses, particularly for the Site 1 pump bay area, TQ Holdings advised there will be further refinements to the design to minimise risks associated with this section of the plant.

Additional measures may include dividing the pump bay surface area into smaller bund segments, incorporating drainage trenches to divide the area or installing protective barriers to minimise escalation into the neighbouring site.

Escalation risk can also be managed by TQ by ensuring that land occupiers north of Site 1 do not:

- locate equipment, piping or structures in this area.
- store or have dangerous goods present in this location.

1.3.3. Buncefield Recommendations

Sherpa has provided a table of Buncefield recommendations in APPENDIX G. For each recommendation, the corresponding status for the PKBLT site is provided. TQ Holdings should ensure that the recommendations are addressed as the detailed site design is finalised.

1.3.4. Cumulative Risk

There is currently no integrated risk model publicly available for the port area. Therefore, the risk that PKBLT site adds to the cumulative risk profile for the area was assessed qualitatively in relation to the adjacent coal stockpiles and grain silos. As coal stockpile fires, and coal and grain dust explosion consequences typically remain onsite, there is low cumulative risk in the area. Risk contours from PKBLT are unlikely to increase the risk of the area.

Figure 1.1: Individual fatality risk contours

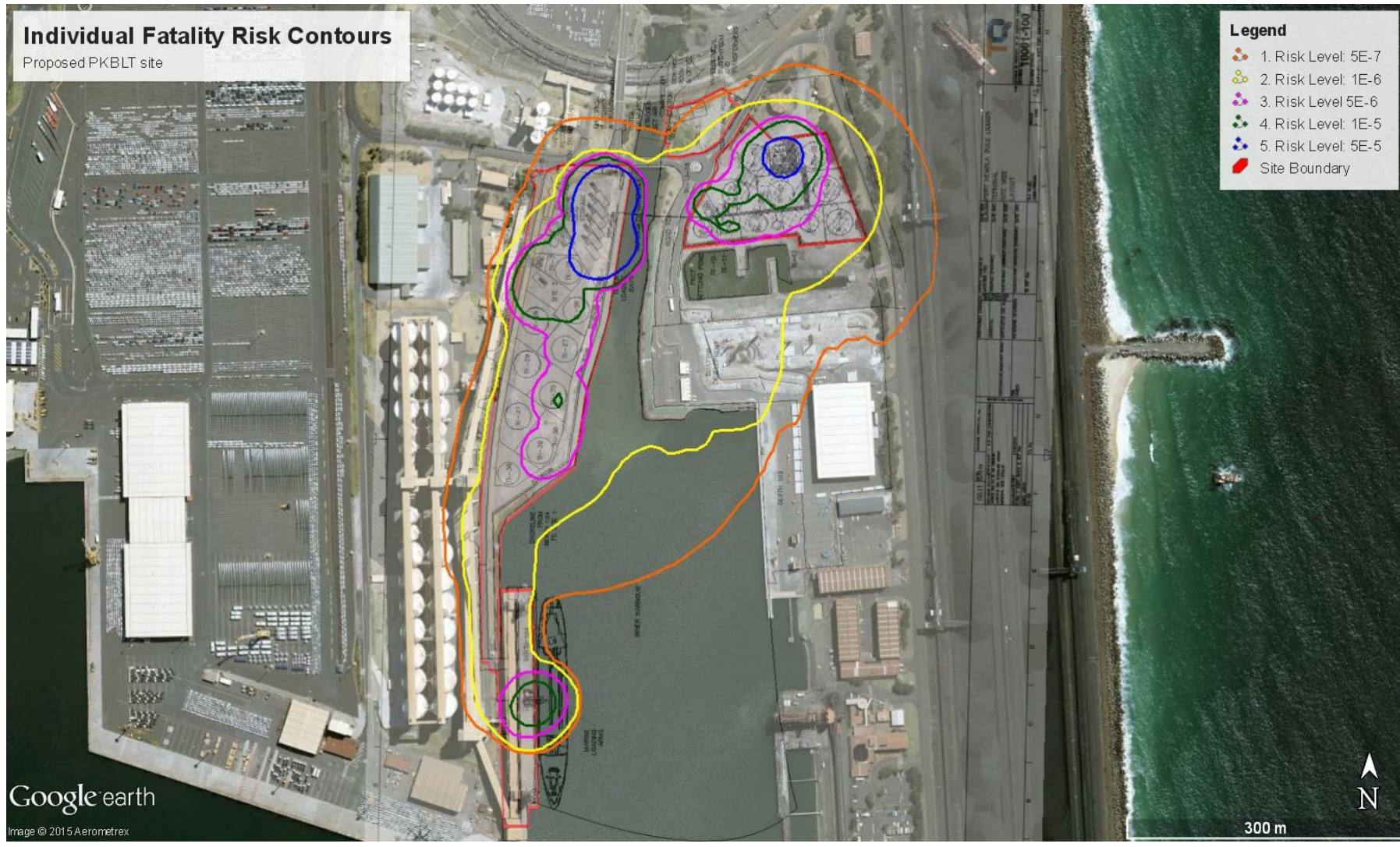


Figure 1.2: Damage and propagation risk contour



2. INTRODUCTION

2.1. Background

TQ Holdings Australia Pty Ltd (TQ Holdings), previously National Terminals Pty Ltd, is planning to develop a bulk liquids terminal within the NSW Ports precinct at Port Kembla, New South Wales, Australia. The terminal will have a storage capacity of 288 ML (Stage 3 maximum capacity) which will be used for combustible and flammable liquids. The proposed development will be located in the vicinity of the Port Kembla Coal Terminal (PKCT), GrainCorp Grain Terminal, Quattro Grain Terminal and Australian Amalgamated Terminal (AAT).

Originally, TQ Holdings was seeking to establish a bulk liquid storage facility for combustible liquids and a large scale Soybean Processing and Biodiesel Production Facility. On 5 May 2009, a Development Application (Approval No. 08_0083) was granted from the NSW Department of Planning & Environment (DPE) for this development. Three modifications for this development has since been granted relating to changes in project land allotment and construction commencement date and minor changes to the facility design.

For the purposes of this document, the existing planning approval (MP_08_0083), including the three approved modifications (MOD1, MOD2 and MOD3) is collectively referred to as 'the approved Project'.

TQ Holdings has determined that developing the approved project (MP_08_0083) is not viable due to a shift in the long term market conditions for soybean crushing and biodiesel production. As such the project plans were revised in 2014 to include additional bulk liquid storage and handling facilities. A new planning approval is required for the additional items.

The proposed Port Kembla Bulk Liquid Terminal (PKBLT) Project will be developed in three stages:

- Stage 1 – includes:
 - Stage 1A (Approved) – refers to aspects of the Stage 1 project scope items that are covered in the existing Development Application (DA) (MP_08_0083).
 - Stage 1B (Balance) – refers to aspects of the Stage 1 project items that are not covered in the approved DA.
- Stage 2 – intermediate terminal capacity (not covered in the approved DA)
- Stage 3 – future capacity (not covered in the approved DA).

The infrastructure and equipment to be constructed under each of the stages are summarised in Table 2.2.

TQ Holdings has submitted a new DA to cover all stages of the development.

2.2. Requirement for Study

A new DA has been submitted to DPE which covers all three stages of the proposed development. To enable the planning approval to progress, the DPE had provided TQ Holdings with draft Secretary’s Environment Assessment Requirements (SEARs). The draft SEARs require an EIS to be submitted.

TQ Holdings has engaged Cardno to develop the EIS for the proposed Project. Cardno has engaged Sherpa to address the ‘Hazards and Risk’ requirements of the SEARs. A draft SEARs was issued by DPE in January 2015. An excerpt from the draft SEARs is provided below.

Hazards and Risk – including a preliminary risk screening completed in accordance with *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development and Applying SEPP 33* (DoP, 2011), with a clear indication of class, quantity and location of all dangerous goods and hazardous materials associated with the project. Should preliminary screening indicate that the project is "potentially hazardous," a Preliminary Hazard Analysis (PHA) must be prepared in accordance with *Hazardous Industry Planning Advisory Paper No. 6 - Guidelines for Hazard Analysis* (DoP, 2011) and *Multi-Level Risk Assessment* (DoP, 2011).

2.2.1. Final SEARs

The final SEARs was issued in October 2015 which outlined key issues that needed to be covered in the EIS. The key issues relating to the ‘Hazards and Risk’ section and the references to the relevant sections in this report are outlined in Table 2.1.

Table 2.1: Final SEARs issues and references to PHA report

Final SEARs Issue	PHA Report Reference
<p>A summary of the results of the PHA undertaken for the proposed development with consideration of the existing site. The PHA should be prepared in accordance with <i>HIPAP No. 6 – Guidelines for Hazard Analysis</i>. The PHA should:</p> <ul style="list-style-type: none"> - identify the hazards associated with the existing site and proposed development, as well as any external hazards (ie natural hazards) to determine the potential for off-site impacts; 	<p>The hazards associated with the proposed development, including external hazards, are covered in the HAZID study in APPENDIX C.</p> <p>The basis of design for the site has taken into consideration the impact of external hazards on the site. This is further described in Section 3.4.</p> <p>A summary of the results of the PHA is included in Section 1.3.</p>
<ul style="list-style-type: none"> - address all relevant recommendations arising from the Buncefield accident; 	<p>This is covered in APPENDIX G.</p>
<ul style="list-style-type: none"> - demonstrate that the proposed development complies with the criteria set out in <i>Hazardous Industry Planning Advisory Paper No 4 – Risk Criteria for Land Use Safety Planning</i> 	<p>The proposed development compliance with HIPAP No 4 criteria is described in Section 10 and summarised in Section 1.3.2.</p>

Final SEARs Issue	PHA Report Reference
- estimate the cumulative impacts from the overall site and the surrounding potentially hazardous developments in the area (if any) and demonstrate that the proposed development does not increase the cumulative risk of the area to unacceptable levels	The impact of the proposed development to the cumulative risk in the area is qualitatively assessed in Section 10.5.
- an evaluation of the impacts of the transport of Dangerous Goods to and from the site in the immediate vicinity	This is covered in the Traffic Impact Assessment in another section of the EIS and is not covered in this PHA Report.

2.3. Study Objectives

The main objective of this report is to address the 'Hazard and Risk' requirements of the draft and final SEARs.

2.4. Study Scope

TQ Holdings proposes to develop the PKBLT in three stages. The major infrastructure included for each phase are summarised in Table 2.2.

This PHA study covers the final terminal operations on completion of Stage 3 including the infrastructure constructed in Stage 1 and 2.

Table 2.2: Proposed terminal infrastructure

Stage	Location	Infrastructures
Stage 1	Berth 104	<ul style="list-style-type: none"> • Three Marine Loading Arms (MLAs) and associated wharf infrastructure • Three shorelines to Site 1
	Site 1	<ul style="list-style-type: none"> • Product tanks <ul style="list-style-type: none"> - 3 x Combustible 6,000 m³ - 3 x Combustible 18,000 m³ - 1 x Combustible 1,500 m³ - 3 x Flammable 18,000 m³ - 2 x Flammable 1,500 m³ - 6 x Flammable Slops 30 m³ • Bund walls • Pump bay and product piping to truck loading bays
	Site 2	<ul style="list-style-type: none"> • Product tanks on Site 2 <ul style="list-style-type: none"> - 2 x Flammable 1,500 m³ • Three loading bays in the gantry • Pump bay and product piping to truck loading bays • Fire system, utilities, stormwater, fencing and pavements for Site 1, Site 2 and Berth 104
	Site 3	<ul style="list-style-type: none"> • Workshop and control room/office facilities

Stage	Location	Infrastructures
Stage 2	Site 2	<ul style="list-style-type: none"> Product tanks <ul style="list-style-type: none"> - 2 x Combustible 18,000 m³ - 3 x Flammable 18,000 m³ - 6 x Flammable Slops 30 m³ Bunding around a reduced section on Site 2 to provide the necessary bund capacity for an 18,000 m³ storage tank Extension of the three shorelines to Site 2 Pump bay and product piping on Site 2 to allow for transfer of product to Site 1 Fire system, utilities, stormwater, fencing and pavements for additional tanks on Site 2 One additional loading bay in the gantry
Stage 3	Berth 104	<ul style="list-style-type: none"> One additional MLA
	Site 2	<ul style="list-style-type: none"> Product tanks <ul style="list-style-type: none"> - 1 x Combustible 18,000 m³ - 2 x Flammable 18,000 m³ - 1 x Combustible 12,000 m³ Intermediate bunding around additional tanks Two additional truck loading bays Fire system, utilities, stormwater, fencing and pavements for additional tanks on Site 2

2.5. Study Exclusions and Limitations

The exclusions and limitations of this study are summarised in Table 2.3.

Table 2.3: Study exclusions and limitations

No.	Exclusions and Limitations	Remarks
1.	Only offsite risk was assessed	Onsite risk to employees and contractors was not assessed as this is not relevant for land use planning purposes.
2.	Context of assessment	This assessment does not address the requirements under the Work Health and Safety (WHS) Regulations 2011 in relation to Major Hazard Facilities (MHF). Assessment of the site was in the context of the HIPAP 4 guidelines.
3.	Ship tanker	This assessment covers potential loss of containment scenarios from the ship to wharf connection including the shoreline. It does not include incidents on the ships. Ships are not under the control of the terminal.
4.	Construction risks	In line with HIPAP 6 guidelines, risks were assessed for the proposed development during its operating phase only.

No.	Exclusions and Limitations	Remarks
5.	Tanks and bunds	Tanks and bunds are assumed to be designed and constructed to the relevant standards including AS1940-2004.
6.	Additive tanks and IBCs	The two additive tanks (TK-41 and TK-42) and additive Intermediate Bulk Containers (IBC) will contain flammable liquid but the exact material has not been finalised. This was modelled as gasoline in the consequence analysis. Note that these scenarios did not contribute to the offsite risk contours.
7.	Standards compliance	Statements in this report relating to compliance to codes and standards are based on advice received from TQ Holdings (including Point No. 5 in this table). Sherpa has not verified compliance with codes and standards.

3. FACILITY DESCRIPTION

3.1. Location and Surrounding Area

The proposed TQ Holdings' PKBLT is to be located in the inner harbour of Port Kembla, which is located 3 km south of Wollongong in NSW. The proposed facility is bounded by Tom Thumb Road to its north, Morton Way to its west, Berth 104 to its south and the Gurungaty Waterway (commonly referred to as the Western Drain) runs through the centre of the proposed facility between Site 1 and 2. The facility is to be located on separate land allotments leased on a long term arrangement from NSW Ports and also includes non-exclusive access and use of Berth 104.

An aerial photo showing the location of the proposed PKBLT site and the surrounding facilities is provided in Figure 3.1.

The surrounding land use is primarily categorised as industrial. There are no significant commercial spaces, warehouses open to the public, or similar developments that routinely have a large number of people occupying them (eg commercial office space, retail centres). Table 3.1 summarises the land uses near the proposed development.

Table 3.1: Industrial land uses near to terminal

Location	Neighbouring Facility
North	Multi-purpose Facility (storage of motor vehicles, general cargo and containers) Wollongong Sewage Treatment Plant Wollongong Greenhouse Park Port Kembla Coal Terminal (PKCT)
East	PKCT
South	PKCT settling pond Australian Amalgamated Terminals (AAT) General Purpose Terminal Quattro Grain Terminal Port Kembla Inner Harbour
West	GrainCorp Grain Terminal Multi-purpose Facility (storage of motor vehicles and general cargo)

The nearest residential area is located at Coniston, which is located approximately 1200 m north-west of the proposed PKBLT facility. The nearest park is approximately 750 m north of the site.

Figure 3.1: Surrounding land uses



3.2. Proposed Terminal Infrastructure

TQ Holdings has a long-term lease for separate land allotments from NSW Ports and includes non-exclusive access and use of Berth 104. The land allotments are shown in Figure 3.2.

The typical land uses for the sites are as follows:

- Site 1 – Combustible and flammable bulk liquids storage and pump bay
- Site 2 – Combustible and flammable bulk liquids storage and truck loading facilities
- Site 3 – Site control room and office block, maintenance workshop and utilities
- Berth 104 – Bulk liquids unloading facilities.

The proposed site comprises a number of storage tanks including 23 product tanks, 13 slops tanks, 2 firewater tanks and 2 additive tanks in Stage 3 operations.

Hazardous materials stored onsite comprises bulk petroleum fuel products (gasoline and diesel), ethanol and additives. The total storage capacity of the site will be up to 288 ML of fuel products (excluding slops, oily water and additive tanks) in Stage 3 operations.

The proposed site will be operational 24 hours, 7 days per week. All terminal activities (controlling tank movements, product transfers, road tanker loading, Vapour Recovery Unit (VRU) monitoring, fire system control and alarms) will be coordinated by the Control Room Operator. Ship import and tank-to-tank transfer operations will only be undertaken when Operations personnel are onsite.

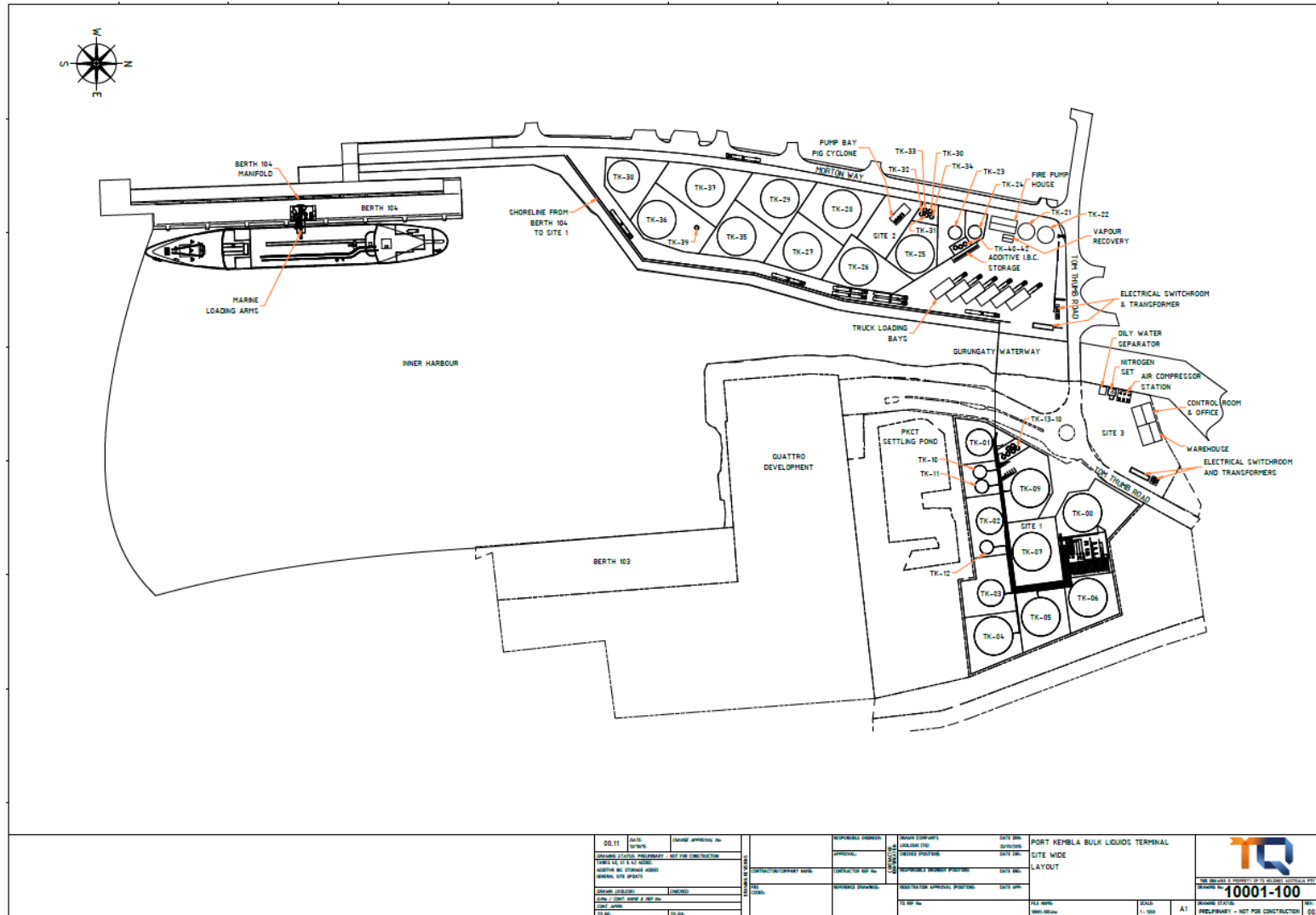
The site will have a perimeter fence, security monitoring and access protocols. It will be equipped with fire fighting provisions as required by the relevant standards.

Figure 3.3 shows the proposed TQ Holdings site layout.

Figure 3.2: TQ Holdings' lease areas



Figure 3.3: Proposed site layout



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3.3. Proposed Terminal Operations

The proposed site will receive, store and export a variety of liquid petroleum products to customers in the region.

3.3.1. Product Receipt and Storage

Gasoline grades will be received by ship at Berth 104 using four Marine Loading Arms (MLAs) and dedicated shore lines. Product is transferred to the Site 2 manifold and then piped directly into the designated tanks split by interconnections made at the transfer manifold. There is also capability for product from the ship to be pumped to Site 1 via the Site 2 manifold. However, the proposed site operation will be ship import into Site 2 tanks, transfer from Site 2 to Site 1 tanks and product export from Site 1 tanks.

Ethanol, biodiesel and additives will be received by road tanker. These vehicles will enter Site 2 via the access gates and proceed to the road tanker gantry. Dedicated unloading pumps will be used to transfer product to the appropriate tanks on Site 1 or Site 2.

Pigging operation

Each shore line is equipped with a pig launcher and receiver at Berth 104 and Site 2 in order to clear product into the tank and leave the line clean for the next product. This is done at the end of each ship import operation. Pig propulsion will be by nitrogen pressure using a reticulation system from the terminal nitrogen tank.

Tank-to-tank transfer/Tank recirculation

Product can be transferred between any tank on any site via the transfer pumps located on each site. On Site 1, the product pumps supplying the loading bays can also be used for tank-to-tank transfer, although the loading of road tankers take precedence. The transfer pumps can also be used for recirculating the contents of any of the tanks as required for product quality purposes.

3.3.2. Storage Tanks and Bunds

The Project have designed storage tanks and bunds and intend to construct them in compliance to API650 and AS1940 *The storage and handling of flammable and combustible liquids* (Ref. 3). They are constructed from carbon steel and are fixed roof tanks if in combustible liquid service or internal floating roof with external dome roof if in flammable liquid service.

All bulk storage tanks will be provided with ducted overflows which direct the flow to the same bund sump in which the tank is located. Flow detection would be provided within the duct, triggering terminal ESD on flow detection. Hydrocarbon detection in the bund sump would activate an alarm in the control room.

External walls of height 1800 mm will be provided around the perimeter of Site 1 and Site 2, and 600 mm high intermediate bund walls will be provided where required.

The storage tank capacities are shown in APPENDIX A.

3.3.3. Product Export

Product distribution will be via single, rigid and B-double road tankers. Road tankers will enter Site 2 from the access gate, approach the main road gantry, park and commence bottom filling via dedicated loading arms. Trucks will be filled with a variety of gasoline blends and diesel/biodiesel percentage blends using either in-line blending immediately prior to road tanker export or in-tank blending.

There are a total of six road tanker loading bays proposed. Each loading bay will have six loading arms. The gantry area will have kerbing around the perimeter and be drained to the slops system.

3.3.4. Injection of Additives

Provision will be made for additive injection:

- Into the shoreline as it is unloaded from the vessel
- During tank-to-tank transfers
- At the gantry into the product stream as it is loaded into road tankers.

Additives will be sourced from Intermediate Bulk Containers (IBCs) and two small tanks using dosing pumps. Additive dosing can also be made to each tank during recirculation by using a mobile dosing trolley and pump connected to a port on the tank inlet piping.

3.3.5. Fire Protection System

The site will be protected by a fire protection system. The system will comprise the following:

- Fire monitors at the berth
- Fire water ring main
- Foam system
- Cooling water deluge system to the tanks.

The ring main, hydrants, foam system and cooling water deluge systems will be designed and installed in accordance with AS2419.1-2005, AS3846-2005, NFPA16 and AS1940-2004 respectively. A manual fire call point system complying with AS1670.1-2004 will be provided along the wharf and escape routes to summon Fire and Rescue New South Wales (FRNSW) (Ref. 3).

3.3.6. Fire and Hydrocarbon Detection Monitoring and Alarms

Fire monitoring equipment will be installed at the gantry and hydrocarbon monitoring systems will be installed in the sump. Upon indication from either of these systems, an alarm will be initiated and the Emergency Shut Down (ESD) procedure will commence.

Emergency shutdown will occur during operations through (Ref. 3):

- Supervisory Control And Data Acquisition (SCADA) – by operator activation
- Emergency Shutdown System – activated at either the berth or terminal control room
- Tank high level – in any tank (in case of line-up error or passing valve allowing filling of wrong tank)
- Tank overflow – in any tank (in case of line-up error or passing valve allowing filling of wrong tank)
- Flame detectors (on the berth, pump bays and road gantry bays).

3.4. Site Design Basis

Table 3.2 summarises how the PKBLT site design has taken into account environmental hazards that may occur in the area. The information in Table 3.2 was provided by TQ Holdings (Ref.4).

Table 3.2: Environmental hazards consideration in PKBLT site design

Environmental Hazard	PKBLT site design consideration
Earthquake	The site structures, including the tanks, has been designed in accordance with AS 1170.4 <i>Structural design actions - Earthquake actions in Australia</i> .
Tsunami (high waves)	The site is located within the inner harbour area and is shielded from ocean waves by the Port Kembla Coal Terminal, and the Port Kembla Harbour breakwater and outer harbour.
Flooding	The project site is not impacted by flooding from Gurungaty Waterway as the site levels are a minimum of 1.7 m above the Probable Maximum Flood (PMF) levels in the watercourse. The bunded areas on Site 1 and Site 2 would provide capacity to temporarily store the 24 hour 100 year Average Recurrence Interval (ARI) rainfall plus a simultaneous major product spill. This is in excess of minimum design requirements.
Heavy winds	The site structures, including the tanks, has been designed in accordance with: - AS 1170.2 <i>Structural design actions - Wind actions</i> - API 650 (2013) <i>Welded Steel Tanks for Oil Storage</i> , as referred by AS 1692 (2006)
Storm surge	The NSW State Government released a Sea Level Rise Policy Statement in October 2009 that included sea level rise planning benchmarks of +0.4m and +0.9m by 2050 and 2100, respectively, which were adopted into the catchment wide flood study (WCFS 2013). The projected sea level rise would not, however, pose a risk to PKBLT due to site elevations.

3.5. Changes from Approved to Proposed Project

This section summarises the background of the approved project.

On 5 May 2009, a DA (MP 08_0083) was granted from the NSW DPE for a large scale Soybean Processing and Biodiesel Production Facility and an associated bulk liquid storage and loading facility. This included, but not limited to, storage of the following:

- Nine Soybean storage silos (part of existing GrainCorp facility)
- Three hexane tanks (Class 3 flammable liquid)
- Two methanol tanks (Class 3 flammable liquid)
- One sodium methylate tank (Class 3 flammable liquid)
- Four tanks containing corrosive substances
- Five biodiesel tanks (C1 combustible liquid).

An Environmental Assessment document was prepared by Maunsell Aecom for this development (Ref. 5).

A Section 75W modification for this development was granted by DPE on 14 March 2013 (MOD1) due to a change in project land allotment and minor changes in the facility design. The land allotments considered in the MOD1 facility is comparable to the proposed development land allotments (Sites 1, 2 and 3) (Ref. 6).

Subsequent Section 75W modifications were approved, MOD2 (Ref. 7) and MOD3 (Ref. 8), which moved the construction commencement to a later date.

Project plans were revised in 2014 to include additional bulk liquid storage and handling facilities and no longer pursued the development of a soybean processing and biodiesel production facility. This means that the combustible liquid storage tanks, berth infrastructure and shorelines are the only aspect of the approved development which can be carried forward to the new development application (under Stage 1A development).

4. METHODOLOGY

4.1. Study Overview

An overview of the SEPP33 and PHA process, including the steps and inputs for this study is shown in Figure 4.1. The PHA study approach is consistent with HIPAP 6 Hazard Analysis Guidelines (Ref.1). The subsequent sections provide further information.

4.2. SEPP33 Analysis

To determine whether the development is '*potentially hazardous*' and the requirement for a PHA, a SEPP33 analysis was conducted.

A description of the methodology of the SEPP33 analysis is provided in APPENDIX A.

4.3. Preliminary Hazard Analysis (PHA)

The following sections provide a description of the PHA methodology.

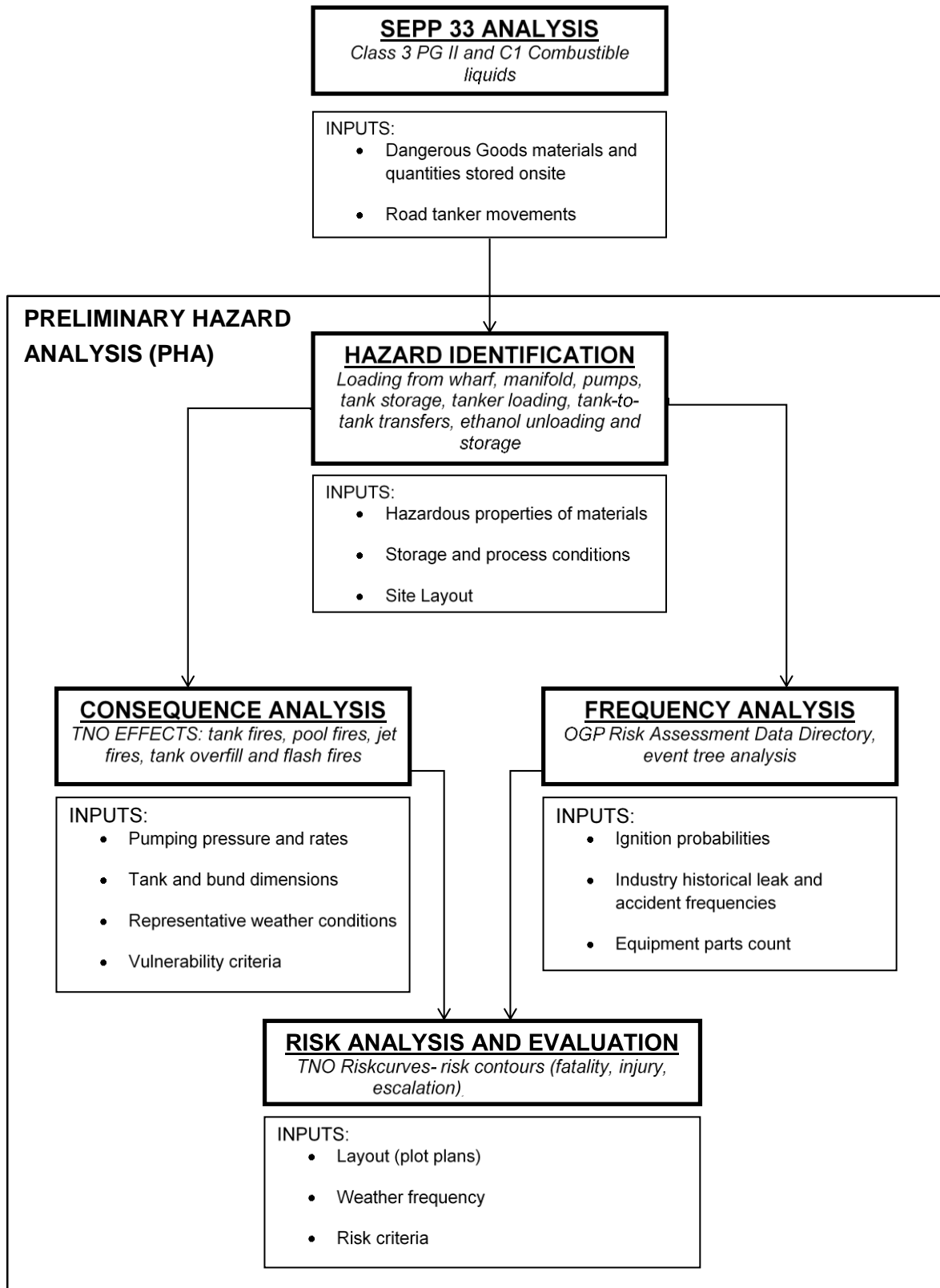
4.3.1. Hazard Identification (HAZID)

Hazard identification is the process of identifying material and situations with the potential to cause harm and establish credible scenarios that could result in an adverse impact, together with their causes, consequences and existing safeguards. The main aims are to:

- Show an understanding of the hazards at the facilities and the mechanisms by which the hazard's potential can be realised
- Show an understanding of the underlying causes of the hazardous scenarios
- Identify the safeguards that are in place to prevent the hazardous scenarios and/or consequence
- Identify hazardous scenarios for quantitative assessment to determine the potential for offsite impact.

A hazard identification table was conducted in a workshop setting with TQ Holdings' personnel (3 June 2015) to develop a list of all potentially hazardous scenarios requiring risk quantification to determine if there are any offsite impacts.

Figure 4.1: Overview of PHA process



4.3.2. Consequence Analysis

Consequence modelling of identified scenarios was undertaken to determine the impact area (as heat radiation or within a flammable cloud) and the resulting extent of injury or fatality effects.

Software and Models

Consequence modelling of identified hazardous events was undertaken using TNO EFFECTS v9.0. TNO EFFECTS is a commercial software package that uses the models in TNO’s Yellow and Green Books (Ref.9 and Ref.10) for calculating the physical effects and consequences of the loss of containment of hazardous materials. PHAST v7.11 was used to model scenarios relating to ethanol releases.

Releases

Loss of containment from equipment was modelled for the representative range of hole sizes in Table 4.1.

The hole size selected for the ranges in Table 4.1 are the geometric means, which give a weighting towards the lower band, since smaller sized leaks tend to occur more frequently.

Table 4.1: Representative hole sizes for modelling loss of containment

Hole size (mm)	Range (mm)
2	1 to 3
6	3 to 10
22	10 to 50
85	50 to 150
Full bore	> 150

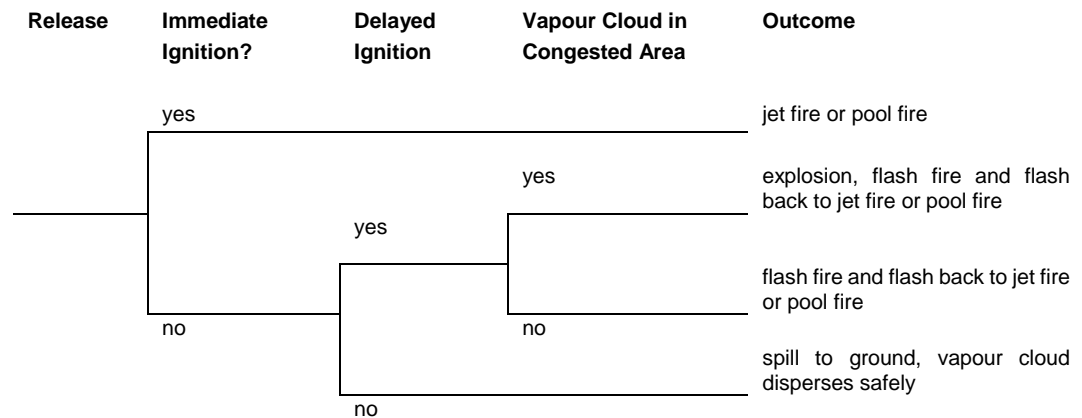
For loss of containment downstream of a pump, the maximum release rate was limited to the normal pumping rate or the process flow rate.

During tank filling, the pump rate is slowed when the high level is approaching. In a worst case scenario for overflow, the fill rate would not be slowed and pumping to a tank would continue at the maximum filling/ship import rate.

Scenarios

Figure 4.2 shows the general event tree showing the possible outcomes following loss of containment of a flammable or combustible liquid.

Figure 4.2: Event tree for loss of containment



When released at pressure, a liquid may form an airborne aerosol and/or fall to the ground. The pressure, hole size and fluid properties including vapour pressure all are factors in whether an aerosol, pool or combination of the two will form. The light components from gasoline such as C4s and C5s will tend to form a vapour cloud from evaporation or an aerosol release. The formation of a vapour cloud depends on the release characteristics and weather.

The rule set used for the outcome given ignition is shown in Table 4.2.

Table 4.2: Scenario rule set for pressurised liquid releases

Fluid	Ignition Timing	Hole Size	Outcome
Gasoline	Immediate	≤ 22 mm	Jet fire
		> 22 mm	Pool fire
	Delayed	≤ 22 mm	Rainout and evaporating pool Flash fire
		> 22 mm	Rainout and evaporating pool Flash fire
Diesel	Immediate	≤ 22 mm	Jet fire
		> 22 mm	Pool fire
	Delayed	≤ 22 mm	Pool fire
		> 22 mm	Pool fire
Ethanol	Immediate	≤ 22 mm	Jet fire
		> 22 mm	Pool fire
	Delayed	≤ 22 mm	Pool fire
		> 22 mm	Pool fire

For loss of containment within a bund, the size of the pool (whether a pool fire or evaporating pool) was limited to the bund size. For a tank rupture scenario, loss of containment is limited to the site bund. This is described further in APPENDIX D.

Tank Overfill

A tank overfill scenario leading to flammable vapour cloud formation and consequences resembling the ‘Buncefield’ scenario was not considered to be credible due to installation of ducted overflow piping directing flow to the bund for flammable tanks.

However, overfilling the tank would still lead to flammable liquid accumulating in the bund. For this study, immediate ignition of the pool would result in an intermediate bund fire. If the pool is not immediately ignited, a flammable vapour cloud would form via neutral dispersion and ignition would result in a flash fire.

Weather Conditions

Historical meteorological weather data for the proposed terminal was obtained from the Bureau of Meteorology (BoM). The acquired data sets were based on readings from the Automatic Weather Station (AWS) at Port Kembla NTC (AWS 068253) which is located approximately 3 km away.

From the acquired data sets, representative weather conditions were consolidated for consequence modelling, as outlined in in Table 4.3. Since evaporation and dispersion are significantly dependent on prevailing weather conditions, a wide range of conditions with significant likelihood of occurrence was selected. The analysis of the data, which is an input to the risk model is included in APPENDIX F.

Spray and pool fires were only modelled under a high wind speed case, D5, since they are less influenced by the prevailing wind and weather conditions and higher wind speeds are more conservative as they result in larger effect distances.

Table 4.3: Weather conditions for consequence modelling

Name	Pasquill Stability Class	Wind speed (m/s)	Description
B3	B	3	Day time, moderate wind condition
D5	D	5	Cloudy or high wind condition
F2	F	2	Night time/early morning, low wind speed

4.3.3. Vulnerability Criteria

The assessment criteria for exposure to hazardous scenarios (eg fires) are given by vulnerability relationships. These are summarised in Table 4.4.

These criteria are based on the probit equation for fires, consistent with the HIPAP 4 guidance. The table includes the exposure levels for injury and property damage from fires given in HIPAP 4 (Ref.2).

Table 4.4: Vulnerability criteria for fire scenarios

Event	Level	Probability of fatality assumed in PHA	Other effects
Jet fire Pool fire	4.7 kW/m ²	-	Injury
	10 kW/m ²	1%	Fatality
	14 kW/m ²	10%	Fatality
	20 kW/m ²	50%	Fatality
	23 kW/m ²	70%	Escalation due to heat radiation
	Within fire envelope	100%	Escalation due to direct impingement
Flash fire	Within LFL (assumed to be flash fire envelope)	100%	No escalation – very short duration event

4.3.4. Frequency Analysis

Hazardous scenarios involve loss of containment of hydrocarbon fuels and subsequent ignition. The likelihood of these scenarios was estimated using historical data for each loss of containment and for ignition. Loss of containment frequencies were determined by estimating the number of equipment items ('parts count') and combining with historical leak frequency data for each equipment type. The main source of historical leak frequencies was the Oil and Gas Producer (OGP) Risk Assessment Data Directory *Process release frequencies* (Ref.11) and TNO Purple Book (Ref.12). The full set of data and sources is included in APPENDIX E.

Full surface tank roof fire frequencies were estimated from LASTFIRE Project Update 2012 (Ref.16) based on the storage tank type.

The frequency of tank overfill leading to intermediate bund fire or flash fire was estimated using event tree analysis. The frequency of catastrophic tank rupture leading to full bund fire or flash fire was estimated using event tree analysis. The derivation and full set of data and sources is included in APPENDIX E.

4.3.5. Probability of Ignition

The ignition probability values used in this study were based on the assessment done by Cox, Lees and Ang (Ref.13). The probabilities are based on the release rate and the phase of the fluid assessed. The ignition probability values used in the QRA are provided in APPENDIX E.

In this study, diesel is stored in common bunds with flammable liquids. Releases for combustible liquids such as diesel are more difficult to ignite due to their high flash point. The ignition probability for diesel was assumed to be one-tenth that of flammable liquids such as gasoline.

4.3.6. Risk Analysis

Risk analysis was performed using TNO Riskcurves v9.0, which combines the consequences and frequencies to produce contours of equal risk values.

The following risk contours were developed:

- Individual fatality risk
- Risk of property damage and accident - heat radiation of 23 kW/m².

4.3.7. Risk Criteria and Evaluation

Table 4.5 summarises the risk criteria against which the hazards from the facility were assessed. These criteria are consistent with the HIPAP 4 *Risk Criteria for Land Use Planning* (Ref.2).

Table 4.5: Risk assessment criteria

Description and land use	Criteria (per year) ^{Note 1}
Individual fatality risk	
Hospitals, child-care facilities and old age housing (sensitive land uses).	5 x 10 ⁻⁷
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1 x 10 ⁻⁶
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5 x 10 ⁻⁶
Sporting complexes and active open space areas (recreational land use).	1 x 10 ⁻⁵
For industrial sites, individual fatality risk level should, as a target, be contained within the boundaries of the site where applicable.	5 x 10 ⁻⁵
Injury risk – heat radiation exceeding 4.7 kW/m²	
Residential and sensitive use.	5 x 10 ⁻⁵
Injury risk – explosion overpressure exceeding 7 kPa	
Residential and sensitive use.	5 x 10 ⁻⁵
Risk of property damage and accident propagation – 23 kW/m² heat flux	
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5 x 10 ⁻⁵
Risk of property damage and accident propagation – 14 kPa explosion overpressure	
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5 x 10 ⁻⁵
Note 1. Criteria specific to toxic injury and irritation are also provided in HIPAP4. These are not included as there are no significant acute toxicity impacts from PKBLT operations.	

5. SEPP33 ANALYSIS

The SEPP33 analysis found that the quantities of Class 3 Packaging Group (PG) II, ie gasoline, stored onsite exceeded the threshold quantities stated in the SEPP33 guideline (Ref. 15). PKBLT is considered '*potentially hazardous*' and a PHA study was required.

The SEPP 33 analysis involved assessing the proposed site as a '*potentially hazardous*' installation only. Assessment of the site as '*potentially offensive*' is covered in another part of the EIS.

Another finding of the SEPP33 analysis was that as the operational weekly vehicle movements are above the SEPP33 transport screening threshold levels, the development is '*potentially hazardous*' with respect to transportation and a route evaluation study is required. This requirement is addressed in the Traffic Impact Assessment by Cardno in accordance with HIPAP No. 11 guideline.

The results of the SEPP33 analysis are reported in APPENDIX A.

6. HAZARD IDENTIFICATION

6.1. Fuel Properties

Materials handled at the PKBLT site are all petroleum based hydrocarbons and small quantities of additives with similar properties to fuels. These have a range of properties with regards to flammability. Representative hazardous materials are summarised in Table 6.1.

Gasoline is the only material with a significant fraction of 'light' components hence the only material where a loss of containment has potential to generate a large vapour cloud. For the purposes of considering the potential for formation of large flammable vapour clouds, the fraction of C4/C5s is of interest. The properties of the different grades of gasoline are very similar.

Gasoline additives are classified as Class 3 flammable liquids. These and other chemicals onsite are not included in Table 6.1 since they are stored in small quantities.

Table 6.1: Hazardous material properties

Characteristic	Gasoline	Diesel	Ethanol
Initial Boiling Point (atm.) (°C)	30-230	260	78
Density (kg/m ³ at 15-20°C)	740	830	789
Autoignition temperature (°C)	>350	340	363
Flash Point (°C)	<-40	>60	13
Vapour Pressure (kPag)	30-99.7	<0.1	8
Lower Flammability Limit (LFL) (%)	1.4	N/A	3.3
Upper Flammability Limit (UFL) (%)	7.6	N/A	19.05
Pool burn rates (kg/m ² .s)	0.055	0.039	0.015
Dangerous Goods Class	3 PGII Flammable	C1 Combustible	3 PGII Flammable
Note:			
1. Pool burn rates obtained from Lees (Ref.14).			

6.2. Hazard Identification Table

The hazard identification table for the site is included in APPENDIX C. The table contains the following information:

- Scenario
- Cause
- Possible consequences
- Safeguards
- Whether the scenario was carried forward for risk quantification.

6.3. Summary of QRA Scenarios

From the hazard identification table in APPENDIX C, Table 6.2 lists the scenarios which were carried forward for quantification and inclusion in the QRA.

Table 6.2: Scenarios carried forward for quantitative assessment

No.	Initial event	Potential consequences	Comment
1.	Berth 104	Jet fire Pool fire Flash fire	<p>Pressurised release from marine loading arm (MLA) and piping.</p> <p>Applicable to both gasoline and diesel fuels.</p> <p>Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release.</p> <p>Liquid pool growth resulting from release/rainout is limited to width of Berth 104.</p> <p>Different ignition probabilities used depending on flash point.</p>
2.	Pipeline – Ship Import	Jet fire Pool fire Flash fire	<p>Pressurised release from the ship import pipeline.</p> <p>Applicable to both gasoline and diesel fuels.</p> <p>Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release.</p> <p>Different ignition probabilities used depending on flash point.</p>
3.	Manifold and Pipework to tanks	Jet fire Pool fire Flash fire	<p>Pressurised release from the manifold and pipework to/from tanks.</p> <p>Covers both the Site 1 and 2 manifolds. Applicable to all fuels.</p> <p>Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release.</p> <p>Liquid pool growth resulting from release/rainout is limited to physical restriction (eg bunding around the manifold).</p> <p>Different ignition probabilities used depending on flash point.</p>
4.	Storage Tank	Tank full surface fire	<p>Applicable to all tanks and fuels (including bulk fuel tanks, slops tanks, additive tanks and excluding oily water tanks).</p>

No.	Initial event	Potential consequences	Comment
5.	Storage Tank Spill to tank compound bund	Tank bund fire Flash fire	<p>Applicable to all tanks and fuels (including bulk fuel tanks, slops tanks, additive tanks and excluding oily water tanks).</p> <p>This scenario represents the ignited event of liquid spill to tank compound bund. Intermediate and full bund fires were assessed depending on tank size. Different ignition probabilities used depending on flash point.</p> <p>Intermediate bund fires are defined as fires that are contained by the intermediate bund walls (600 mm height).</p> <p>Full bund fires are defined as fires that contained by the external bund walls (1800 mm height) around the site perimeter.</p> <p>Pool evaporation of gasoline in bund may produce a flammable cloud. No such effect is expected for ethanol and diesel.</p>
6.	Tank overfill	Intermediate bund fire Flash fire	<p>Immediate ignition of a pool resulting from tank overfill is applicable to all fuels.</p> <p>Delayed ignition of a flammable cloud resulting from tank overfill is applicable to gasoline fuel only.</p> <p>Refer to Section 4.3.2 for a more detailed explanation.</p>
7.	Pump Manifold (including Pumps)	Jet fire Pool fire Flash fire	<p>Pressurised release from pump and discharge piping.</p> <p>Applicable to all fuels.</p> <p>Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release.</p> <p>Liquid pool growth resulting from release/rainout is limited to physical restriction (eg bunding around the pump manifold).</p> <p>Different ignition probabilities used depending on flash point.</p>
8.	Road tanker loading release	Jet fire Pool fire Flash fire	<p>Pressurised release from loading line or arm, limited to the load-out pumping rate.</p> <p>Applicable to both gasoline and diesel fuels.</p> <p>Jet or pool fire depending on mist and rainout release. Flash fire applicable to gasoline only from pool evaporation after rainout from release.</p> <p>Different ignition probabilities used depending on flash point.</p>

No.	Initial event	Potential consequences	Comment
9.	Ethanol unloading release	Jet fire Pool fire	<p>Pressurised release from loading line or arm, limited to the import rate.</p> <p>Jet or pool fire depending on mist and rainout release.</p> <p>Flash fires envelope are usually small, will instantaneously flash back to the pool, resulting in a pool fire.</p>
10.	Biodiesel unloading release	Jet fire Pool fire	<p>Pressurised release from loading line or arm, limited to the import rate.</p> <p>Jet or pool fire depending on mist and rainout release.</p>
11.	Additive IBCs	Pool fire	Flammable liquid pool (modelled as gasoline) involving up to 14 IBCs stored in the curbed area.

7. QRA OPERATIONAL BASIS

A number of assumptions were made to undertake the QRA. The QRA results are dependent on the assumptions made in defining the input scenarios. It is therefore important to understand any limiting assumptions in conjunction with the QRA results.

The QRA has utilised information including the proposed terminal operational data, throughput information and typical products (that will be handled) to arrive at a product allocation basis and throughput.

The QRA basis, including the proposed terminal operational data and throughputs used in this assessment, are provided in APPENDIX B. The basis was confirmed by TQ Holdings.

8. CONSEQUENCE ANALYSIS

Consequence analysis involves qualitative and/or quantitative review of the identified hazardous incidents to estimate the potential to cause injury, fatalities or damage to property. In this study, the materials are flammable with minimal acute toxicity issues. Hence, only fire scenarios, including dispersion of flammable vapours were modelled.

The following consequences were evaluated to determine the characteristics of unignited and ignited scenarios of hydrocarbon releases on the proposed terminal (as per Table 6.2):

- Jet fires
- Pool fires
- Flash fires due to pool evaporation
- Tank full surface roof fires
- Tank bund fires.

For scenarios where the calculated release rate exceeds the process flow rate, the consequences were modelled using the process flow rate (eg pump discharge rate).

All scenarios were included in the frequency assessment, ie even if the consequence assessment showed that there was no significant impact outside the site boundary (for example small leak sizes).

The assumptions used to undertake consequence analysis are listed in Table 8.1.

Consequence modelling results are provided in APPENDIX D with respect to the specified vulnerability criteria described in Section 4.3.3.

Table 8.1: Assumptions used for consequence analysis

No.	Consequence Scenario Type	Assumptions
1.	General	<ul style="list-style-type: none"> All pipework around the site was assumed to be DN300, except at the road tanker gantry which was assumed to be DN200 due to lower flowrates.
2.	Jet Fires	<ul style="list-style-type: none"> Leak sizes less than or equal to 25 mm were modelled as jet fires for all fuels.
3.	Pool Fires	<ul style="list-style-type: none"> Pool fire scenarios for diesel/biodiesel were modelled. However, it is a combustible liquid and requires significant ignition energy to ignite. Ignition probability for diesel was assumed to be one-tenth that of flammable liquids such as gasoline. Equilibrium pool size was estimated using pool burn rates and where required, pool growth size is limited by the physical constraint within the design (eg site dimension, bund size). Releases from the MLAs are assumed to be limited to the width of the Berth 104 (18 m). Leaks from the pumps and manifold on both Site 1 and 2 are assumed to be contained within the bund provided. Releases from the gantry (loading/unloading) are confined within 150 mm high kerbing, which has been approximated to be 5 x 25 m around each loading bay. Releases were not expected to spill over due to drainage provisions. Pipework from and to manifold is not restricted by any constraint that limits the pool growth size.
4.	Flash Fires	<ul style="list-style-type: none"> Pool evaporation leading to flash fires were modelled for gasoline only. Refer to Section 4.3.2 for explanation of tank overfill scenarios considered.
5.	Tank Roof Fires	<ul style="list-style-type: none"> For IFR tanks, this scenario represents a rim seal fire escalating to a full surface tank fire and subsequent collapse of the external roof. For combustible tanks, this scenario represents escalation from a flammable tank.
6.	Tank Bund Fires	<ul style="list-style-type: none"> Intermediate bund fires (or fires contained within intermediate bund walls of 600 mm height) were associated with tank overfill scenarios. This is based on 15 minutes overfill during ship import operations (worst case scenario). Full bund fires (or fires contained within the external bund walls of 1800 mm height) were associated with large mechanical leaks from bulk storage tanks, except for the smaller tanks (ie slops, additives). Delayed ignition of bund contents was modelled as flash fires.

9. FREQUENCY ANALYSIS

9.1. Overview

The frequency of an event is defined as the number of occurrences of the event over a specified time period; with the period in risk analysis generally taken as one year. Frequency analysis involves estimating the likelihood of occurrence of each of the identified hazardous scenarios considered in this study, using historical equipment failure frequencies and populating the Event Trees developed to characterise the accident pathways.

The overview methodology to estimate scenario frequencies is described in Section 4.3.4.

The following supporting data is included in APPENDIX E:

- Historical equipment leak frequencies
- Parts count
- Online time probability
- Probability of ignition
- Event tree analysis
- Outcome frequencies
- Storage tank fire frequencies (including tank overfill).

9.2. Effect of Safeguards

There are a number of safeguards that have been accounted for in the risk model as they reduce the frequency of a scenario. The safeguards accounted for in the analysis are:

- Rim seal fire detection and automatic foam suppression system
- For bulk storage tanks, slops tanks and additive tanks, to prevent tank overfill leading to a release covering the intermediate bund:
 - Dual redundant radar tank level gauging system
 - Second radar level instrument and operator action, assuming sufficient time to respond and stop inlet flow
 - Safety Integrity Level 2 (SIL 2) rated independent level gauging system with high level set point that will initiate terminal ESD
 - Hydrocarbon detection in the intermediate bund sump and operator response.

- Operator initiated ESD for loss of containment has been assumed to occur at:
 - Berth 104 (maximum event contained within wharf bunded area)
 - Road tanker gantries (maximum event contained within loading bay kerbing)
 - Tank overfill during ship import (maximum 15 mins overfill event).

APPENDIX E describes how safeguards have been accounted for in the QRA.

10. RISK ANALYSIS

The results of the consequence and frequency analysis were integrated into a quantitative risk model for the site. The quantitative risk analysis was completed for the preliminary design of the site. A discussion of the results in the context of HIPAP 4 criteria and risk contours for individual fatality, injury and property damage/propagation are presented in the following sections.

10.1. Injury Risk

Injury heat radiation contours do not extend into the nearest residential and sensitive land use areas. Explosion overpressures were not evaluated in relation to injury risk as they are not generated. Therefore, the PKBLT site meets the HIPAP 4 injury risk criteria.

10.2. Individual Fatality Risk

Figure 10.1 shows the individual fatality risk contour levels for the PKBLT operations. HIPAP 4 states that the 5×10^{-5} per year criterion should, as a **target**, be contained within the boundaries of the site where applicable.

The 5×10^{-5} per year risk contour extends into the Gurungaty waterway east of Site 2 (up to 20 m from site boundary). This does not meet the **target** of retaining the risk contour within the site boundary where applicable. The affected area is a shallow waterway, which precludes ship or boat access, and is within the port area, which restricts public access. Hence it is unlikely people will be present in this area and exposed to the risk.

The remaining risk contours do not reach recreational, commercial, residential or sensitive land uses. It is noted that the office buildings on adjacent installations are zoned as industrial land. Commercial land uses in the HIPAP 4 guidelines refer to commercial areas as buildings where the general public may be able to access.

10.3. Property Damage and Propagation Risk

Damage and propagation risk due to heat radiation impacts were assessed for PKBLT site to determine the potential for escalation to neighbouring facilities. The concern is an accident at PKBLT may trigger a hazardous event on a neighbouring facility. Explosion overpressures were not evaluated in relation to property damage and propagation risk as they are not generated.

The 5×10^{-5} per year contour associated with damage and propagation risk to neighbouring potentially hazardous installations are presented in Figure 10.2. The risk contour associated with incident heat radiation (23 kW/m^2) from site operations extends offsite at the following locations:

- On Site 2, the risk contour extends into the waterway. This land is not zoned to accommodate potentially hazardous installations and meets the HIPAP 4 criteria.

- On Site 1, the risk contour extends into the land north of Site 1 (up to 5 m from site boundary). This land is zoned to accommodate potentially hazardous installations. Therefore, the 5×10^{-5} per year propagation risk contour does not meet the HIPAP 4 risk criteria. It is noted that there is currently no equipment, structures or dangerous goods located in the area the risk contour extends into.

Section 10.4 discusses the major risk contributors to the offsite risk contours and the risk reduction measures considered.

Table 10.1 summarises the compliance against the fatality and escalation risk criteria for the preliminary design.

Table 10.1: Summary of compliance of HIPAP 4 risk criteria

Description and land use	HIPAP 4 Criteria (per year)	Criteria Met
Individual fatality risk		
Hospitals, child-care facilities and old age housing (sensitive land uses).	5×10^{-7}	Yes
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}	Yes
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}	Yes
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}	Yes
For industrial sites, individual fatality risk level should, as a target, be contained within the boundaries of the site where applicable.	5×10^{-5}	No (Note 1)
Risk of property damage and accident propagation – 23 kW/m² heat flux		
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5×10^{-5}	No (Note 2)
Risk of property damage and accident propagation – 14 kPa explosion overpressure		
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5×10^{-5}	Yes (Note 3)
Notes: 1. The risk contour extends offsite into the Gurungaty waterway (up to 20 m from site boundary). 2. The risk contour extends into the PKCT land which is zoned to accommodate potentially hazardous installations north of Site 1 (up to 5 m from site boundary). 3. Explosion overpressures were not evaluated in relation to property damage/propagation risk as they are not generated.		

Figure 10.1: Individual fatality risk contours – Stage 3

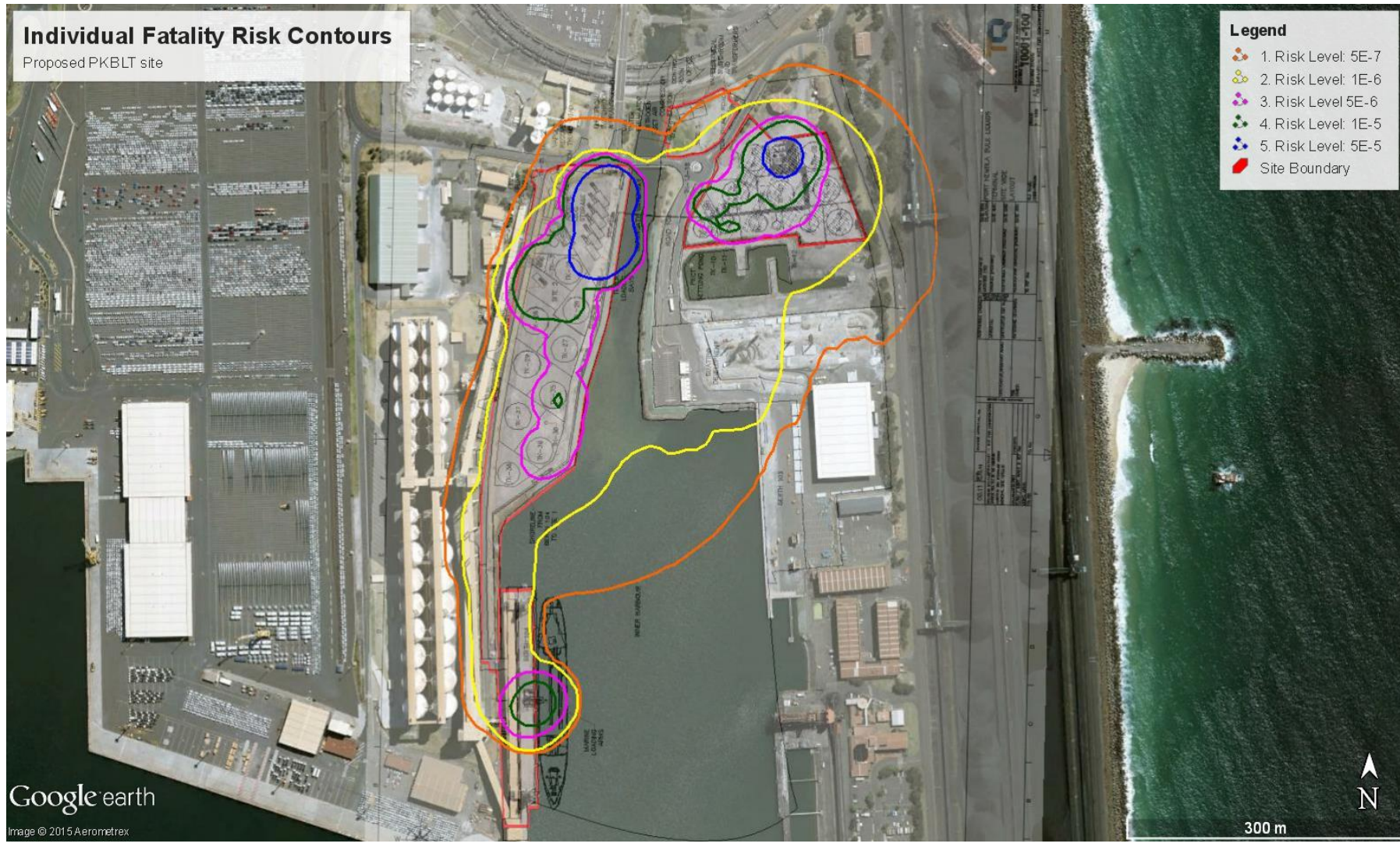


Figure 10.2: Damage and propagation risk contour – Stage 3



10.4. Major Risk Contributors

10.4.1. Damage and Propagation Risk

The 5×10^{-5} propagation risk contour extends offsite into the PKCT land north of Site 1 by 5 m but does not impact on any equipment or structures. The major risk contributors of the propagation risk contour north of Site 1 is shown in Table 10.2. The location of the analysis point is shown in Figure 10.4.

Table 10.2: Major risk contributors at selected points – damage/accident propagation

Analysis Point	Scenario	Risk Contribution Note 1
Analysis Point 1 (North of Site 1)	Intermediate Bund Fire from Pump Bay during Gasoline Road Tanker Export	57%
	Intermediate Bund Fire from Pump Bay during Diesel Road Tanker Export	23%
	Gasoline Tank Roof Fire – TK-08	7%
	Total	87%
Note 1: Only the major risk contributor scenarios are recorded in this table and hence the total risk contribution do not add up to 100%.		

Options to reduce the propagation risk include:

- Fire detection and foam suppression systems provided in the pump bay. This was not accounted for in the risk model due to the uncertainty in their ability to reduce the immediate impact of the incident. However it would reduce the severity of the fire.
- Hydrocarbon spill detection provided in the pump bay sump. This was not accounted for in the risk model as a large release and immediate ignition has occurred. However it would reduce the severity of the fire.

The PHA is based on a preliminary design of the site. As the detailed design progresses, particularly for the Site 1 pump bay area, TQ Holdings advised there will be further refinements to the design to minimise risks associated with this section of the plant. Additional measures may include dividing the pump bay surface area into smaller bund segments, incorporating drainage trenches to divide the area or installing protective barriers to minimise escalation into the neighbouring site.

Escalation risk can also be managed by TQ by ensuring that land occupiers north of Site 1 do not:

- locate equipment, piping or structures in this area.
- store or have dangerous goods present in this location.

10.4.2. Individual Fatality Risk

The 5×10^{-5} fatality risk contour extends offsite into the waterway between the sites but does not impact on areas where people are likely to be present. The major risk

contributors of the offsite fatality risk contour is shown in Table 10.3. The location of the analysis point is shown in Figure 10.3.

Options to reduce the fatality risk include:

- Automatic fire detection and stops road tanker export pumps. This was not accounted for in the risk model as a release and immediate ignition has occurred.

Table 10.3: Major risk contributors at selected points – individual fatality

Analysis Point	Scenario	Risk Contribution Note 1
Analysis Point 2 (East of Site 2)	Jet Fire – Gasoline leak from Road Tanker Gantry	81%
	Jet Fire – Diesel leak from Road Tanker Gantry	15%
	Total	96%
Note 1: Only the major risk contributor scenarios are recorded in this table and hence the total risk contribution do not add up to 100%.		

10.5. Assessment of Cumulative Risk

The final SEARs requires TQ Holdings to estimate the cumulative risk that PKBLT site presents to the existing risk profile for the area (if any). As there is no quantitative risk model for the existing site and surrounding development available in the public domain, the change to the cumulative risk model was assessed qualitatively.

The existing land uses adjacent to the PKBLT site include:

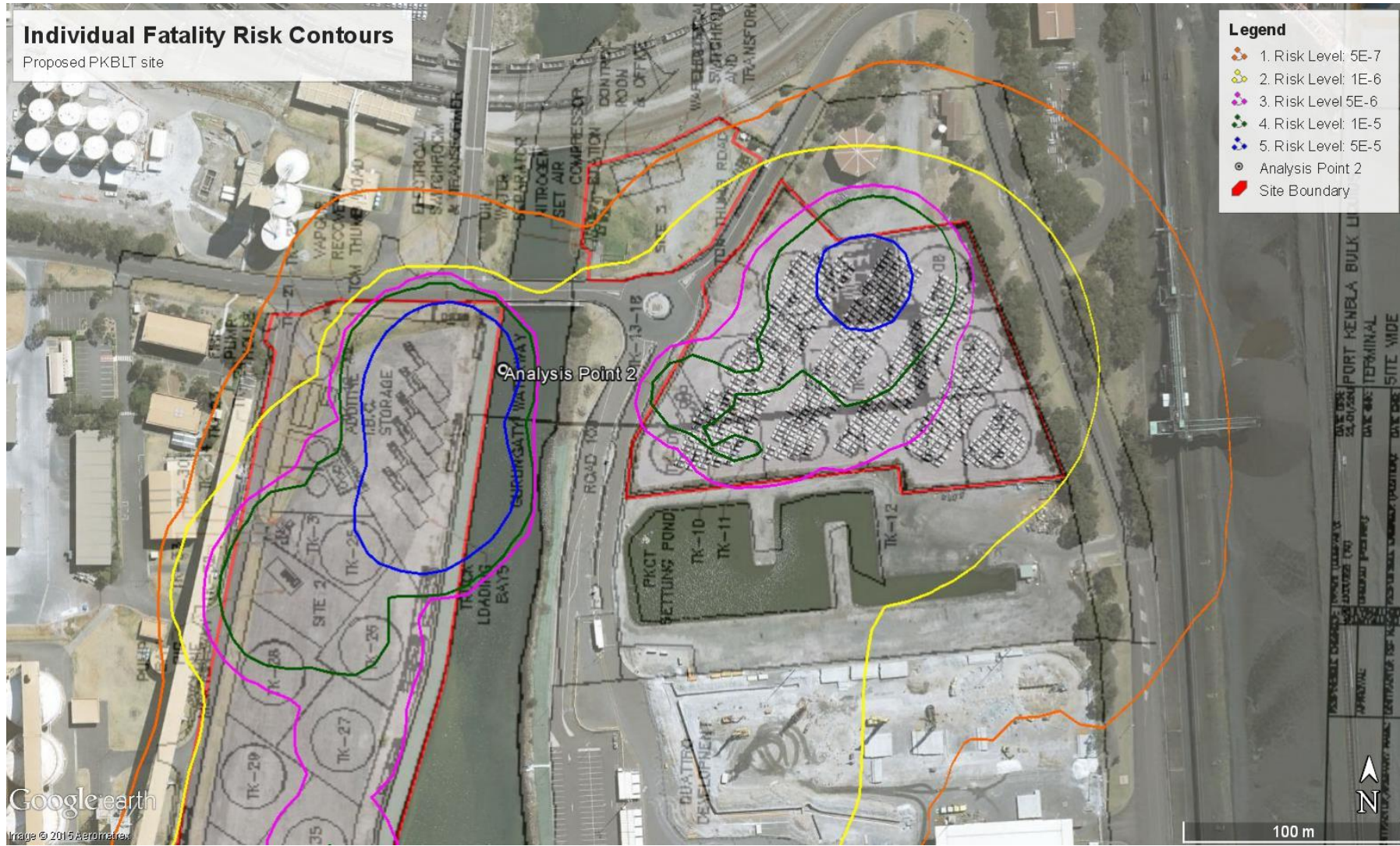
- Coal stockpiles to the west of Site 1 at PKCT
- Grain silos to the east of Site 2 at the Grain Terminal
- Grain silos to the south of Site 1 at the Quattro development.

The main risks associated with the coal stockpiles are coal dust explosions and stockpile fires. Dust explosion risks are typically managed by design and codes and standards. Consequences are typically limited to structural damage onsite. The separation distance from the coal stockpile to the nearest tank on PKBLT site is 90 m. Escalation from a coal stockpile fire to the nearest tank is not considered credible based on the separation distance.

The main risk associated with grain silo storage is dust explosions. These consequences are typically retained onsite. As a result the fatality risk is retained onsite.

In the absence of risk models for adjacent developments in the area, a qualitative assessment of their risk indicates that there is low cumulative risk in the area as risk contours typically remain onsite for all developments.

Figure 10.3: Individual fatality risk contours – Analysis point



11. CONCLUSIONS

11.1. SEPP 33 Analysis Findings

The SEPP33 analysis found that the quantities of Class 3 PG II, ie gasoline, stored onsite exceeded the threshold quantities stated in the SEPP33 guideline (Ref. 15). The proposed development is '*potentially hazardous*' and a PHA study is required.

The SEPP33 analysis also found that a route evaluation study is required as weekly vehicle movements of Class 3 PG II materials are above the SEPP33 transport screening threshold levels. This requirement is addressed in the Traffic Impact Assessment by Cardno in accordance with HIPAP No. 11 guideline.

11.2. Preliminary Hazard Analysis Findings

A quantitative PHA was completed for the preliminary design of the site. The results of the PHA are compared with the HIPAP 4 criteria in Table 11.1.

Table 11.1: Summary of compliance of HIPAP 4 risk criteria

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Individual fatality risk		
Hospitals, child-care facilities and old age housing (sensitive land use).	5×10^{-7}	Yes
Residential developments and places of continuous occupancy such as hotels and tourist resorts (residential land use).	1×10^{-6}	Yes
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres (commercial land use).	5×10^{-6}	Yes
Sporting complexes and active open space areas (recreational land use).	1×10^{-5}	Yes
For industrial sites, individual fatality risk level should, as a target, be contained within the boundaries of the site where applicable.	5×10^{-5}	No
Injury risk – heat radiation exceeding 4.7 kW/m²		
Residential and sensitive use.	5×10^{-5}	Yes ^{Note 1}
Injury risk – explosion overpressure exceeding 7 kPa		
Residential and sensitive use.	5×10^{-5}	Yes ^{Note 2}
Risk of property damage and accident propagation – 23 kW/m² heat flux		
Neighbouring potentially hazardous installations or at land zoned to accommodate such installations.	5×10^{-5}	No

Description and land use	HIPAP 4 Criteria (per year)	Criterion Met
Risk of property damage and accident propagation – 14 kPa explosion overpressure		
Neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings.	5 x 10 ⁻⁵	Yes ^{Note 2}
<p>Note.</p> <p>1. Injury heat radiation contours do not extend into the nearest residential and sensitive land use areas.</p> <p>2. Explosion overpressures were not evaluated in relation to injury and property damage/ propagation risk as they are not generated.</p>		

The 5 × 10⁻⁵ per year individual fatality risk contour extends into the Gurungaty waterway east of Site 2 (up to 20 m from site boundary). This does not meet the **target** of retaining the risk contour within the site boundary where applicable. The affected area is a shallow waterway, which precludes ship or boat access, and is within the port area, which restricts public access. Hence it is unlikely people will be present in this area and exposed to the risk. Further risk reduction measures were not considered.

The 5 × 10⁻⁵ per year property damage and accident propagation risk contour extends into the neighbouring land north of Site 1 (up to 5 m from site boundary). This land is zoned to accommodate potentially hazardous installation. It is noted that there is currently no equipment, structures or dangerous goods located in the area.

The PHA is based on a preliminary design of the site. As the detailed design progresses, TQ Holdings advised there will be further refinements to the design to minimise risks associated with the site.

APPENDIX A. SEPP 33 ANALYSIS

A1. Methodology

The screening process published in the NSW Department of Planning and Environment (DPE) guideline *Hazardous & Offensive Development Application Guidelines – Applying SEPP33 (January 2011)* (Ref. 15) was used to establish whether the development is ‘*potentially hazardous*’. The analysis did not include assessing the site as ‘*potentially offensive*’. This is covered in the Traffic Impact Assessment in another section of the Environmental Impact Statement (EIS).

State Environmental Planning Policy (SEPP33) defines ‘*potentially hazardous*’ as follows:

‘Potentially hazardous industry’ means a development for the purposes of an industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:

(a) to human health, life or property; or

(b) to the biophysical environment, and:

includes a hazardous industry and a hazardous storage establishment.’

To determine whether a proposed development is ‘*potentially hazardous*’, the screening in SEPP33 considers the type and quantity of hazardous materials to be stored on the site and the distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

‘Hazardous materials’ are defined within the SEPP33 guideline as substances that fall within the classification of the Australian Dangerous Goods (ADG) Code.

A2. Dangerous goods

A2.1. Types and quantities of DG

A list of expected types and quantities of Dangerous Goods (DG) to be stored or handled at the development, together with the relevant SEPP33 screening threshold is presented in Table A.2. This is based on the storage tank capacities listed on the ‘Storage Vessel Concept Design Specs’ document provided by TQ Holdings (as of 21 April 2015), and is summarised in Table A.1.

A2.2. Storage arrangements

Storage arrangements are as described in Section 3 of the Preliminary Hazard Analysis (PHA) report. As the site configuration is such that storage of dangerous goods are in two separate areas (Site 1 and Site 2), the quantities of dangerous goods on each site and the combined site were considered.

The SEPP33 threshold quantity of Class 3 PG II materials is 5 tonnes based on the distance of the Site 1 bund wall to the site boundary of 1 m. Although C1 combustible liquid is classified as a dangerous good, it is stored in the same bund as Class 3 PG II materials. According to the SEPP33 guidelines, these combustible liquids should also be considered as Class 3 PG II materials. Table A.2 shows that the total quantity of Class 3 PG II materials on Port Kembla Bulk Liquids Terminal (PKBLT) site is 228,200 tonnes which is above the SEPP33 threshold quantity.

Therefore, the development is '*potentially hazardous*' and a PHA is required for the site.

A2.3. Transport

SEPP 33 guideline specifies that a '*proposed development may be potentially hazardous if the number of generated traffic movements (for significant quantities of hazardous materials entering or leaving the site) is above the annual or weekly cumulative vehicle movements*' (Ref. 15). For PKBLT, road tanker movements carrying Class 3 PG II materials need to be considered. If a site generates greater than 45 vehicle movements of Class 3 PG II materials per week, the proposal is considered to be potentially hazardous, and a transport route evaluation study should be completed in accordance with the DPE *HIPAP 11: Route Selection*.

TQ Holdings has advised that daily vehicle movements to and from the site will be approximately 209 road tankers, of which 35% is attributed to Class 3 PG II materials. This equates to approximately 512 vehicle movements per week of Class 3 PG II materials, which is greater than the SEPP33 screening threshold of 45 vehicle movements per week.

As a result, the development is '*potentially hazardous*' with respect to transportation and a route evaluation study in accordance with *HIPAP 11: Route Selection* will be required. This requirement is covered in Cardno's Traffic Impact Assessment.

Table A.1: Storage tank contents and capacities

Tank	Site ^{Note 1}	Product	Diameter (m)	Height (m)	Tank volume (m³)
TK-01	Site 1	Diesel	20	21.5	6,126
TK-02	Site 1	Diesel	20	21.5	6,126
TK-03	Site 1	Diesel	20	21.5	6,126
TK-04	Site 1	Diesel	29	28.9	18,032
TK-05	Site 1	Diesel	29	28.9	18,032
TK-06	Site 1	Diesel	29	28.9	18,032
TK-07	Site 1	Gasoline	29	28.9	18,032
TK-08	Site 1	Gasoline	29	28.9	18,032
TK-09	Site 1	Gasoline	29	28.9	18,032
TK-10	Site 1	Gasoline	10	21.5	1,532
TK-11	Site 1	Gasoline	10	21.5	1,532
TK-12	Site 1	Diesel	10	21.5	1,532
TK-13	Site 1	Diesel	3	4.8	32
TK-14	Site 1	Diesel	3	4.8	32
TK-15	Site 1	Oily water	3	4.8	32
TK-16	Site 1	Gasoline	3	4.8	32
TK-17	Site 1	Gasoline	3	4.8	32
TK-18	Site 1	Gasoline	3	4.8	32
TK-23	Site 2	Ethanol	10	21.5	1,532
TK-24	Site 2	Ethanol	10	21.5	1,532
TK-25	Site 2	Gasoline	29	28.9	18,032
TK-26	Site 2	Gasoline	29	28.9	18,032
TK-27	Site 2	Gasoline	29	28.9	18,032
TK-28	Site 2	Diesel	29	28.9	18,032
TK-29	Site 2	Diesel	29	28.9	18,032

Tank	Site ^{Note 1}	Product	Diameter (m)	Height (m)	Tank volume (m³)
TK-30	Site 2	Diesel	3	4.8	32
TK-31	Site 2	Gasoline	3	4.8	32
TK-32	Site 2	Gasoline	3	4.8	32
TK-33	Site 2	Oily water	3	4.8	32
TK-34	Site 2	Gasoline	3	4.8	32
TK-35	Site 2	Gasoline	29	28.9	18,032
TK-36	Site 2	Gasoline	29	28.9	18,032
TK-37	Site 2	Diesel	29	28.9	18,032
TK-38	Site 2	Diesel	24	28.9	12,260
TK-39	Site 2	Gasoline	3	4.8	32
TK-40	Site 2	Oily water	3	4.8	32
TK-41	Site 2	Flammable liquid additive	3	4.8	30
TK-42	Site 2	Flammable liquid additive	3	4.8	30

Notes:
1. On Site 2, there is also a curbed bund (Area – 97 m², Volume – 10 m³) where there is storage space for up to 14 Intermediate Bulk Containers (IBCs). Each IBC contains 1 m³ of flammable liquid additive.

Table A.2: SEPP33 hazardous material storage screening summary

Material	Purpose	UN no.	DG class	Quantity stored on site		SEPP33 threshold and determination
				m ³	tonnes	
Site 1						
Flammable	Storage	1203	3 PG II	57,350	42,550	Threshold quantity for Class 3 PG II is based on distance of bund wall from nearest site boundary. Based on Figure 9 in SEPP 33 (Ref 15) and 1 m distance to bund wall, the threshold quantity is 5 tonnes ^{Note 1} .
Combustible	Storage	3075	-	74,006	61,720	No threshold identified for Combustibles C1, based on SEPP33. However, since diesel is stored in the same bund as Class 3 PG II materials, total inventory of diesel would be classified as Class 3 PG II.
Total Class 3 PG II materials on Site 1				104,270		
Site 2						
Flammable	Storage	1203	3 PG II	93,433	69,130	Threshold quantity for Class 3 PG II is based on distance of bund wall from nearest site boundary. Based on Figure 9 in SEPP 33 (Ref 15) and 1 m distance to bund wall, the threshold quantity is 5 tonnes ^{Note 1} .
Combustible	Storage	3075	-	66,388	54,810	No threshold identified for Combustibles C1, based on SEPP33. However, since diesel is stored in the same bund as Class 3 PG II materials, total inventory of diesel would be classified as Class 3 PG II.
Total Class 3 PG II materials on Site 2				123,930		
Total Class 3 PG II materials on PKBLT				228,200		Total Class 3 PG II storage on PKBLT (including C1 Combustible liquid because it is stored in the same bund) exceed SEPP33 threshold quantity of 5 tonnes. Development is considered ' <i>potentially hazardous</i> ' and a PHA is required.
Note 1: The distance of bund wall from nearest site boundary was taken to be 1 m based on Site 1 layout.						

APPENDIX B. QRA OPERATIONAL BASIS

The information in the following table was supplied and approved by TQ Holdings.

Proposed Operation (Stage 3)			
Overview			
	Value	Unit	Comments
Site Throughput Total	2,947	ML/year	Calculated based on: - Road tanker movements and average tanker load for each road tanker (B-doubles). Note: Export is via road tanker only.
Incoming Product Transfer			
	Value	Unit	Comments
(Ship Import) Transfer Rate	1,250	m ³ /hr	Ship import rate via 4 parallel lines. 1,250 m ³ /hr is the maximum flow through one shoreline directed into a single tank. Typical transfer rate is 1,000 m ³ /hr but maximum is used to be conservative. This is equivalent to 7 m/s in tank inlet piping.
(Ship Import) Transfer Pressure	10	barg	Discharge pressure at the berth manifold was designed for 9 barg. TQ Holdings have confirmed using 10 barg to be conservative.
(Ship Import) Ship Volume	50,000 to 120,000	m ³	-
(Ship Import) Number of Marine Loading Arms (MLAs)	4	-	Maximum number of MLAs for Stage 3 operations.
(Ship Import) Transfer Duration	17	hr	Assume that 4 MLAs are connected up to ship. Average ship volume is assumed to be 85,000 m ³ .
(Ship Import) Online Time	544	hours/year	32 vessels per year.
(Ship Import) % Wharf Online Time	6%	per year	Calculated based on: - Number of hours online per year
(Ship Import) % Product Split (Combustible: Flammable)	65:35	-	Basis of design

Document number: PJ-PK-0001-REPT-010
Revision: 3
Revision Date: 4-Dec-2015
File name: PJ-PK-0001-REPT-010

	Value	Unit	Comments
(Ship Import) Piggings Frequency	-	-	Piggings is done at the end of the each shipment. Once per shoreline.
(EtOH Unloading) Transfer Rate	72,000	L/hour	1,200 litres/minute.
(EtOH Unloading) Transfer Pressure	10	barg	-
(EtOH Unloading) Transfer Frequency	1	transfer/day	-
(EtOH Unloading) Road Tanker Load	50,000	L/tanker	Typical delivery of ethanol will be by B-double road tanker.
(EtOH Unloading) Number of Hose Connections	2,920	times/year	Assume 3 connections for B-double road tanker.
(EtOH Unloading) Online Time	253	hours/year	Calculated based on: - Average road tanker load - Average transfer rate
(EtOH Unloading) % Gantry Online Time	3%	per year	Calculated based on: - Number of hours online per year
(Biodiesel Unloading) Transfer Rate	72,000	L/hour	Calculated based on transfer rate of 1200 litres/minute.
(Biodiesel Unloading) Transfer Pressure	10	barg	-
(Biodiesel Unloading) Transfer Frequency	2	transfers/day	Basis of design
(Biodiesel Unloading) Road Tanker Load	50,000	L/tanker	Typical delivery of biodiesel will be by B-double road tanker.
(Biodiesel Unloading) Number of Hose Connections	5,840	times/year	Assume 3 connections for B-double road tanker.
(Biodiesel Unloading) Online Time	507	hours/year	Calculated based on: - Average road tanker load - Average transfer rate
(Biodiesel Unloading) % Gantry Online Time	6%	per year	Calculated based on: - Number of hrs online per year
Outgoing Product Transfer			
(Product Loading) Road Tanker (Export) Throughput Total	2,947,448	m ³ /year	Based on road tanker movements and average tanker load for each road tanker (B-doubles)
(Product Loading) Road Tanker Movements	206	per day	Assumed 65:35 combustible/flammable

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	Value	Unit	Comments
(Product Loading) Road Tanker Load	39,200	L/tanker	Expected numbers of trucks: B-double trucks (50%): 50,000 L/truck Single trucks (40%): 31,000 L/truck Rigid trucks (10%): 18,000 L/truck
(Product Loading) Road Tanker Loading Time	25	minutes/loadout	-
(Product Loading) Road Tanker Loading Pressure	6	barg	-
(Product Loading) Road Tanker Loading Rate (3 arms)	432,000	litres/hour	2400 litres/minute per loading arm. Each arm will fill different compartment (allowing different products for each compartment on a B-double). Total loading rate is based on filling rate of 3 arms (max at a given time)
(Product Loading) % Gantry Online Time	100%	per year	Calculated based on: 206 vehicles/day across all products Average time to load is 25 minutes 24 hours of operation in a day
(Product Loading) % Loading Bay Online Time	60%	per year	Calculated based on: 206 vehicles/day across all products Average time to load is 25 minutes Assume product loading occurs equally across 6 loading bays
(Product Loading) Number of Hose Connections	263,165	times/year	Assume 1 connections for rigid and single trucks, and 3 connections for B-Double trucks.
Storage			
(Tank-to-tank transfer) Frequency of operation	5	per week/tank	
(Tank-to-tank transfer) Duration	24	hour/operation	
(Tank-to-tank transfer) Number of tanks	9	tanks	Number of ULP and diesel storage tanks on Site 2.
(Tank-to-tank transfer) Online Time	1,080	hours/year	Assumed 65:35 combustible/flammable
(Tank-to-tank transfer) Pressure	10	barg	

APPENDIX C. HAZARD IDENTIFICATION REGISTER

The following table shows the revision history of the Hazard Identification (HAZID) Register.

Revision	Date	Comments	By	Checked
3	04-Dec-2015	Issued for inclusion in EIS	M. Braid	S. Chia

HAZID REGISTER



Project: 20950 TQ Holdings Port Kembla Bulk Liquids Terminal
 Last Risk Register Rev: 3
 Rev Date: 4-Dec-15

ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
1	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 flammable liquids	Flammable liquid leak at wharf / shoreline / manifold	1. Valve stem leak 2. Flange / gasket leak 3. Pipework leak 4. Marine loading arm (MLA) swivel joint leak 5. External corrosion 6. Mechanical damage (eg. vehicle, third party maintenance from other berth users) 7. Line valve (eg. drain) accidentally / inadvertently opened	1. Pipework design for Class 3 flammable liquids 2. Regular / preventative maintenance (eg pipework, MLA) 3. Construction standards (eg painting) 4. Standard Operating Procedures (SOPs) (eg ship unloading) 5. Mechanical protection of line (eg bollards)	1. Operator surveillance "walking the line" 2. Closed Circuit Televisions (CCTVs) at berth monitored at control room 3. Marine Security Identification Card (MSIC) controlled access 4. Emergency Shutdown (ESD) 5. Hazardous area classification 6. Fire / foam monitors 7. Vessel fire systems at berth 8. Port authority / Site Emergency Response Procedures (ERP)	1. Spill into harbour and environmental issue 2. Jet / spray fire (if ignited) 3. Spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	Site will have dedicated foam systems (specific for ethanol and class 3 fuel products)	Yes
2	Berth 104	Fire / explosion (following release)	Ship Import	Class C1 combustible liquids	Combustible liquid leak at wharf / shoreline / manifold	See ID 1	See ID 1	See ID 1	1. Spill into harbour and environmental issue 2. Pool fire (if ignited)	-	Yes
3	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 flammable liquids	Marine loading arm failure leading to flammable liquid release (operational)	1. Ship movement (bad weather, poor monitoring) 2. Poor connection 3. Emergency scenario where ship required to pull away from berth 4. MLA / trolley movement 5. Operator error	1. Mooring around vessel secured to berth 2. MLA design incorporates position sensors and alarm 3. MLA disconnect and emergency release coupling (ERC) 4. Operational procedures (Port authority) 5. MLA operating limits 6. Control interlocks on MLA movement and trolley 7. SOPs 8. MLA (ship side) coupling connection sensors 9. Anchor point for trolley	1. SOPs (pressure test MLA connections prior to discharge) 2. Operator detection and response 3. CCTVs 4. Position sensor on MLA to detect movement out of range 5. ESD (fire alarm and shutdown) 6. Fire / foam monitors 7. ERP	1. Spill into harbour and environmental issue 2. Jet / spray fire (if ignited) 3. Spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
4	Berth 104	Fire / explosion (following release)	Ship Import	Class C1 combustible liquids	MLA failure leading to combustible liquid release (operational)	See ID 3	See ID 3	See ID 3	1. Spill into harbour and environmental issue 2. Pool fire (if ignited)	-	Yes
5	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 flammable liquids	MLA failure (parked position)	1. High winds 2. Operator error	1. Anchor point for trolley 2. MLAs drained of product following transfer	1. Operator detection and response 2. CCTVs 3. ERP	1. Minor spill into harbour and environmental issue 2. Minor jet / spray fire (if ignited) 3. Minor spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	-	No - small quantity in comparison to other flammable material inventories on site
6	Berth 104	Fire / explosion (following release)	Ship Import	Class C1 combustible liquids	MLA failure (parked position)	See ID 5	See ID 5	See ID 5	1. Minor spill into harbour and environmental issue 2. Minor pool fire (if ignited)	-	No - small quantity in comparison to other flammable material inventories on site
7	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 / C1	Loss of containment (LOC) of flammable liquid	1. Security breach	1. Port restricted area 2. MSIC card required 3. Port security and patrols 4. Pipeline emptied and resting on nitrogen blanket	1. Operator detection and response 2. CCTVs	1. LOC, and fire (if ignited)	-	No - outside scope
8	Berth 104	Fire / explosion (following release)	Ship Import	Class 3 / C1	Fire at berth	See IDs 1, 3 and 5	See IDs 1, 3 and 5 1. Isolation of potential ignition sources on the berth	1. Grain conveyors have some inherent protection (eg concrete / steel structure) 2. Fire / foam monitors 3. Vessel fire systems at berth 4. Port Authority / Site ERP	1. Escalated event to conveyors (Graincorp) 2. Escalated event to ship	-	No - outside scope
9	Berth 104	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	LOC of flammable liquid during draining and pigging (pig launcher)	1. Operator error (incorrectly isolates pig chamber prior to opening door) 2. Draining of MLA	1. Pig station / seal design 2. Lock-in pin (indicates if pressure still present) 3. Pig indicators 4. SOPs 5. Preventative maintenance (monthly, yearly checks)	1. Operator detection and response 2. CCTVs 3. ESD / emergency isolation points 4. ERP	1. Jet / spray fire (if ignited) 2. Spill onto berth, mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
10	Berth 104	Fire / explosion (following release)	Pigging	Class C1 combustible liquids	LOC of combustible liquid during draining and pigging (pig launcher)	1. Operator error (incorrectly isolates pig chamber prior to opening door)	See ID 9	See ID 9	1. Pool fire (if ignited)	-	Yes
11	Berth 104	Fire / explosion (following release)	Slops	Class 3 / C1	LOC of flammable liquid	1. Connection failure with vacuum truck 2. Operator error 3. Corrosion	1. Operator attendance 2. SOPs 3. Materials of construction for slop storage and handling	1. Spill cleanup kit 2. Fire extinguishers / protection	1. Minor spill (less than 100L), and fire (if ignited), potential for injury	-	Yes
12	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Tank overflow during ship import leading to flammable liquid release	1. Failure of level indicator 2. Human error / failure to line up or change over to correct tank (terminal side) 3. Human error / ship fails to stop pumping when instructed (ship side)	1. SOPs 2. Automated control system 3. High level alarm and operator response 4. High High level and terminal ESD (including wharf valves) 5. Independent level detection 6. Terminal to ship communication protocols 7. Bund wall height only 1.8m and good natural ventilation around site (reduces potential for vapour cloud formation)	1. Operator detection and response 2. Fills intermediate bund with detection (level and / or hydrocarbon) 3. Hazardous area classification 4. Fire system on adjacent tanks (for cooling) / AS1940 compliant 5. Foam pourers on all storage tanks / AS 1940 compliant	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	Once design has been finalised, a fire protection systems review will be undertaken.	Yes
13	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Tank overflow during ship import leading to combustible liquid release	See ID 12	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 12	Yes
14	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during ship import	1. Valve misalignment / human error	1. SOPs 2. Online density measurement in shoreline, transfer line and tank 3. Automated control and level protection system	1. Frangible tank roof 2. Storage tanks have vent reliefs (partially effective) 3. Intertank transfer pump and piping 4. Hazardous area classification 5. Fire / foam protection (provided on all tanks)	1. Overflow leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited) 3. Product contamination	-	Yes
15	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	LOC from pipework (within terminal) leading to flammable liquid release	1. Corrosion 2. External impact 3. Maintenance work 4. Pressure surge 5. Thermal jacking of pipeline pressure 6. Operator error (eg valve left open) 7. Product theft	1. Regular maintenance and inspection 2. Mechanical protection 3. Traffic management (eg. Road markings, speed limits, one way zones) 4. Thermal relief valves 5. Pipeline / equipment designed for expected maximum operating pressures (eg. surge analysis) 6. SOPs 7. Site security fence / restricted access	1. Operator patrols 2. CCTV 3. Controlled access (swipe cards onto site) 4. Driver induction 5. Isolation valves 6. Fire protection 7. ESD	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited 3. Product contamination	-	Yes

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ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
16	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	LOC from pipework (within terminal) leading to combustible liquid release	See ID 15	See ID 15	See ID 15	1. Pool fire (if ignited)	-	Yes
17	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid leak from tank	1. Tank rupture 2. Fitting leak on tank connection 3. Corrosion of tank base / weld 4. Faulty fabrication 5. Metal fatigue 6. Blocked vent 7. Mechanical impact (eg crane)	1. Tanks designed to American Petroleum Institute (API) standards 2. Hydrotested when constructed 3. Lining on bottom of tank 4. Preventative maintenance / inspection 5. By design, minimising connection points below tank liquid point 6. ITP QA QC / Fabrication 7. Safe work systems (eg Permission to work (PTW), lifting studies)	1. Operator detection and response 2. Intermediate bund with detection (level and / or hydrocarbon) and alarm 3. SOP / routine dewatering 4. In-tank water monitoring system 5. Splash shields provided around storage tanks close to external bund 6. Fire system on adjacent tanks (for cooling) / AS1940 compliant 7. Foam pourers on all storage tanks / AS 1940 compliant	1. Pool fire and potential full surface bund fire 2. Flash fire	-	Yes
18	Site 1 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Combustible liquid leak from tank	See ID 17	See ID 17	See ID 17	1. Pool fire and potential full surface bund fire (if ignited)	-	Yes
19	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Leak of pump in vicinity of storage tank leading to release of flammable liquid	1. Pump seal failure 2. Pumping against closed valve on pump discharge	1. Preventative maintenance procedures 2. Pump seal design	1. Regular patrols 2. Level / hydrocarbon detection 3. Hazardous area classification 4. Fire detection around pump bay 5. Terminal ESD 6. Site ERP	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	Fire design review still to be completed as part of detailed design (eg. Pump bay area)	No. Pump in vicinity of storage tank is used for dewatering
20	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Leak of pump in vicinity of storage tank leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	See ID 19	No. Pump in vicinity of storage tank is used for dewatering
21	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Pump bay area inside bund	1. Pump seal failure 2. Pumping against closed valve on pump discharge 3. Leak in bund where pumps sit	See ID 19	1. Regular patrols 2. Level / hydrocarbon detection in bund 3. Fire detection around pump bay 4. Terminal ESD 5. Site ERP	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	Site layout still to optimised (in particular site 1 transfer pumps)	Yes
22	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Pump bay area inside bund	See ID 21	See ID 19	See ID 21	1. Pool fire (if ignited)	See ID 21	Yes
23	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Tank overflow during tank-to-tank transfer leading to flammable liquid release	1. Failure of level indicator 2. Human error / failure to line up or change over to correct tank	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	To be covered in HAZOP	Yes
24	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Tank overflow during tank-to-tank transfer leading to combustible liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 23	Yes
25	Site 1 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during tank-to-tank transfer	See ID 14	See ID 14	See ID 14	1. Overflow leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
26	Site 1 Storage	Fire / explosion (following release)	Recirculation	Class 3 / C1	Recirculation to incorrect tank	1. Human error / wrong line-up	See ID 14	See ID 14	1. Overflow leading to LOC of flammable liquid and fire (if ignited) 2. Quality off-spec	-	Yes
27	Site 1 Storage	Fire / explosion (following release)	Recirculation	Class 3 flammable liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	1. Insufficient liquid level	1. Control system and interlock on mixing nozzle operation 2. SOPs (sufficient liquid level)	1. SOPs (eg. Manual dipping) 2. Tank level detection 3. Frangible tank roof 4. Hazardous area classification 5. Fire system on adjacent tanks (for cooling) / AS1940 compliant 6. Foam pourers on all storage tanks / AS 1940 compliant	1. Damage to internal floating roof (IFR), increase in vapour emissions. Potential for explosion inside tank (if ignited)	-	Yes
28	Site 1 Storage	Fire / explosion (following release)	Recirculation	Class C1 combustible liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	See ID 27	See ID 27	See ID 27	1. Vapour formation, and potential to form flammable diesel mist. Potential for explosion inside tank (if ignited)	-	Yes
29	Site 1 Storage	Fire / explosion (following release)	Working tank	Class 3 flammable liquids	Product loading pump leak leading to release of flammable liquid	See ID 19	See ID 19	See ID 19	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
30	Site 1 Storage	Fire / explosion (following release)	Working tank	Class C1 combustible liquids	Product loading pump leak leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	-	Yes
31	Site 1 Storage	Fire / explosion (following release)	Working tank	Class 3 / C1	Pump runs dry	1. Insufficient liquid in tank 2. Wrong valve line-up / blocked line	1. Level control system 2. Low level trip 3. SOPs 4. Limit switches for inlet and outlet valves / pump permissives	1. Pump low flow protection 2. Terminal ESD 3. Fire detection around pump bay 4. Site ERP	1. Damage to pump, potential mechanical failure / explosion 2. Suck air into piping (in event of low tank level), flammable mixture formation and explosion in pump/piping	-	No - does not lead to release of flammable/combustible liquid
32	Site 1 Storage	Fire / explosion (following release)	Blending (In-tank)	Class 3 flammable liquids	Tank overflow during P98 and ULP blending (in tank) leading to flammable liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE if sufficient vapours and ignited	See ID 23	Yes
33	Site 1 Storage	Fire / explosion (following release)	Blending (In-tank)	Class C1 combustible liquids	Tank overflow during biodiesel and diesel blending (in tank) leading to combustible liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 23	Yes
34	Site 1 Storage	Fire / explosion (following release)	Dewatering	Class 3 flammable liquids	Release of flammable liquid to bund	1. Tank drain valve left open 2. Tank sampling valve left open (operator error)	1. SOPs	1. High level alarm and inlet valve closed on slops tank 2. High High level trip initiates terminal ESD 3. Bunding 4. Fire protection system 5. Site ERP	1. Overflow of slops tank, pool fire and potential full surface bund fire 2. Flash fire	-	Yes
35	Site 1 Storage	Fire / explosion (following release)	Dewatering	Class C1 combustible liquids	Release of combustible liquid to bund	See ID 34	See ID 34	See ID 34	1. Overflow of slops tank, pool fire (if ignited)	-	Yes
36	Site 1 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	LOC of flammable liquid during pigging (pig receiver)	1. High pressure nitrogen used for pushing pigs	1. Emergency relief vents on tanks 2. Pigging vents on IFR 3. Diffuse fill nozzle in storage tank	1. Operator detection and response 2. Terminal ESD 3. ERP	1. Damage to IFR due to nitrogen blowby, increased vapour emissions 2. Damage to tank roof due to nitrogen blowby, potential to blow roof off 3. Jet / Spray fire (if ignited) 4. Mist and pool evaporation, flash fire if sufficient vapours and ignited	See ID 23	Yes - included as release from ship import pipeline

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ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
37	Site 1 Storage	Fire / explosion (following release)	Pigging	Class C1 combustible liquids	LOC of combustible liquid during pigging (pig receiver)	See ID 36	See ID 36	See ID 36	1. Damage to tank roof due to nitrogen blowby, potential to blow roof off 2. Pool fire (if ignited)	See ID 23	Yes - included as release from ship import pipeline
38	Site 1 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	Release of stored energy when opening pig receiver	1. Locked in pressure / operator error 2. Operator error (incorrectly isolates pig chamber prior to opening door)	1. SOPs 2. Pig receiver design prevents opening when pressurised	1. Pig receiver pressure indication 2. Pig receiver locking plug has integral pressure relief	1. Equipment damage and potential injury / fatality	-	No - does not lead to release of flammable/combustible liquid
39	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Tank overflow during ship import leading to flammable liquid release	See ID 12	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	See ID 12	Yes
40	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Tank overflow during ship import leading to combustible liquid release	See ID 12	See ID 12	See ID 12	1. Pool fire (if ignited)	See ID 12	Yes
41	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during ship import	See ID 14	See ID 14	See ID 14	1. Overflow leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
42	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	LOC from pipework (within terminal) leading to flammable liquid release	See ID 15	See ID 15	See ID 15	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
43	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	LOC from pipework (within terminal) leading to combustible liquid release	See ID 15	See ID 15	See ID 15	1. Pool fire (if ignited)	-	Yes
44	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class 3 flammable liquids	Flammable liquid leak from tank	See ID 17	See ID 17	See ID 17	1. Pool fire and potential full surface bund fire 2. Flash fire	-	Yes
45	Site 2 Storage	Fire / explosion (following release)	Tank Filling/Storage	Class C1 combustible liquids	Combustible liquid leak from tank	See ID 17	See ID 17	See ID 17	1. Pool fire and potential full surface bund fire	-	Yes
46	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Leak of pump in vicinity of storage tank leading to release of flammable liquid	See ID 19	See ID 19	See ID 19	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	See ID 19	No. Pump in vicinity of storage tank is used for dewatering
47	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Leak of pump in vicinity of storage tank leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	See ID 19	No. Pump in vicinity of storage tank is used for dewatering
48	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Pump bay area inside bund	See ID 21	See ID 19	See ID 21	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	Site layout still to optimised (in particular site 2 transfer pumps)	Yes
49	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Pump bay area inside bund	See ID 21	See ID 19	See ID 21	1. Pool fire (if ignited)	See ID 48	Yes
50	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Tank overflow during tank-to-tank transfer leading to flammable liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE, if sufficient vapours and ignited	-	Yes
51	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class C1 combustible liquids	Tank overflow during tank-to-tank transfer leading to combustible liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire (if ignited)	-	Yes
52	Site 2 Storage	Fire / explosion (following release)	Tank-to-tank transfer	Class 3 flammable liquids	Flammable liquid sent into combustible storage tanks during tank-to-tank transfer	See ID 14	See ID 14	See ID 14	1. Overflow leading to LOC of flammable liquid and fire (if ignited) 2. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
53	Site 2 Storage	Fire / explosion (following release)	Recirculation	Class 3 flammable liquids	Recirculation to incorrect tank leading to release of flammable liquid	See ID 26	See ID 14	See ID 14	1. Overflow leading to LOC of flammable liquid and fire (if ignited) 2. Quality off-spec	-	Yes
54	Site 2 Storage	Fire / explosion (following release)	Recirculation	Class 3 flammable liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	See ID 27	See ID 27	See ID 27	1. Damage to internal floating roof (IFR), increase in vapour emissions. Potential for explosion inside tank (if ignited)	-	Yes
55	Site 2 Storage	Fire / explosion (following release)	Recirculation	Class C1 combustible liquids	Recirculation via mixing nozzle into tank with insufficient liquid level	See ID 27	See ID 27	See ID 27	1. Vapour formation, and potential to form flammable diesel mist. Potential for explosion inside tank (if ignited)	-	Yes
56	Site 2 Storage	Fire / explosion (following release)	Working tank	Class 3 flammable liquids	Product loading pump leak leading to release of flammable liquid	See ID 19	See ID 19	See ID 19	1. Jet / spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
57	Site 2 Storage	Fire / explosion (following release)	Working tank	Class C1 combustible liquids	Product loading pump leak leading to release of combustible liquid	See ID 19	See ID 19	See ID 19	1. Pool fire (if ignited)	-	Yes
58	Site 2 Storage	Fire / explosion (following release)	Working tank	Class 3 / C1	Pump runs dry	See ID 31	See ID 31	See ID 31	1. Damage to pump, potential mechanical failure / explosion 2. Suck air into piping (in event of low tank level), flammable mixture formation and explosion in tank	-	No - does not lead to release of flammable/combustible liquid
59	Site 2 Storage	Fire / explosion (following release)	Blending (In-tank)	Class 3 flammable liquids	Tank overflow during P98 and ULP blending (in tank) leading to flammable liquid release	See ID 23	See ID 12	See ID 12	1. Pool fire and potential full surface bund fire 2. Tank roof fire and escalation to adjacent tanks 3. Mist and pool evaporation, flash fire / VCE if sufficient vapours and ignited	-	Yes
60	Site 2 Storage	Fire / explosion (following release)	Dewatering	Class 3 flammable liquids	Release of flammable liquid to bund	See ID 34	See ID 34	See ID 34	1. Overflow of slops tank, pool fire and potential full surface bund fire 2. Flash fire	-	Yes
61	Site 2 Storage	Fire / explosion (following release)	Dewatering	Class C1 combustible liquids	Release of combustible liquid to bund	See ID 34	See ID 34	See ID 34	1. Overflow of slops tank, pool fire (if ignited)	-	Yes
62	Site 2 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	LOC of flammable liquid during pigging (pig receiver)	See ID 36	See ID 36	See ID 36	1. Damage to IFR due to nitrogen blowby, increased vapour emissions 2. Damage to tank roof due to nitrogen blowby, potential to blow roof off 3. Jet / Spray fire (if ignited) 4. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
63	Site 2 Storage	Fire / explosion (following release)	Pigging	Class C1 combustible liquids	LOC of combustible liquid during pigging (pig receiver)	See ID 36	See ID 36	See ID 36	1. Damage to tank roof due to nitrogen blowby, potential to blow roof off 2. Pool fire (if ignited)	-	Yes
64	Site 2 Storage	Fire / explosion (following release)	Pigging	Class 3 flammable liquids	Release of stored energy when opening pig receiver	See ID 38	See ID 38	See ID 38	1. Equipment damage and potential injury / fatality	-	No - does not lead to offsite impacts

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ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
65	Site 2 Storage	Fire / explosion (following release)	Additive injection	Class 3 flammable liquids	LOC during handling and operation	1. Poor connection 2. Manual handling (dropped load, puncture)	1. SOPs for inventory control and level monitoring. 2. Fit-for-purpose dosing equipment (stainless steel lines used)	1. Hazardous area classification 2. Spill kits 3. Fire fighting equipment (eg. Extinguishers)	1. Spill and pool fire (if ignited), minor impact due to low quantity	There will be a variety of hazards, class 3 was chosen as representative for HAZID. Additives can be stored in 20L to 30m3 vessels.	No - small quantity in comparison to other flammable material inventories on site
66	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class 3 flammable liquids	Flammable liquid leak during road tanker export / import	1. Failure of flexible connections / hose / loading arm 2. Leak from valves or fittings 3. Damaged road tanker	1. SOPs for loadout (driver inspection prior to loading) 2. Safe work systems (eg driver induction) 3. Preventative maintenance	1. Driver always present 2. CCTV's 3. Dead man system 4. Hazardous area classification 5. Truck area banded and collects to a central area with fire trap 6. ESD 7. Fire detection and foam deluge (road gantry)	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
67	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class C1 combustible liquids	Combustible liquid leak during road tanker export / import	See ID 66	See ID 66	See ID 66	1. Pool fire (if ignited)	-	Yes
68	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class 3 flammable liquids	Overfill of road tanker during road tanker export leading to release of flammable liquid	1. Driver error / incorrect parcel size entered / incorrect compartment connected 2. Tanker compartment not drained prior to loading	1. SOPs for loadout (driver inspection prior to loading) 2. Safe work systems (eg driver induction) 3. Road tanker details (including compartment sizes and safe fills) are registered on the loading system 4. Truck ID in loading bay prior to loading	1. Scully system (high level protection) 2. Hazardous area classification 3. Truck area banded and collects to a central area with fire trap 4. ESD 5. Fire detection and foam deluge (road gantry)	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
69	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class C1 combustible liquids	Overfill of road tanker during road tanker export leading to release of combustible liquid	See ID 68	See ID 68	See ID 68	1. Pool fire (if ignited)	-	Yes
70	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class 3 flammable liquids	Road tanker driveway whilst still connected (after road tanker export) leading to release of flammable liquid	1. Driver error	1. SOPs 2. Truck brake interlock 3. Safe work systems	1. CCTV 2. Hazardous area classification 3. Fire detection and protection	1. Jet / Spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
71	Site 2 Gantry	Fire / explosion (following release)	Road tanker filling/export/backfill	Class C1 combustible liquids	Road tanker driveway whilst still connected (after road tanker export) leading to release of combustible liquid	See ID 70	See ID 70	See ID 70	1. Pool fire (if ignited)	-	Yes
72	Site 2 Gantry	Fire / explosion (following release)	Blending (In-line)	Class 3 flammable liquids	Overfill of road tanker during ethanol and ULP blending (in line) leading to release of flammable liquid	1. Failure of level indicator 2. Human error / failure to line up or change over to correct tank	See ID 68	See ID 68	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
73	Site 2 Gantry	Fire / explosion (following release)	Blending (In-line)	Class 3 flammable liquids	Overfill of road tanker during ULP and P98 blending (in line) leading to release of flammable liquid	See ID 72	See ID 68	See ID 68	1. Jet / spray fire (if ignited) and potential for incident escalation 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
74	Site 2 Gantry	Fire / explosion (following release)	Blending (In-line)	Class C1 combustible liquids	Overfill of road tanker during biodiesel and diesel blending (in line) leading to release of combustible liquid	See ID 72	See ID 68	See ID 68	1. Pool fire (if ignited)	-	Yes
75	Site 2 Gantry	Fire / explosion (following release)	Road tanker import	Class 3 flammable liquids	Overfill of ethanol tank during road tanker import	1. Tank level gauge failure reading low level 2. Valve misalignment and material sent into wrong tank 3. Driver error	See ID 12	See ID 12	1. Jet / Spray fire (if ignited) 2. Mist and pool evaporation, flash fire if sufficient vapours and ignited	-	Yes
76	Site 2 Gantry	Fire / explosion (following release)	Road tanker import	Class C1 combustible liquids	Overfill of biodiesel tank during road tanker import	See ID 75	See ID 12	See ID 12	1. Pool fire (if ignited)	-	Yes
77	Site 2 Gantry	Fire / explosion (following release)	Road tanker import	Class 3 flammable liquids	Flammable liquid (ethanol) sent into combustible storage tanks during road tanker import	See ID 14	See ID 14	See ID 14	1. Product loss of quality 2. In worst case overfill leading to LOC of flammable liquid and fire (if ignited) 3. Overpressure of tank vapour space (fixed roof) leading to LOC of flammable liquid and fire (if ignited)	-	Yes
78	Site 2 Gantry	Fire / explosion (following release)	Vapour Recovery Unit	Class 3 / C1	Leak at vapour recovery unit	1. Failure of vessel due to corrosion 2. Overflow of hydrocarbon product into Vapour Recovery Unit (VRU) 3. Overloading (depressuring wharf line, road gantry)	1. Liquid knock out vessel upstream of VRU and high level alarm 2. Preventative maintenance	1. Operator patrols 2. Operator monitoring of system 3. By design / VRU will have flame / detonation arrestor	1. Release of vapour 2. Potential for fires (flash) and environmental impact	-	No - small hydrocarbon inventory
79	Site 3	Exposure to personnel	Nitrogen system	Nitrogen	Use of nitrogen instead of air in confined spaces during maintenance	1. Human error	1. Dedicated fittings for air and nitrogen 2. Labelling 3. SOPs 4. Safe work practices (PTWs) 5. Continuous monitoring of oxygen in confined space	-	1. Potential asphyxiation	-	No - does not lead to offsite impacts
80	Site 3	Exposure to personnel	Nitrogen system	Nitrogen	LOC of liquid nitrogen	1. Mechanical failure during refilling activities	1. Safe work practices 2. 3rd party nitrogen supplier 3. Mechanical protection (eg bollards)	-	1. Cold burns, exposure to asphyxiant	-	No - does not lead to offsite impacts
81	Site 3	Exposure to personnel	Electrical	Energy source	Exposure to live electrical equipment / conductors	1. Human error 2. Damaged equipment	1. Safe work practices (PTW, LOTO, isolations) 2. No high voltage equipment onsite 3. IP2X 4. Electrical equipment tested and tagged	1. Residual-current devices on outlets for portable equipment	1. Electrocution, potential for fatality	-	No - does not lead to offsite impacts
82	Site 3	General Discussion	Electrical	Air	Non-intrinsically safe equipment causing an ignition in a flammable atmosphere	-	1. Safe work practices (inductions) 2. No mobile phones onsite 3. IS equipment used onsite	1. Design reviews 2. Installation QA / QC	1. Potential fatality	This underpins credit taken for hazardous area classification and minimising ignition probability on site.	No - does not lead to offsite impacts
83	Site 3	General Discussion	Air	Air	Not considered a major safety issue	-	-	-	-	-	No - not a major safety issue
84	Site 3	Waste products and materials	Oily water	Oily water	Uncontrolled discharge of oily water	1. Stormwater / contamination	1. Stormwater in areas where hydrocarbon leaks can occur, are collected and sent to wastewater treatment 2. Sluice gate to contain contaminated water onsite	-	1. Environmental impact 2. Breach of license conditions	-	No - not a major safety issue
85	Site 3	General Discussion	General	-	Workshop / office fire	1. Electrical fire 2. Poor house keeping (oily rags) 3. Kitchen fire 4. Spillage of hydrocarbon in workshop / hot work	1. Housekeeping 2. All electrical equipment tested and tagged 3. Building will be BCA compliant 4. Safe work practices (eg draining of equipment)	1. Building located in non-hazardous areas 2. Building has smoke detectors 3. Fire extinguishers	1. Fire, potential for injury	-	No - does not lead to offsite impacts
86	Sitewide	Natural Occurrence	General	-	Tank / equipment damage from weather event	1. Strong winds 2. Earthquake 3. Flooding 4. Lightning strikes	1. Tanks designed to API 2. Site above 1 in 100 year flood zone 3. Lightning protection	-	1. LOC leading to fire (if ignited)	-	No - outside scope

HAZID REGISTER

ID	Plant Area	Guide Word	Operational Mode	Hazard / Material	Hazardous Scenario	Causes	Controls - Prevention	Controls - Detection / Mitigation	Consequence	Comments	Carried Forward to QRA
87	Sitewide	External Dependencies	General	-	Incident on neighbouring facility	1. Fire in neighbouring facility / grain silo dust explosion, escalating to tanks	1. Facility designed to AS1940	1. ERP	1. Potential for injury to site personnel, evacuation required.	Not considered a major safety issue and risk onto site	No - outside scope
88	Sitewide	External Dependencies	General	-	Derailment of train on neighbouring facility	1. Driver error 2. Track integrity failure	1. Train speed limits 2. SOPs	-	1. Potential for injury worst case	Team consider this to be a very unlikely circumstance	No - outside scope
89	Sitewide	External Dependencies	General	-	Aircraft crash	1. Pilot error 2. Bad weather 3. Engine failure	1. Not on major flight path	-	1. LOC leading to fire (if ignited)	-	No - outside scope
90	Sitewide	Security Issues	General	-	Breach of security / sabotage	1. Disgruntled employee 2. Intruder	1. Background checks / MSIC requirement 2. Access control	1. CCTV 2. Secured site 3. Port authority security patrols 4. Operator patrols	1. Equipment loss or damage, fuel loss	-	No - outside scope
91	Sitewide	Sudden release of energy	General	-	Use of hoses with compressed air / nitrogen	1. High pressure gas	1. Safe work practices 2. Preventative maintenance procedures 3. Depressuring of lines after use 4. Hose fitting design to prevent quick disconnect under pressure	1. Vent valves on all hoses connections to allow safe venting before disconnecting	1. Potential fatality	-	No - does not lead to offsite impacts
92	Sitewide	General Discussion	General	-	Construction of plant adjacent to operating site	1. Phased development	1. Site development has considered in the design minimising the impact of construction activities when various plant areas are in operation. 2. NT undertaking construction HAZID and safety study once program is finalised	-	1. Potential hot work / construction activities interaction with flammable product movements. In worst case accident, LOC leading to fire / explosion (if ignited)	-	No - outside scope

APPENDIX D. CONSEQUENCE ANALYSIS

The following consequences were evaluated to determine the characteristics of unignited and ignited scenarios of hydrocarbon releases for the proposed Port Kembla Bulk Liquids Terminal:

- Jet fires
- Pool fires
- Flash fires
- Tank roof fires
- Tank bund fires.

D1. Jet Fire

Jet fire results are summarised in Table D.1. These tables provide the dimensions of the jet fires for each identified release conditions (ie based on the product type and pressure) for release sizes less than 25 mm, as per the rule set outlined in Table 4.2. Additionally, distance to heat radiation levels of interest (as per Table 4.4) are also reported.

These results represent continuous release without isolation which represents the worst case scenario for any given leak.

Table D.1: Jet Fire Consequence Results

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Jet Fire (at wind speed 5 m/s)						
					Length (m)	Width (m)	Horizontal Distance to Heat Radiation from Leak (m)				
							23 kW/m ²	20 kW/m ²	14 kW/m ²	10 kW/m ²	4.7 kW/m ²
Berth - Ship Import Shoreline Pumps/ Manifold/ Pipework	Gasoline	10	2	0.1	3	1	5	5	5	6	7
			6	0.7	8	3	13	13	15	16	19
			22	9.3	25	11	42	43	47	51	63
Pumps/ Manifold/ Road Gantry - Tanker Export	Gasoline	6	2	0.1	3	1	4	5	5	5	6
			6	0.5	8	3	12	13	14	15	18
			22	7.3	23	10	39	40	44	47	58
Berth - Ship Import Shoreline Pumps/ Manifold/ Pipework Road Gantry - Tanker Import	Diesel	10	2	0.1	3	1	5	5	5	6	7
			6	0.7	8	3	13	13	14	15	19
			22	9.4	24	10	41	43	46	50	61
Pumps/ Manifold/ Road Gantry - Tanker Export	Diesel	6	2	0.1	3	1	4	4	6	5	6
			6	0.6	7	3	12	12	13	14	17
			22	7.4	23	10	38	40	43	46	57
Road Gantry - Tanker Import Pumps/Manifold/Pipework	Ethanol	10	2	0.1	5	2	6	7	7	7	8
			6	0.7	14	6	17	17	18	20	23
			22	6.9	35	15	46	47	50	53	61

D2. Pool Fire

Pool fire results are summarised in Table D.2. The reported results include the release rate, equivalent pool diameter and distance to heat radiation levels of interest (as specified in Table 4.4).

In this assessment, liquid hydrocarbon from a leak was assumed to form a circular pool (spreading in all directions), unless limited by the bund. Subsequently, the pool fire dimensions were calculated assuming equilibrium where the burn rate equals the release rate of the material.

The fire duration and potentially the size of a pool fire is dependent upon the time to detect and stop a leak. These results represent continuous release without isolation which represents the worst case scenario for any given leak. The size of the liquid pool in most areas may also be limited by bunds, the terrain and drainage.

The limiting size used in the QRA for different release locations were:

- Berth 104: 254 m²
 - Basis - Limited by the width of the berth.
 - Equivalent to 18 m pool diameter.
- Ship import / transfer pipework: Not limited
 - Basis – Assumed that the pool fire was not limited in size as there is no bunding/kerbing included in current design
- Manifold / Pump Bay: 1138 m² (Site 1) and 1215 m² (Site 2)
 - Basis – Manifold and pumps are located within bunded pump bays which would limit pool growth for large releases.
 - Equivalent to 39 m (Site 1) and 38 m (Site 2) pool diameter.
 - Note: For ethanol leaks from the Site 2 manifold or pump bay (during road tanker unloading), the resulting pool fire is limited by the pump bay bund which has an area of 116 m² (equivalent to 12 m pool diameter).
- Road Tanker Gantry:
 - Basis - Limited by the kerbing provided around each loading bay (5 m x 25 m) and drainage which would limit pool growth for large releases.
 - Equivalent to 13 m pool diameter.

Table D.2: Pool Fire Consequence Results

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Equivalent Pool Diameter (m)	Pool Fire (at wind speed 5 m/s) Horizontal Distance to Heat Radiation from Pool Centre (m)					
						Flame Length	23	20	14	10	4.7
							kW/m ³	kW/m ²	kW/m ²	kW/m ²	kW/m ²
Berth 104 - Ship Import	Gasoline	10	85	138	18	24	31	32	36	39	46
			RUP (250)	260*	18	24	31	32	36	39	46
Shoreline/Pipework (Outside of bunds)	Gasoline	10	85	138	52	56	74	77	84	91	109
			RUP (300)	260*	71	73	96	99	108	117	141
Site 1 Manifold/Pumps (Tank-to-tank transfer)	Gasoline	10	85	138	38	44	58	60	66	71	85
			RUP (300)	260*	38	44	58	60	66	71	85
Site 1 Manifold/Pumps (Road Tanker Export)	Gasoline	6	85	30*	25	31	40	42	47	51	60
			RUP (300)	30*	25	31	40	42	47	51	60
Site 2 Manifold/Pumps	Gasoline	10	85	138	39	46	61	63	69	75	90
			RUP (300)	260*	39	46	61	63	69	75	90
Road Gantry - Export	Gasoline	6	85	30*	13	14	27	31	36	40	48
			RUP (200)	30*	13	14	21	22	24	25	30
Berth 104 - Ship Import	Diesel	10	85	140	18	23	30	32	35	38	45
			RUP (250)	288*	18	23	30	32	35	38	45
Shoreline/Pipework (Outside of bunds)	Diesel	10	85	140	53	56	74	76	84	91	109
			RUP (300)	288*	76	76	99	103	112	122	147
Site 1 Manifold/Pumps (Tank-to-tank transfer)	Diesel	10	85	140	38	43	57	59	65	70	84
			RUP (300)	288*	38	43	57	59	65	70	84
Site 1 Manifold/Pumps (Road Tanker Export)	Diesel	6	85	30*	26	30	40	42	47	50	60
			RUP (300)	30*	26	30	40	42	47	50	60
Site 2 Manifold/Pumps	Diesel	10	85	140	41	45	59	61	67	73	87
			RUP (300)	288*	41	45	59	61	67	73	87
Road Gantry - Export	Diesel	6	85	33*	13	14	21	22	23	25	30

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Equivalent Pool Diameter (m)	Pool Fire (at wind speed 5 m/s) Horizontal Distance to Heat Radiation from Pool Centre (m)					
						Flame Length	23 kW/m ³	20 kW/m ²	14 kW/m ²	10 kW/m ²	4.7 kW/m ²
			RUP (200)	33*	13	14	21	22	23	25	30
Road Gantry - Biodiesel Import	Diesel	10	85	18*	13	14	21	22	23	25	30
			RUP (200)	18*	13	14	21	22	23	25	30
Site 2 Manifold/Pumps	Ethanol	10	85	16*	12	14	17	17	19	21	26
			RUP (300)	16*	12	14	17	17	19	21	26
Road Gantry - Ethanol Import	Ethanol	10	85	16*	13	15	17	18	19	21	27
			RUP (200)	16*	13	15	17	18	19	21	27
<p>Note:</p> <p>1. * indicates that the release rate is limited by the process/transfer flow rate</p> <p>2. Where appropriate, pool growth from large liquid releases of liquid are limited by physical restriction on site (eg by design - kerbing and bunding). These include areas such as the berth, the transfer manifold and pump manifold.</p>											

D3. Flash Fire

Vapour clouds result from the evaporation of light components of releases of gasoline which pool on the ground. Similar to pool fires, the maximum size of a pool can be limited by bund walls. The limiting sizes are described in Section D2 (Pool fires).

The rate of evaporation and the dispersion characteristics from a spill are dependent on the weather conditions. The modelling showed that flammable clouds only develop under very stable and low wind speed condition (represented by F2 weather stability class).

Flash fire modelling was only undertaken for gasoline due to the presence of hydrocarbon 'light ends' (typically C4-C5), which are not prevalent for heavier fuels such as diesel. Typical vapour clouds from gasoline spills are denser than air.

Flash fire modelling for ethanol indicate that the flammable vapour cloud downwind distances are very small and less than the pool diameter. Hence, it was assumed that pool fire is the more likely scenario as the small vapour cloud may directly flash back to the source pool resulting in a pool fire.

Flash fire scenarios modelled can be summarised into the following categories:

- Major leaks from storage tanks resulting in pool evaporation of full bund contents resulting in flammable vapour cloud (Table D.3).
- Tank overfill resulting in pool evaporation of intermediate bund contents resulting in flammable vapour cloud (Table D.3)
- Operational releases: small, medium and large releases (Table D.4).

Note that the 'Buncefield scenario' where tank overfill resulting in a cascading, splash zone generating larger volumes of vapour with corresponding large dispersion distances was not modelled. This is due to the ducted overflow piping design provided on gasoline and ethanol tanks directing overflow to the bunds. Refer to Appendix D5 for information on assigning tank bund consequences to tank overfill and major leak scenarios.

Modelling results for flash fires are reported in terms of fire width and length to 100% LFL concentrations.

Flash fires were modelled for steady state (equilibrium) case assuming a continuous release without isolation or detection, and therefore represent the worst case cloud size. Ignition of the cloud before equilibrium would result in a smaller flash fire.

Table D.3: Flash Fire Consequence Results – Storage Tanks (Major Leak and Tank Overfill – Pool evaporation)

Tank ID	Product	Bund Area (m2)	Equivalent Pool Diameter (m)	Mass in tank (tonnes)	Flash Fire - Distance to LFL from Leak (m) - F2		
					Evap Rate (kg/s)	Length	Width
TK-07 (BD-07)	Gasoline	1831	48	13,344	8	59	114
TK-08 (BD-08)	Gasoline	1769	47	13,344	8	57	111
TK-09 (BD-09)	Gasoline	1715	47	13,344	8	56	110
TK-10 (BD-01C)	Gasoline	694	30	1,271	3	35	63
TK-11 (BD-01C)	Gasoline	694	30	1,271	3	35	63
TK-16 (BD-01B)	Gasoline	238	17	24	1	16	31
TK-17 (BD-01B)	Gasoline	238	17	24	1	16	31
TK-18 (BD-01B)	Gasoline	238	17	24	1	16	31
TK-25 (BD-12A)	Gasoline	1313	41	13,344	6	48	93
TK-26 (BD-13)	Gasoline	1619	45	13,344	7	54	105
TK-27 (BD-14)	Gasoline	1685	46	13,344	8	56	109
TK-31 (BD-12B)	Gasoline	232	17	24	1	15	30
TK-32 (BD-12B)	Gasoline	232	17	24	1	15	30
TK-34 (BD-12B)	Gasoline	232	17	24	1	15	30
TK-35 (BD-17)	Gasoline	1671	46	13,344	7	55	107
TK-36 (BD-18)	Gasoline	1925	50	13,344	8	60	117
TK-39 (BD-18)	Gasoline	1925	50	24	8	57	111
TK-41 (BD-21)	Gasoline	109	12	24	1	8	17
TK-42 (BD-21)	Gasoline	109	12	24	1	8	17
TK-07/08/09 (BD-Site1)	Gasoline	16310	144	13,344	65	255	422
TK-10/11 (BD-01A/01B/01C/ 02/09)	Gasoline	5079	80	1,271	21	124	212
TK-25/26/27/35/36 (BD-Site2)	Gasoline	16644	146	13,344	67	258	426

Table D.4: Flash Fire Consequence Results – Operational

Component/ Equipment	Product	Pressure (barg)	Hole size (mm)	Release rate (kg/s)	Equivalent Pool Diameter (m)	Flash Fire - Distance to LFL (m) - F2		
						Evap Rate (kg/s)	Length	Width
Berth 104 - Ship Import	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	18	1	15	26
			85	138	18	1	16	32
			RUP (250)	260	18	1	17	32
Shoreline/Pipework (Outside of bunds)	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	43	5	43	78
			85	138	167	72	247	450
			RUP (300)	260	230	134	372	653
Site 1 Pump Bay (BD-10) Manifold/Pipework (Tank-to-tank transfer)	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	38	4	38	69
			85	138	38	5	42	83
			RUP (300)	260	38	5	44	88
Site 1 Pump Bay (BD-10) Manifold/Pipework (Road Tanker Export)	Gasoline	6	2	0.1	4	0.04	-	-
			6	0.5	11	0.4	-	-
			22	7.3	26	2	-	-
			85	30	27	2	18	36
			RUP (300)	30	27	2	18	36
Site 2 Pump Bay (BD-12 Inter) Manifold/Pipework	Gasoline	10	2	0.1	4	0.04	-	-
			6	0.7	11	0.4	-	-
			22	9	12	0.5	0.5	9
			85	138	62	12	6	46
			RUP (300)	260	62	13	6	48
Road Gantry - Export	Gasoline	6	2	0.1	3	0.04	0.04	-
			6	0.5	10	0.4	0.2	-
			22	7	12.6	2	0.6	7
			85	30	12.6	2	0.2	10
			RUP (200)	30	12.6	2	0.2	10

D4. Tank Roof Fire

The tank top full surface area fire scenario was assessed to represent the collapse of internal floating roof resulting in a full surface roof fire and subsequent collapse of the external roof. The tank roof fire consequence results are presented in Table D.5.

D5. Tank Bund Fire

The tank bund fire scenario was assessed for mechanical failure/leaks and tank overfill causes. The consequence of a tank overfill was based on 15 minute overfill during ship import operation¹. As a worst case, this is equivalent to filling the intermediate bund. Therefore, intermediate bund fires were assigned to tank overfill scenarios. Bund sizes and tank bund fire consequence results are presented in Table D.6.

The tank mechanical failure/leaks consequence varies for three tank types based on their capacities:

- Intermediate bund fire events for tanks where the entire content volume would only fill the intermediate bund volume:
 - On Site 1, this includes flammable slops tanks (TK-16 to TK-18) and combustible slops tanks (TK-13 and TK-14).
 - On Site 2, this includes flammable slops tanks (TK-31, TK-32, TK-34), combustible slops tanks (TK-30) and additive storage tanks (TK-41 and TK-42).
- Bund fire events where the entire tank contents would fill its intermediate bund and adjacent bunds:
 - On Site 1, this includes flammable tanks (TK-10 and TK-11).
- Full bund fire events for tanks where the volume would fill the full bund:
 - On Site 1, this includes flammable tanks (TK-07 to TK-09) and combustible tanks (TK-01 to TK- 06, and TK-12)
 - On Site 2, this includes flammable tanks (TK-25 to TK-27, TK-35 and TK-36) and combustible tanks (TK-28, TK-29, TK-37 and TK-38).

¹ A 15 minutes overfill duration is based on hydrocarbon leak detection in the bund and operator response to stop the incoming flow to the tank. The facility is manned during ship import and the tank is also provided with SIL 2 high level trip and flow detection in the ducted overflow piping that will initiate an emergency shutdown of the entire terminal.

Table D.5: Tank Roof Fire Consequence Results

Tank Number	Diameter (m)	Height (m)	Typical Product	Distance (m) to Heat Radiation from Tank Centre					
				Flame Length	23 kW/m ²	20 kW/m ²	14 kW/m ²	10 kW/m ²	4.7 kW/m ²
TK-01	20	20.8	Diesel	25	33	35	39	42	50
TK-02	20	20.8	Diesel	25	33	35	39	42	50
TK-03	20	20.8	Diesel	25	33	35	39	42	50
TK-04	29	28.2	Diesel	34	45	47	52	56	67
TK-05	29	28.2	Diesel	34	45	47	52	56	67
TK-06	29	28.2	Diesel	34	45	47	52	56	67
TK-07	29	28.2	Gasoline	35	46	48	52	57	68
TK-08	29	28.2	Gasoline	35	46	48	52	57	68
TK-09	29	28.2	Gasoline	35	46	48	52	57	68
TK-10	10	20.5	Gasoline	15	19	20	23	25	29
TK-11	10	20.5	Gasoline	15	19	20	23	25	29
TK-12	10	20.5	Diesel	15	19	20	23	25	29
TK-13	3	4.8	Diesel	6	7	8	9	10	12
TK-14	3	4.8	Diesel	6	7	8	9	10	12
TK-16	3	4.8	Gasoline	6	7	8	9	10	12
TK-17	3	4.8	Gasoline	6	7	8	9	10	12
TK-18	3	4.8	Gasoline	6	7	8	9	10	12
TK-23	10	20.5	Ethanol	12	14	14	16	17	22
TK-24	10	20.5	Ethanol	12	14	14	16	17	22
TK-25	29	28.2	Gasoline	35	46	48	52	57	68
TK-26	29	28.2	Gasoline	35	46	48	52	57	68
TK-27	29	28.2	Gasoline	35	46	48	52	57	68
TK-28	29	28.2	Diesel	34	45	47	52	56	67
TK-29	29	28.2	Diesel	34	45	47	52	56	67
TK-30	3	4.8	Diesel	6	7	8	9	10	12
TK-31	3	4.8	Gasoline	6	7	8	9	10	12
TK-32	3	4.8	Gasoline	6	7	8	9	10	12
TK-34	3	4.8	Gasoline	6	7	8	9	10	12
TK-35	29	28.2	Gasoline	35	46	48	52	57	68
TK-36	29	28.2	Gasoline	35	46	48	52	57	68
TK-37	29	28.2	Diesel	34	45	47	52	56	67
TK-38	24	28.2	Diesel	29	38	40	44	48	57
TK-39	3	4.8	Gasoline	6	7	8	9	10	12
TK-41	3	4.8	Gasoline	6	7	8	9	10	12
TK-42	3	4.8	Gasoline	6	7	8	9	10	12

Table D.6: Tank Bund Fire Consequence Results

Bund ID	Bund Type	Bund Contents	Bund Surface Area (m ²)	Equivalent Diameter (m)	Modelled Product	Distance (m) to Heat Radiation from Bund Centre					
						Flame Length	23 kW/m ²	20 kW/m ²	14 kW/m ²	10 kW/m ²	4.7 kW/m ²
BD-01A	Internal	TK-01	1032	36	Diesel	41	54	56	61	66	79
BD-01B	Internal	TK-16/17/18	238	17	Gasoline	23	27	28	30	33	39
BD-01B	Internal	TK-13/14	238	17	Diesel	23	27	28	30	32	38
BD-01C	Internal	TK-10/11	694	30	Gasoline	35	46	48	53	57	68
BD-02	Internal	TK-02	1307	41	Diesel	45	59	61	67	72	87
BD-03	Internal	TK-03/12	1591	45	Diesel	49	64	67	80	87	96
BD-04	Internal	TK-04	1591	45	Diesel	49	64	67	80	87	96
BD-05	Internal	TK-05	1725	47	Diesel	51	66	69	75	81	98
BD-06	Internal	TK-06	1455	43	Diesel	47	62	64	70	76	91
BD-07	Internal	TK-07	1831	48	Gasoline	53	69	72	79	85	103
BD-08	Internal	TK-08	1769	47	Gasoline	52	69	71	78	85	102
BD-09	Internal	TK-09	1715	47	Gasoline	51	67	70	76	82	99
BD-10	Internal	Site 1 Pump Bay	1138	38	Gasoline	44	58	60	66	71	85
BD-10	Internal	Site 1 Pump Bay	1138	38	Diesel	43	57	s59	65	70	84
BD-11	External	TK-23/24	1131	38	Ethanol	34	43	45	50	54	65
BD-11A	Internal	TK-23	695	30	Ethanol	23	36	38	41	45	53
BD-11B	Internal	TK-24	327	20	Ethanol	21	25	26	29	31	41
BD-12A	Internal	TK-25	1408	42	Gasoline	47	62	65	71	76	92
BD-12B	Internal	TK-31/32/33	232	17	Gasoline	23	28	29	32	34	40
BD-12B	Internal	TK-30	232	17	Diesel	22	28	29	31	34	40
BD-12C	Internal	Site 2 Pump Bay	1215	39	Gasoline	44	59	62	68	74	88
BD-12C	Internal	Site 2 Pump Bay	1215	39	Diesel	44	57	60	66	71	85
BD-12C	Pump	Site 2 Pump Bay	116	12	Gasoline	17	23	24	27	29	34
BD-12C	Pump	Site 2 Pump Bay	116	12	Diesel	17	22	23	26	29	34
BD-12C	Pump	Site 2 Pump Bay	116	12	Ethanol	14	16	17	18	20	26
BD-13	Internal	TK-26	1619	45	Gasoline	50	66	68	75	81	97

Bund ID	Bund Type	Bund Contents	Bund Surface Area (m ²)	Equivalent Diameter (m)	Modelled Product	Distance (m) to Heat Radiation from Bund Centre					
						Flame Length	23 kW/m ²	20 kW/m ²	14 kW/m ²	10 kW/m ²	4.7 kW/m ²
BD-14	Internal	TK-27	1685	46	Gasoline	51	67	69	76	82	98
BD-15	Internal	TK-28	1620	45	Diesel	49	65	67	74	80	96
BD-16	Internal	TK-29	1615	45	Diesel	49	65	67	74	80	96
BD-17	Internal	TK-35	1671	46	Gasoline	51	67	69	76	82	98
BD-18	Internal	TK-36/39	1925	50	Gasoline	54	71	73	80	87	104
BD-19	Internal	TK-37	2017	51	Diesel	54	71	73	80	87	104
BD-20	Internal	TK-38	1339	41	Diesel	46	59	62	67	73	87
BD-21	Internal	TK-41/42	109	12	Gasoline	17	21	22	24	26	31
BD-22	Internal	Additive IBC storage	97	11	Gasoline	16	21	22	24	26	30
BD-Site1	External	BD-01 to BD-10	16310	120 ¹	Gasoline	113	148	153	167	181	220
BD-Site1	External	BD-01 to BD-10	16310	120 ¹	Diesel	111	143	150	163	177	215
BD-01 to 09	External	BD-01 to BD-09	15150	120 ¹	Gasoline	113	148	153	167	181	220
BD-01 to 09	External	BD-01 to BD-09	15150	120 ¹	Diesel	111	145	150	163	177	215
BD-Site2	External	BD-12 to BD-20	16644	75 ²	Gasoline	76	100	104	113	122	148
BD-Site2	External	BD-12 to BD-20	16644	75 ²	Diesel	75	99	102	111	121	145
BD-01A/01B/ 01C/02/09	Internal	BD- 01A/01B/01C/02/09	5079	66 ³	Gasoline	48	90	93	102	110	133
BD- 01C/02/03/07/09	Internal	BD-01C/02/03/07/09	7116	66 ³	Gasoline	48	90	93	102	110	133

Note:

1. For consequence modelling purposes, BD-Site1 was assumed as a rectangular bund where the width was 120 m. This was used to define the maximum pool diameter.
2. For consequence modelling purposes, BD-Site2 was assumed as a rectangular bund where the width was 75 m. This was used to define the maximum pool diameter.
3. For consequence modelling purposes, BD-01A/01B/01C/02/09 and BD-01C/02/03/07/09 was assumed as a rectangular bund where the width was 66 m. This was used to define the maximum pool diameter.

APPENDIX E. FREQUENCY ANALYSIS

E1. Equipment Leak Frequencies

Table E.1 gives the historical equipment leak frequencies. Data from the OGP Risk Assessment Data Directory was used where available (Ref. 11). For process equipment, the 'Full Releases' leak frequencies were used.

Table E.1: Historical equipment leak frequencies

Equipment type and size	Frequency (per year) by Hole Size ¹					Source
	2 mm	6 mm	22 mm	85 mm	Full bore	
Process piping (50 mm)	5.5E-05	1.8E-05	7.0E-06			OGP
Process piping (150 mm)	2.6E-05	8.5E-06	2.7E-06	6.0E-07		OGP
Process piping (300 mm)	2.3E-05	7.6E-06	2.4E-06	3.7E-07	1.7E-07	OGP
Flange, raised face (50 mm)	2.6E-06	7.6E-07	1.2E-06			OGP
Flange, raised face (150 mm)	3.7E-06	1.1E-06	9.0E-07	6.0E-07		OGP
Flange, raised face (300 mm)	5.9E-06	1.7E-06	1.4E-06	1.8E-07	3.4E-07	OGP
Valve Actuating (50 mm)	2.4E-04	7.3E-05	3.0E-05			OGP
Valve Actuating (150 mm)	2.2E-04	6.6E-05	1.9E-05	8.6E-06		OGP
Valve Actuating (300 mm)	2.1E-04	6.3E-05	1.8E-05	2.4E-06	6.0E-06	OGP
Valve Manual (50 mm)	2.0E-05	7.7E-06	4.9E-06			OGP
Valve Manual (150 mm)	3.1E-05	1.2E-05	4.7E-06	2.4E-06		OGP
Valve Manual (300 mm)	4.3E-05	1.7E-05	6.5E-06	1.2E-06	1.7E-06	OGP
Instrument fitting	1.8E-04	6.8E-05	2.5E-05			OGP
Filter	1.3E-03	5.1E-04	1.9E-04	3.5E-05	2.0E-05	OGP
Pump Centrifugal	5.1E-03	1.8E-03	5.9E-04	9.7E-05	4.8E-05	OGP
Tank Rupture	-	-	-	-	3.0E-06	OGP
Loading arm – per connection per operating hour (Road Tanker & Ships)	-	-	3.0E-07	-	3.0E-08	TNO Purple Book
Major Tank Failure (Continuous release of the complete inventory to atmosphere in 10 minutes)	-	-	-	-	5.0E-06	TNO Purple Book

Note: 1. Piping release frequencies are per metre-year.

E2. Parts Count

A typical parts count was completed for the site areas and operations type where a potential for hydrocarbon release was identified, based on industry experience for similar terminals.

The site was rationalised into 6 systems including:

- WHF (Wharf)
- MAN (Manifold)
- RTU (Road Tanker Unloading)

- RTL (Road Tanker Loading)
- PMP (Pumps)
- PPW (Pipework).

Table E.2: Systems Defined for the QRA

ID	Scenario description	Area Description
WHF-001	Ship Import (Gasoline)	Wharf: Ship Import
WHF-002	Ship Import (Diesel)	Wharf: Ship Import
MAN-001	Site 2 Manifold Ship Import (Gasoline)	Site 2 Manifold: Ship Import
MAN-002	Site 2 Manifold Ship Import (Diesel)	Site 2 Manifold: Ship Import
MAN-003	Site 2 Manifold RT Import (Ethanol)	Site 2 Manifold: Road Tanker Import
MAN-004	Site 2 Manifold RT Import (Biodiesel)	Site 2 Manifold: Road Tanker Import
MAN-005	Site 2 Manifold TT Transfer (Gasoline)	Site 1 & 2 Manifold: Tank to Tank Transfer
MAN-006	Site 2 Manifold TT Transfer (Diesel)	Site 1 & 2 Manifold: Tank to Tank Transfer
MAN-007	Site 1 Manifold RT Export (Gasoline)	Site 1 Manifold: Road Tanker Export
MAN-008	Site 1 Manifold RT Export (Diesel)	Site 1 Manifold: Road Tanker Export
RTL-001	Road Tanker Export 1-6 (Gasoline)	Road Tanker Export
RTL-002	Road Tanker Export 1-6 (Diesel)	Road Tanker Export
RTU-001	Road Tanker Import 1 (Ethanol)	Road Tanker Import
RTU-002	Road Tanker Import 1 (Biodiesel)	Road Tanker Import
PMP-001	Pump RT Import (Ethanol)	Site 2 Pump: Road Tanker Import
PMP-002	Pump RT Import (Biodiesel)	Site 2 Pump: Road Tanker Import
PMP-003	Pump TT Transfer (Gasoline)	Site 2 Pump: Tank to Tank Transfer
PMP-004	Pump TT Transfer (Diesel)	Site 2 Pump: Tank to Tank Transfer
PMP-005	Pump RT Export (Gasoline)	Site 1 Pump: Road Tanker Export
PMP-006	Pump RT Export (Diesel)	Site 1 Pump: Road Tanker Export
PPW-001	Pipework Ship Import (Gasoline)	Pipework: Ship Import
PPW-002	Pipework Ship Import (Diesel)	Pipework: Ship Import
PPW-003	Pipework RT Import (Ethanol)	Pipework: Road Tanker Import
PPW-004	Pipework RT Import (Biodiesel)	Pipework: Road Tanker Import
PPW-005	Pipework TT Transfer (Gasoline)	Pipework: Tank to Tank Transfer
PPW-006	Pipework TT Transfer (Diesel)	Pipework: Tank to Tank Transfer
PPW-007	Pipework RT Export (Gasoline)	Pipework: Road Tanker Export
PPW-008	Pipework RT Export (Diesel)	Pipework: Road Tanker Export

A typical parts count sheet used for the QRA is presented below. The example below applies for the Site 2 manifold during ship import of gasoline (MAN-001). The complete parts count sheets for all the sections are not reproduced in this report.

Parts Count Sheet											sherpa consulting
CLIENT	Cardno										
JOB DESC	National Terminals PKBLT PHA										
Area Code	MAN										
Area Desc	Site 2 Manifold: Ship Import										
Section No	001										
Initiating Event ID	MAN-001										
Event Description	Site 2 Manifold Ship Import (Gasoline)										
Release Type	L										
Equipment Item	Tag	Number	Move- ments per year	Op. Hrs per year	Leak Frequency per Hole					Size in mm x 10 (Leaks/Year)	RUP
					002	006	022	085	500	999	
Instrument fitting	PIP_FTA	5		190	1.96E-05	7.39E-06	2.72E-06				
Flanges ANSI Raised Face - 50mm	FLG_RF_050	20		190	1.13E-06	3.30E-07	5.22E-07				
Flanges ANSI Raised Face - 300mm	FLG_RF_300	48		190	6.16E-06	1.77E-06	1.47E-06	1.91E-07			3.55E-07
Valve (manual) - 50mm	VLM_050	10		190	4.35E-06	1.67E-06	1.07E-06				
Valve (manual) - 300mm	VLM_300	10		190	9.35E-06	3.69E-06	1.41E-06	2.61E-07			3.69E-07
Valve (automated) - 300mm	VLA_300	10		190	4.56E-05	1.37E-05	3.91E-06	5.22E-07			1.30E-06
Filter	VES_FLT	4		190	1.13E-04	4.43E-05	1.65E-05	3.04E-06			1.74E-06
Process Piping - 300mm	PIP_300	120		190	6.00E-05	1.98E-05	6.26E-06	9.65E-07			4.43E-07

E3. Online Time Factor

An online factor was applied to the leak frequencies of each identified section (as provided in Table E.2). The online time factor reduces the leak frequency based on the proportion of time that the equipment is used.

The online time factors were calculated based on the terminal operational data provided, summarised in Table E.5.

E4. Ignition Probability

The ignition probability values used in this study were based on the assessment done by Cox, Less and Ang (Ref.13). The probabilities are based on the release rate and the phase of the fluid assessed. The ignition probability values used in the QRA are provided in Table E.3.

Using the values described in Table E.3, further analysis was undertaken to calculate the ignition probabilities of the assessed flammable substances that result into fires. These values are presented in Table E.4.

Release of combustible liquids such as diesel are more difficult to ignite due to their high flash point. In this study, an assumption was factored to the ignition probability for diesel to be one-tenth that of flammable liquids such as gasoline.

Table E.3: Ignition probabilities

Mass Flow Rate	Ignition probability of a gas or mixture	Ignition probability of a liquid.	Fraction of explosions given ignition of a gas, liquid or mixture	Explosion probability of a gas or mixture	Explosion probability of a liquid
<1 kg/s	0.01	0.01	0.04	0.0004	0.0004
1 - 50 kg/s	0.07	0.03	0.12	0.0084	0.0036
>50 kg/s	0.3	0.08	0.3	0.09	0.024

Table E.4: Ignition Probabilities for Fires

Mass Flow rate	Immediate Ignition of gas/mixed resulting in fire	Delayed Ignition of gas/mixed resulting in fire	Immediate Ignition of liquid resulting in fire
<1 kg/s	0.0096	0.0004	0.0096
1 - 50 kg/s	0.0616	0.0084	0.0264
>50 kg/s	0.21	0.09	0.056

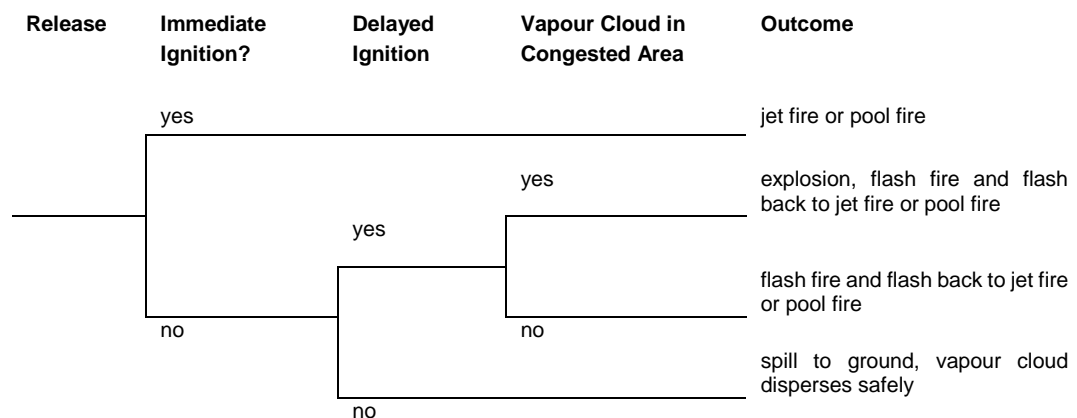
The ignition probabilities for all sections (as provided in Table E.2) and relevant leak sizes assessed in the QRA are summarised in Table E.5.

E5. Event Tree Analysis

A release of flammable liquid (eg gasoline, diesel, and ethanol) may lead to a variety of consequences, including jet fire, pool fire, flash fire and vapour cloud explosion - subject to the occurrence of particular events following the release (eg ignition).

An event tree is a logic diagram that identifies, for a single initiating event, a variety of consequences resulting from the success or failure of systems intended to mitigate that event. The frequency of these consequences is then estimated using the event tree logic and probabilistic analyses.

The possible outcomes following loss of containment of a flammable or combustible liquid are described in the event trees shown below.



The event tree probabilities used in the QRA model are presented in Table E.5, which includes:

- Operating time (online time factor)
- Ignition probability adjustment factor
- Release rates
- Probability of immediate ignition
- Probability of delayed ignition.

The event tree analyses were undertaken for all leak sizes applicable to all identified sections to generate the outcome frequencies for all leak events identified. The outcome frequencies (fire) for all leak events are presented in Section E6.

E6. Outcome Frequencies

The release and fire outcome frequencies for all events are summarised in Table E.6.

Table E.5: Event Tree Probabilities

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
WHF-001	Ship Import (Gasoline)	190	1	002	WHF-001-002	0.07669	0.0096	0.0004
			1	006	WHF-001-006	0.69015	0.0096	0.0004
			1	022	WHF-001-022	9.27	0.0616	0.0084
			1	085	WHF-001-085	138	0.21	0.09
			1	RUP	WHF-001-RUP	260	0.21	0.21
WHF-002	Ship Import (Diesel)	354	0.1	002	WHF-002-002	0.0775	0.00096	0.00004
			0.1	006	WHF-002-006	0.698	0.00096	0.00004
			0.1	022	WHF-002-022	9.37	0.00616	0.00084
			0.1	085	WHF-002-085	140	0.021	0.00900
			0.1	RUP	WHF-002-RUP	288	0.021	0.02100
MAN-001	Site 1 & 2 Manifold Ship Import (Gasoline)	190	1	002	MAN-001-002	0.07669	0.0096	0.00040
			1	006	MAN-001-006	0.69015	0.0096	0.00040
			1	022	MAN-001-022	9.27	0.0616	0.00840
			1	085	MAN-001-085	138	0.21	0.09000
			1	RUP	MAN-001-RUP	260	0.21	0.21000
MAN-002	Site 1 & 2 Manifold Ship Import (Diesel)	354	0.1	002	MAN-002-002	0.0775	0.00096	0.00004
			0.1	006	MAN-002-006	0.698	0.00096	0.00004
			0.1	022	MAN-002-022	9.37	0.00616	0.00084
			0.1	085	MAN-002-085	140	0.021	0.00900
			0.1	RUP	MAN-002-RUP	288	0.021	0.02100
MAN-003	Site 2 Manifold RT Import (Ethanol)	253	1	002	MAN-003-002	0.0797	0.0096	0.00040
			1	006	MAN-003-006	0.717	0.0096	0.00040
			1	022	MAN-003-022	9.63	0.0616	0.00840
			1	085	MAN-003-085	16	0.0616	0.00840
			1	RUP	MAN-003-RUP	16	0.21	0.21000
MAN-004	Site 2 Manifold RT Import (Biodiesel)	507	0.1	002	MAN-004-002	0.0775	0.00096	0.00004
			0.1	006	MAN-004-006	0.698	0.00096	0.00004
			0.1	022	MAN-004-022	9.37	0.00616	0.00084

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
			0.1	085	MAN-004-085	18	0.00616	0.00084
			0.1	RUP	MAN-004-RUP	18	0.021	0.02100
MAN-005	Site 2 Manifold TT Transfer (Gasoline)	378	1	002	MAN-005-002	0.07669	0.0096	0.00040
			1	006	MAN-005-006	0.69015	0.0096	0.00040
			1	022	MAN-005-022	9.2685	0.0616	0.00840
			1	085	MAN-005-085	138	0.21	0.09000
			1	RUP	MAN-005-RUP	365	0.21	0.21000
MAN-006	Site 2 Manifold TT Transfer (Diesel)	702	0.1	002	MAN-006-002	0.0775	0.00096	0.00004
			0.1	006	MAN-006-006	0.698	0.00096	0.00004
			0.1	022	MAN-006-022	9.37	0.00616	0.00084
			0.1	085	MAN-006-085	140	0.021	0.00900
			0.1	RUP	MAN-006-RUP	288	0.021	0.02100
MAN-007	Site 1 Manifold RT Export (Gasoline)	8,760	1	002	MAN-007-002	0.0605	0.0096	0.00040
			1	006	MAN-007-006	0.544	0.0096	0.00040
			1	022	MAN-007-022	7.31	0.0616	0.00840
			1	085	MAN-007-085	30	0.0616	0.00840
			1	RUP	MAN-007-RUP	30	0.21	0.21000
MAN-008	Site 1 Manifold RT Export (Diesel)	8,760	0.1	002	MAN-008-002	0.0612	0.00096	0.00004
			0.1	006	MAN-008-006	0.55	0.00096	0.00004
			0.1	022	MAN-008-022	7.39	0.00616	0.00084
			0.1	085	MAN-008-085	33	0.00616	0.00084
			0.1	RUP	MAN-008-RUP	33	0.021	0.02100
RTL-001	Road Tanker Export 1-6 (Gasoline)	1,828 ¹	1	002	RTL-001-002	0.0605	0.0096	0.0004
			1	006	RTL-001-006	0.544	0.0096	0.0004
			1	022	RTL-001-022	7.31	0.0616	0.0084
			1	085	RTL-001-085	30	0.0616	0.0084
			1	RUP	RTL-001-RUP	30	0.21	0.21
RTL-002	Road Tanker Export 1-6 (Diesel)	3,394 ¹	0.1	002	RTL-002-002	0.0612	0.00096	0.00004
			0.1	006	RTL-002-006	0.55	0.00096	0.00004
			0.1	022	RTL-002-022	7.39	0.00616	0.00084

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
RTU-001	Road Tanker Import 1 (Ethanol)	253	0.1	085	RTL-002-085	33	0.00616	0.00084
			0.1	RUP	RTL-002-RUP	33	0.021	0.02100
			1	002	RTU-001-002	0.0797	0.0096	0.0004
			1	006	RTU-001-006	0.717	0.0096	0.0004
			1	022	RTU-001-022	9.63	0.0616	0.0084
			1	085	RTU-001-085	16	0.0616	0.0084
RTU-002	Road Tanker Import 1 (Biodiesel)	507	0.1	002	RTU-002-002	0.0775	0.00096	0.00004
			0.1	006	RTU-002-006	0.698	0.00096	0.00004
			0.1	022	RTU-002-022	9.37	0.00616	0.00084
			0.1	085	RTU-002-085	18	0.00616	0.00084
			0.1	RUP	RTU-002-RUP	18	0.021	0.02100
PMP-001	Pump RT Import (Ethanol)	253	1	002	PMP-001-002	0.0797	0.0096	0.0004
			1	006	PMP-001-006	0.717	0.0096	0.0004
			1	022	PMP-001-022	9.63	0.0616	0.0084
			1	085	PMP-001-085	16	0.0616	0.0084
			1	RUP	PMP-001-RUP	16	0.21	0.21
PMP-002	Pump RT Import (Biodiesel)	507	0.1	002	PMP-002-002	0.0775	0.00096	4E-05
			0.1	006	PMP-002-006	0.698	0.00096	4E-05
			0.1	022	PMP-002-022	9.37	0.00616	0.00084
			0.1	085	PMP-002-085	18	0.00616	0.00084
			0.1	RUP	PMP-002-RUP	18	0.021	0.021
PMP-003	Pump TT Transfer (Gasoline)	378	1	002	PMP-003-002	0.07669	0.0096	0.00040
			1	006	PMP-003-006	0.69015	0.0096	0.00040
			1	022	PMP-003-022	9.2685	0.0616	0.00840
			1	085	PMP-003-085	138	0.21	0.09000
			1	RUP	PMP-003-RUP	365	0.21	0.21000
PMP-004	Pump TT Transfer (Diesel)	702	0.1	002	PMP-004-002	0.0775	0.00096	4E-05
			0.1	006	PMP-004-006	0.698	0.00096	4E-05
			0.1	022	PMP-004-022	9.37	0.00616	0.00084

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
			0.1	085	PMP-004-085	140	0.021	0.009
			0.1	RUP	PMP-004-RUP	288	0.021	0.021
PMP-005	Pump RT Export (Gasoline)	1,566 ²	1	002	PMP-005-002	0.0605	0.0096	0.00040
			1	006	PMP-005-006	0.544	0.0096	0.00040
			1	022	PMP-005-022	7.31	0.0616	0.00840
			1	085	PMP-005-085	30	0.0616	0.00840
			1	RUP	PMP-005-RUP	30	0.21	0.21000
PMP-006	Pump RT Export (Diesel)	4,073 ²	0.1	002	PMP-006-002	0.0612	0.00096	4E-05
			0.1	006	PMP-006-006	0.55	0.00096	4E-05
			0.1	022	PMP-006-022	7.39	0.00616	0.00084
			0.1	085	PMP-006-085	33	0.00616	0.00084
			0.1	RUP	PMP-006-RUP	33	0.021	0.021
PPW-001	Pipework Ship Import (Gasoline)	190	1	002	PPW-001-002	0.07669	0.0096	0.00040
			1	006	PPW-001-006	0.69015	0.0096	0.00040
			1	022	PPW-001-022	9.27	0.0616	0.00840
			1	085	PPW-001-085	138	0.21	0.09000
			1	RUP	PPW-001-RUP	260	0.21	0.21000
PPW-002	Pipework Ship Import (Diesel)	354	0.1	002	PPW-002-002	0.0775	0.00096	4E-05
			0.1	006	PPW-002-006	0.698	0.00096	4E-05
			0.1	022	PPW-002-022	9.37	0.00616	0.00084
			0.1	085	PPW-002-085	140	0.021	0.009
			0.1	RUP	PPW-002-RUP	288	0.021	0.021
PPW-003	Pipework RT Import (Ethanol)	253	1	002	PPW-003-002	0.0797	0.0096	0.0004
			1	006	PPW-003-006	0.717	0.0096	0.0004
			1	022	PPW-003-022	9.63	0.0616	0.0084
			1	085	PPW-003-085	16	0.0616	0.0084
			1	RUP	PPW-003-RUP	16	0.21	0.21
PPW-004	Pipework RT Import (Biodiesel)	507	0.1	002	PPW-004-002	0.0775	0.00096	0.00004
			0.1	006	PPW-004-006	0.698	0.00096	0.00004

Scenario	Description	Operating Time (hours/year)	Ignition Probability Adjustment Factor	Leak Size (mm)	Scenario Tag	Release Rate (kg/s)	Ignition Probability	
							Immediate	Delayed
			0.1	022	PPW-004-022	9.37	0.00616	0.00084
			0.1	085	PPW-004-085	18	0.00616	0.00084
			0.1	RUP	PPW-004-RUP	18	0.021	0.02100
PPW-005	Pipework TT Transfer (Gasoline)	378	1	002	PPW-005-002	0.07669	0.0096	0.0004
			1	006	PPW-005-006	0.69015	0.0096	0.0004
			1	022	PPW-005-022	9.2685	0.0616	0.0084
			1	085	PPW-005-085	138	0.21	0.09
			1	RUP	PPW-005-RUP	365	0.21	0.21
PPW-006	Pipework TT Transfer (Diesel)	702	0.1	002	PPW-006-002	0.0775	0.00096	0.00004
			0.1	006	PPW-006-006	0.698	0.00096	0.00004
			0.1	022	PPW-006-022	9.37	0.00616	0.00084
			0.1	085	PPW-006-085	140	0.021	0.00900
			0.1	RUP	PPW-006-RUP	288	0.021	0.02100
PPW-007	Pipework RT Export (Gasoline)	8760	1	002	PPW-007-002	0.0605	0.0096	0.00040
			1	006	PPW-007-006	0.544	0.0096	0.00040
			1	022	PPW-007-022	7.31	0.0616	0.00840
			1	085	PPW-007-085	30	0.0616	0.00840
			1	RUP	PPW-007-RUP	30	0.21	0.21000
PPW-008	Pipework RT Export (Diesel)	8760	0.1	002	PPW-008-002	0.0612	0.00096	0.00004
			0.1	006	PPW-008-006	0.55	0.00096	0.00004
			0.1	022	PPW-008-022	7.39	0.00616	0.00084
			0.1	085	PPW-008-085	33	0.00616	0.00084
			0.1	RUP	PPW-008-RUP	33	0.021	0.02100
1. Operating hour is per loading bay. 2. Operating hour is per loading pump.								

Table E.6: Outcome Frequencies – Proposed Operation

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/ Pool Fire Frequency
WHF-001_002	9.20E-5	3.64E-8	8.83E-7
WHF-001_006	3.21E-5	1.27E-8	3.08E-7
WHF-001_022	2.40E-4	1.89E-6	1.48E-5
WHF-001_085	8.01E-5	5.70E-6	1.68E-5
WHF-001_RUP	2.49E-5	4.12E-6	5.22E-6
WHF-002_002	3.28E-4	1.31E-8	3.15E-7
WHF-002_006	1.21E-4	4.85E-9	1.17E-7
WHF-002_022	4.69E-4	3.91E-7	2.89E-6
WHF-002_085	1.53E-4	1.35E-6	3.21E-6
WHF-002_RUP	4.86E-5	9.99E-7	1.02E-6
MAN-001_002	2.59E-4	1.03E-7	2.49E-6
MAN-001_006	9.27E-5	3.67E-8	8.90E-7
MAN-001_022	3.39E-5	2.67E-7	2.09E-6
MAN-001_085	4.98E-6	3.54E-7	1.05E-6
MAN-001_RUP	4.21E-6	6.99E-7	8.84E-7
MAN-002_002	4.81E-4	1.92E-8	4.62E-7
MAN-002_006	1.72E-4	6.88E-9	1.65E-7
MAN-002_022	6.29E-5	5.25E-8	3.88E-7
MAN-002_085	9.25E-6	8.15E-8	1.94E-7
MAN-002_RUP	7.82E-6	1.61E-7	1.64E-7
MAN-003_002	3.45E-4	1.37E-7	3.31E-6
MAN-003_006	1.23E-4	4.89E-8	1.18E-6
MAN-003_022	4.51E-5	3.56E-7	2.78E-6
MAN-003_085	6.63E-6	5.23E-8	4.08E-7
MAN-003_RUP	5.61E-6	9.30E-7	1.18E-6
MAN-004_002	6.90E-4	2.76E-8	6.63E-7
MAN-004_006	2.47E-4	9.87E-9	2.37E-7
MAN-004_022	9.02E-5	7.53E-8	5.56E-7
MAN-004_085	1.33E-5	1.11E-8	8.17E-8
MAN-004_RUP	1.12E-5	2.30E-7	2.35E-7
MAN-005_002	5.15E-4	2.04E-7	4.94E-6
MAN-005_006	1.84E-4	7.29E-8	1.77E-6
MAN-005_022	6.73E-5	5.30E-7	4.14E-6
MAN-005_085	9.89E-6	7.03E-7	2.08E-6
MAN-005_RUP	8.36E-6	1.39E-6	1.76E-6
MAN-006_002	9.56E-4	3.82E-8	9.17E-7
MAN-006_006	3.42E-4	1.37E-8	3.28E-7
MAN-006_022	1.25E-4	1.04E-7	7.69E-7
MAN-006_085	1.84E-5	1.62E-7	3.86E-7
MAN-006_RUP	1.55E-5	3.19E-7	3.26E-7
MAN-007_002	6.68E-3	2.65E-6	6.41E-5
MAN-007_006	2.21E-3	8.76E-7	2.12E-5
MAN-007_022	7.87E-4	6.21E-6	4.85E-5
MAN-007_085	8.77E-5	6.91E-7	5.40E-6
MAN-007_RUP	1.11E-4	1.84E-5	2.33E-5

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/ Pool Fire Frequency
MAN-008_002	1.19E-2	4.77E-7	1.14E-5
MAN-008_006	4.27E-3	1.70E-7	4.10E-6
MAN-008_022	1.56E-3	1.30E-6	9.60E-6
MAN-008_085	2.29E-4	1.91E-7	1.41E-6
MAN-008_RUP	1.94E-4	3.98E-6	4.07E-6
RTL-001_002	6.81E-3	2.70E-6	6.54E-5
RTL-001_006	2.37E-3	9.41E-7	2.28E-5
RTL-001_022	1.07E-2	8.45E-5	6.60E-4
RTL-001_085	1.62E-1	1.28E-3	9.97E-3
RTL-001_RUP	1.01E-3	1.68E-4	2.12E-4
RTL-002_002	1.26E-2	5.05E-7	1.21E-5
RTL-002_006	4.41E-3	1.76E-7	4.23E-6
RTL-002_022	1.99E-2	1.66E-5	1.23E-4
RTL-002_085	3.00E-1	2.51E-4	1.85E-3
RTL-002_RUP	1.88E-3	3.86E-5	3.95E-5
RTU-001_002	1.03E-4	4.07E-8	9.85E-7
RTU-001_006	3.63E-5	1.44E-8	3.49E-7
RTU-001_022	8.89E-5	7.00E-7	5.47E-6
RTU-001_085	5.13E-3	4.04E-5	3.16E-4
RTU-001_RUP	8.18E-6	1.36E-6	1.72E-6
RTU-002_002	2.05E-4	8.20E-9	1.97E-7
RTU-002_006	7.27E-5	2.90E-9	6.98E-8
RTU-002_022	1.78E-4	1.48E-7	1.09E-6
RTU-002_085	1.03E-2	8.56E-6	6.31E-5
RTU-002_RUP	1.64E-5	3.36E-7	3.44E-7
PMP-001_002	1.61E-4	6.36E-8	1.54E-6
PMP-001_006	5.68E-5	2.25E-8	5.46E-7
PMP-001_022	1.89E-5	1.49E-7	1.17E-6
PMP-001_085	3.14E-6	2.47E-8	1.93E-7
PMP-001_RUP	1.39E-6	2.30E-7	2.92E-7
PMP-002_002	3.21E-4	1.28E-8	3.08E-7
PMP-002_006	1.14E-4	4.54E-9	1.09E-7
PMP-002_022	3.79E-5	3.16E-8	2.33E-7
PMP-002_085	6.27E-6	5.24E-9	3.86E-8
PMP-002_RUP	2.78E-6	5.71E-8	5.83E-8
PMP-003_002	7.19E-4	2.85E-7	6.90E-6
PMP-003_006	2.54E-4	1.01E-7	2.44E-6
PMP-003_022	8.47E-5	6.68E-7	5.22E-6
PMP-003_085	1.40E-5	9.98E-7	2.95E-6
PMP-003_RUP	6.21E-6	1.03E-6	1.30E-6
PMP-004_002	1.33E-3	5.33E-8	1.28E-6
PMP-004_006	4.72E-4	1.89E-8	4.53E-7
PMP-004_022	1.57E-4	1.31E-7	9.69E-7
PMP-004_085	2.61E-5	2.30E-7	5.47E-7

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/ Pool Fire Frequency
PMP-004_RUP	1.15E-5	2.37E-7	2.42E-7
PMP-005_002	6.95E-3	2.75E-6	6.67E-5
PMP-005_006	2.46E-3	9.74E-7	2.36E-5
PMP-005_022	8.19E-4	6.45E-6	5.04E-5
PMP-005_085	1.36E-4	1.07E-6	8.36E-6
PMP-005_RUP	6.01E-5	9.97E-6	1.26E-5
PMP-006_002	2.58E-3	1.03E-7	2.48E-6
PMP-006_006	9.13E-4	3.65E-8	8.77E-7
PMP-006_022	3.04E-4	2.54E-7	1.87E-6
PMP-006_085	5.04E-5	4.21E-8	3.10E-7
PMP-006_RUP	2.23E-5	4.59E-7	4.69E-7
PPW-001_002	1.10E-3	4.36E-7	1.06E-5
PPW-001_006	3.63E-4	1.44E-7	3.49E-6
PPW-001_022	1.15E-4	9.05E-7	7.07E-6
PPW-001_085	1.77E-5	1.26E-6	3.72E-6
PPW-001_RUP	8.13E-6	1.35E-6	1.71E-6
PPW-002_002	2.04E-3	8.16E-8	1.96E-6
PPW-002_006	6.75E-4	2.70E-8	6.48E-7
PPW-002_022	2.13E-4	1.78E-7	1.31E-6
PPW-002_085	3.29E-5	2.90E-7	6.90E-7
PPW-002_RUP	1.51E-5	3.10E-7	3.17E-7
PPW-003_002	7.99E-5	3.16E-8	7.67E-7
PPW-003_006	2.64E-5	1.05E-8	2.53E-7
PPW-003_022	8.33E-6	6.57E-8	5.13E-7
PPW-003_085	1.28E-6	1.01E-8	7.91E-8
PPW-003_RUP	5.90E-7	9.79E-8	1.24E-7
PPW-004_002	1.60E-4	6.38E-9	1.53E-7
PPW-004_006	5.28E-5	2.11E-9	5.07E-8
PPW-004_022	1.67E-5	1.39E-8	1.03E-7
PPW-004_085	2.57E-6	2.15E-9	1.58E-8
PPW-004_RUP	1.18E-6	2.43E-8	2.48E-8
PPW-005_002	4.47E-4	1.77E-7	4.29E-6
PPW-005_006	1.48E-4	5.85E-8	1.42E-6
PPW-005_022	4.66E-5	3.67E-7	2.87E-6
PPW-005_085	7.18E-6	5.11E-7	1.51E-6
PPW-005_RUP	3.30E-6	5.48E-7	6.93E-7
PPW-006_002	8.29E-4	3.31E-8	7.96E-7
PPW-006_006	2.74E-4	1.10E-8	2.63E-7
PPW-006_022	8.65E-5	7.23E-8	5.33E-7
PPW-006_085	1.33E-5	1.18E-7	2.80E-7
PPW-006_RUP	6.13E-6	1.26E-7	1.29E-7
PPW-007_002	8.05E-3	3.19E-6	7.73E-5
PPW-007_006	2.66E-3	1.05E-6	2.55E-5
PPW-007_022	8.40E-4	6.62E-6	5.17E-5

Scenario ID	Total Release Frequency	Flash Fire Frequency	Jet Fire/ Pool Fire Frequency
PPW-007_085	1.30E-4	1.02E-6	7.98E-6
PPW-007_RUP	5.95E-5	9.87E-6	1.25E-5
PPW-008_002	8.05E-3	3.22E-7	7.73E-6
PPW-008_006	2.66E-3	1.06E-7	2.55E-6
PPW-008_022	8.40E-4	7.01E-7	5.17E-6
PPW-008_085	1.30E-4	1.08E-7	7.98E-7
PPW-008_RUP	5.95E-5	1.22E-6	1.25E-6

E7. Storage Tank Incident Frequencies

E7.1. Tank Roof Fire

The tank roof fire frequencies used in the QRA study were calculated based on the most recent Large Atmospheric Storage Tank Fire (LASTFIRE) Project Update 2012 (Ref.16).

LASTFIRE Project Update 2012 indicates that there have been no full-surface tank roof fires recorded for IFR tanks. The rim seal fire frequency for an IFR tank is given as 4.4×10^{-5} per year.

A tank roof fire frequency for Internal Floating Roof (IFR) tanks of 4.4×10^{-6} per year was adopted for this study. This accounts for rim seal fire detection on all IFR tanks that would prevent escalation to a full surface tank roof fire by applying foam to the floating pan.

The tank roof fire frequency for flammable slops and additive tanks is 2.1×10^{-5} per year (Ref. 16).

The tank roof fire frequencies for combustible bulk and slops tanks were calculated based on escalation from a flammable tank roof fire and accounts for spray water cooling provided on the combustible tanks.

E7.2. Tank Bund Fire

Both intermediate and full bund fires were assessed in the QRA. The tank bund fire frequencies were calculated using the event tree analyses. Derivations of these frequencies are provided below.

Tank Overfill Frequency

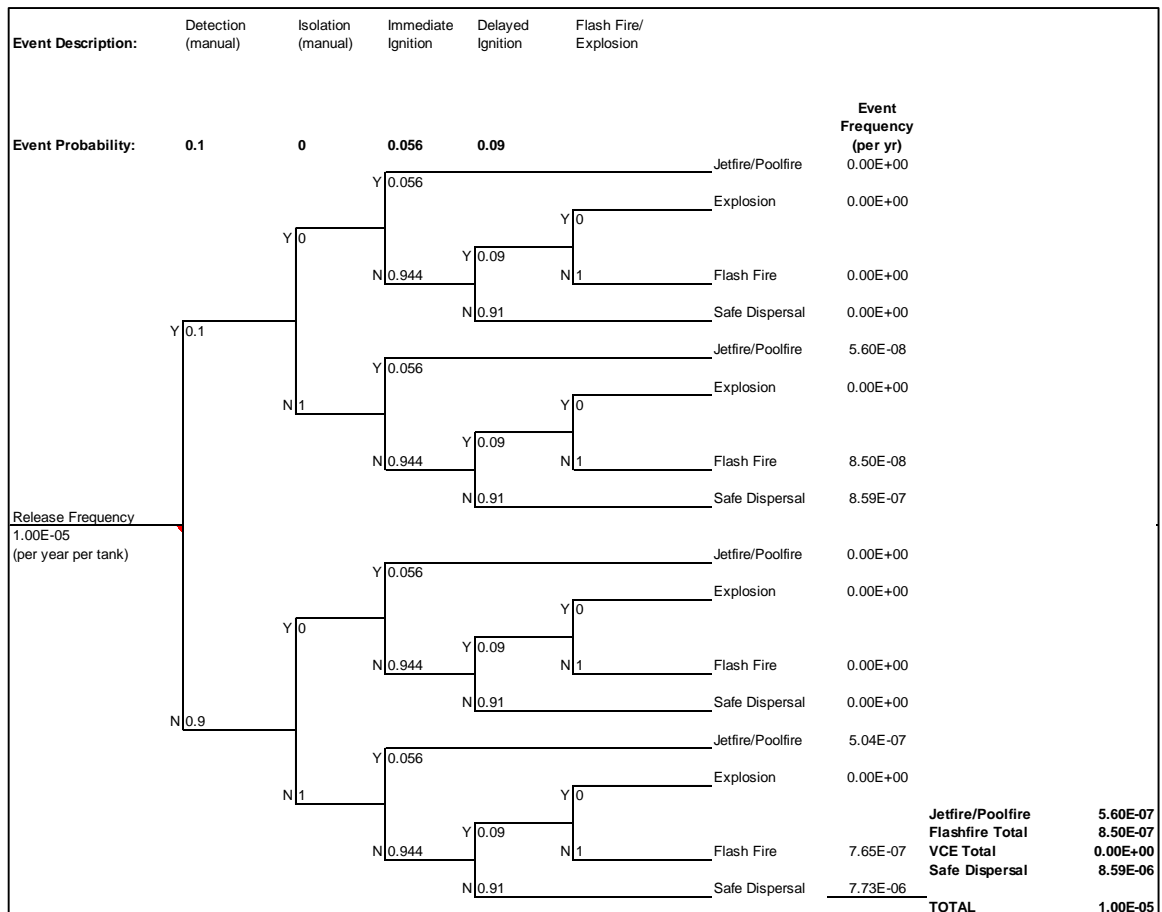
This frequency was applied for all intermediate bund fire events. An event tree was developed using tank overfill frequency as the base frequency for the analysis, shown in Figure E.1. This is deemed to be appropriate for small bund fires as these type of failures are easier to isolate (eg. closing valves, ESD and pumps), allowing quicker response and minimising the resulting pool size.

The frequency of a tank overflow leading to a large spill was estimated to be 1×10^{-5} per year (due to operator error during valve line-up or tank level gauge failure) based on the following configuration:

- All tanks are fitted with dual redundant radar level gauge system
- All tanks are fitted with a second radar level instrument and operator action, assuming sufficient time to respond and stop inlet flow
- All tanks are fitted with an independent SIL 2 rated level gauging system with high high level set point that automatically leads to filling operations shutdown
- Hydrocarbon detection in the intermediate bund sump and operator response.

The frequency of small bund fire used in the QRA was determined to be 5.6×10^{-7} per tank-year.

Figure E.1: Event Tree for Tank Overflow Scenario



The catastrophic failure of one plastic IBC was determined to be equivalent to catastrophic failure of 'Small and Medium Atmospheric Tanks', with a frequency of 1.6×10^{-5} per vessel year (Ref. 17). This value is multiplied by probability of immediate or delayed ignition of flammable liquid/mixture leading to a fire in Table E.4 to obtain the fire frequency.

APPENDIX F. WEATHER DATA AND ANALYSIS

F1. Data Source

Historical meteorological weather data for the proposed terminal was obtained from the Bureau of Meteorology (BoM). The acquired data sets were based on readings from the Automatic Weather Station (AWS) at Port Kembla NTC (AWS 068253) which is located approximately 3 km away.

F2. Pasquill Stability Class

Gifford (Ref.18) defines the conditions for different stability classes as summarised in Table F.1.

Table F.1: Meteorological Conditions Defining the Pasquill-Gifford Stability Classes

Surface wind speed, m/s	Daytime insolation			Night time conditions	
	Strong	Moderate	Slight	Thin overcast or >4/8 low cloud	≥ 3/8 cloudiness
<2	A	A-B	B	F	F
2-3	A-B	B	C	E	F
3-4	B	B-C	C	D	E
4-6	C	C-D	D	D	D
>6	C	C	D	D	D

F3. Representative Stability Class and Wind Speed

Suitable analysis of the obtained raw data was performed to obtain the representative weather conditions (including wind speed and stability classes) appropriate for the QRA. For the purpose of the study, the data were consolidated into six different representative weather conditions which are:

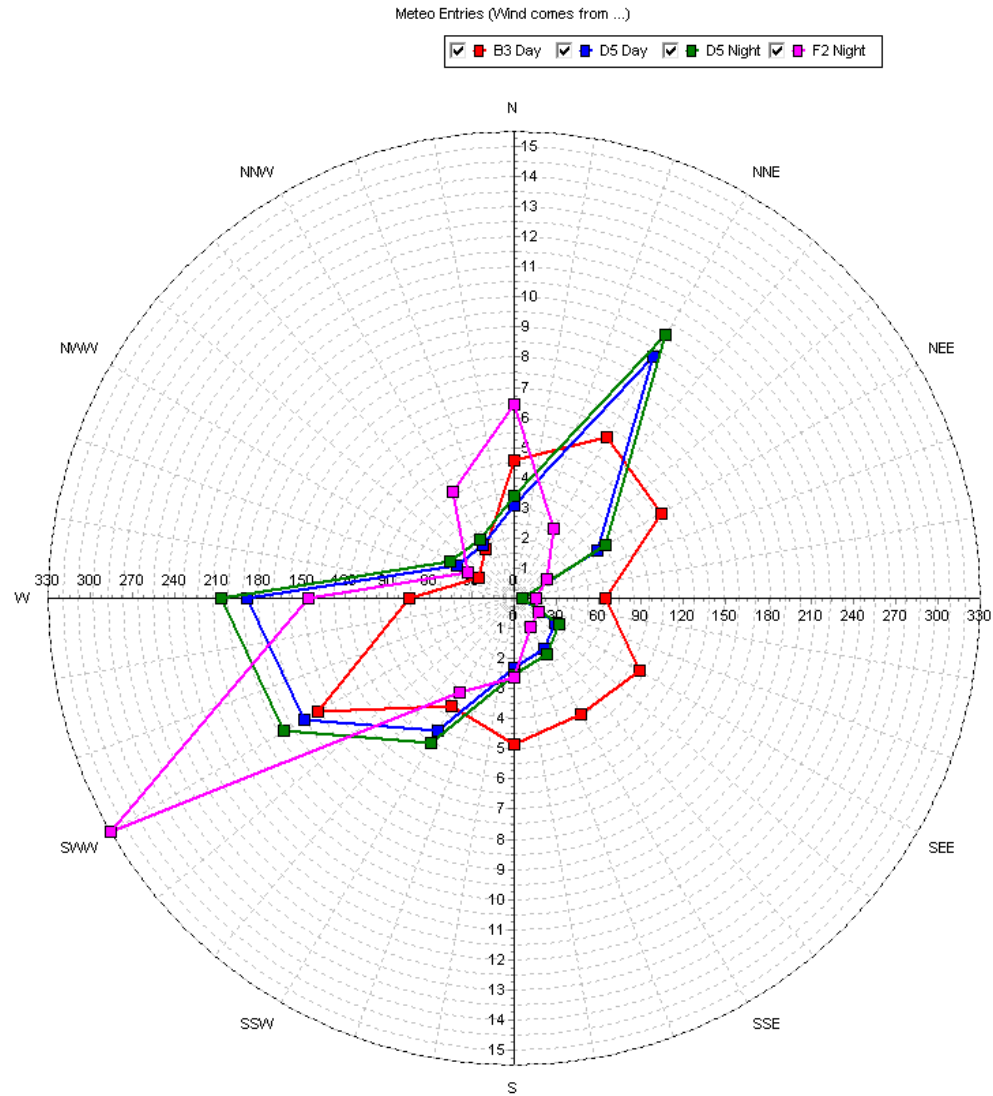
- Pasquill Stability Class: B; wind speed 3 m/s (B3)
- Pasquill Stability Class: D; wind speed 5 m/s (D5)
- Pasquill Stability Class: F; wind speed 2 m/s (F2).

The meteorological data sets used for the QRA are presented in Table F.2. Additionally, the wind rose map is also provided in Figure F.1.

Table F.2: Meteorological data sets used for the QRA

Direction wind from (degrees true)	B3		D5		F2		Total Day	Total Night
	Day	Night	Day	Night	Day	Night		
0	4.58	0	3.09	3.38	0	6.42	7.67	9.80
30	6.17	0	9.25	10.13	0	2.66	15.42	12.79
60	5.66	0	3.20	3.50	0	1.25	8.86	4.76
90	3.03	0	0.25	0.28	0	0.73	3.28	1.00
120	4.84	0	1.59	1.75	0	0.93	6.44	2.68
150	4.45	0	1.96	2.15	0	1.09	6.41	3.24
180	4.87	0	2.31	2.53	0	2.64	7.18	5.17
210	4.13	0	5.06	5.54	0	3.59	9.19	9.13
240	7.55	0	8.06	8.82	0	15.52	15.61	24.34
270	3.49	0	8.89	9.73	0	6.85	12.38	16.58
300	1.37	0	2.22	2.44	0	1.76	3.59	4.19
330	1.91	0	2.06	2.25	0	4.06	3.97	6.31

Figure F.1: Wind Rose Distribution



APPENDIX G. ASSESSMENT OF BUNCEFIELD RECOMMENDATIONS

The final SEARs under *Hazard and Risk* issues requires TQ Holdings to apply the relevant recommendations arising from the final Buncefield Investigation to PKBLT site. The recommendations are listed below and the corresponding status for the PKBLT site. The PKBLT site is currently in the development application stage. As a result, specific details relating to equipment integrity, workforce responsibilities and fire protection requirements have yet to be finalised. As a result, the majority of these recommendations should be addressed in future studies and as part of the PKBLT MHF Safety Case report.

Table G.1: Buncefield Recommendations – Response Table

Buncefield Recommendation	Requirement for Project
<p>1</p> <p>The competent authority and operators of Buncefield type sites should develop and agree a common methodology to determine the SIL level for overfill prevention systems in line with EN61511. This methodology should take account of :</p> <ul style="list-style-type: none"> • The existence of nearby sensitive resources or populations • The nature and intensity of depot operations • Realistic reliability expectations for tank gauging systems; and • The extent/rigour of operator monitoring. Application of the methodology should be clearly demonstrated in the COMAH safety report. 	<p>To comply with the Buncefield recommendations, a Safety Requirement Specification (SRS) style document should be developed. The SRS details the lifecycle management of Safety Instrumented Functions (SIFs). This will include the requirement for SIL allocation and verification of SIFs.</p> <p>Safety integrity level (SIL) requirements for overfill prevention systems against AS IEC 61511 should be assessed as part of the design process.</p> <p>There are no sensitive locations in the vicinity of PKBLT due to its location in a special uses Port area.</p> <p>TQ Holdings should develop the SIL allocation methodology. The MHF Safety Case should clearly outline the methodology taken. Relevant maintenance and testing regimes to meet AS IEC 61511 should be in place based on the outcome of the SIL allocation study and the equipment and systems selection process.</p>

Buncefield Recommendation	Requirement for Project
<p>2 Operators of Buncefield type sites should, as a priority, review and amend as necessary their management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. This should include, but not be limited to reviews of the following:</p> <ul style="list-style-type: none"> • The arrangements and procedures for periodic proof testing of storage tank overfill prevention systems to minimise the likelihood of any failure that could result in loss of containment; any revisions identified pursuant to this review should be put into immediate effect • The procedures for implementing changes to equipment and systems to ensure any such changes do not impair the effectiveness of equipment and systems in preventing loss of containment or in providing emergency response. 	<p>TQ Holdings should implement a management system for:</p> <ul style="list-style-type: none"> • periodic proof testing of storage tank overfill prevention systems. This should be done prior to site commissioning • procedure to implement changes to equipment and systems. The Management of Change (MOC) process should be refined and outlined in the MHF Safety Case report. <p>Refer to Recommendation 1 – covering lifecycle management of SIFs.</p>
<p>3 Operators of Buncefield type sites should protect against loss of containment of gasoline and other highly flammable liquids by fitting a high integrity, automatic operating overfill prevention system that is physically and electrically separate from the tank gauging system.</p>	<p>The method of preventing a loss of containment due to overfill should be determined during the SIL allocation study. Refer to Recommendation 1 – covering lifecycle management of SIFs.</p>
<p>4 Overfill protection systems (comprising means of level detection, logic/ control equipment and independent means of flow control) should be engineered, operated, and maintained to achieve and maintain an appropriate level of safety integrity in accordance with the requirements of BS EN 61511.</p>	<p>Refer to Recommendation 1 – covering lifecycle management of SIFs.</p>
<p>5 All elements of an overfill protection system should be proof tested in accordance with the validated arrangements and procedures sufficiently frequently to ensure the specified safety integrity level is maintained in practice in accordance with the requirements of BS EN 61511.</p>	<p>Refer to Recommendation 1.</p>

Buncefield Recommendation		Requirement for Project
6	<p>The sector should put in place arrangements to ensure the receiving site (as opposed the transmitting location) has ultimate control of tank filling. The receiving site should be able to safely terminate or divert a transfer without depending on the actions of a remote third party, or on the availability of communications to a remote location. These arrangements will need to consider upstream implications for the pipeline network, other facilities on the system and refineries.</p>	<p>PKBLT site will be receiving bulk petroleum liquids by ship tankers. TQ will have control over the filling of the Site 1 and 2 tanks from ships. Operators will be present onsite to monitor ship transfer operations. There will be a written procedure and competency based training available for all transfer activities.</p> <p>TQ Holdings' operators will be able to initiate ESD at the berth or from the control room. High level trip in any tank will initiate terminal ESD and terminate ship transfer.</p>
7	<p>In conjunction with Recommendation 6, the sector and the Competent Authority should undertake a review of the adequacy of existing safety arrangements, including communications, employed by those responsible for pipeline transfers of fuel.</p>	<p>Refer to Recommendation 6.</p>
8	<p>The sector, including its supply chain of equipment manufacturers and suppliers, should review and report without delay on the scope to develop improved components and systems, including but not limited to the following:</p> <ul style="list-style-type: none"> • Alternative means of ultimate high level detection for overfill prevention that do not rely on components internal to the storage tank, with the emphasis on ease of inspection, testing, reliability and maintenance; • Increased dependability of tank level gauging systems through improved validation of measurements and trends, allowing warning of faults and through using modern sensors with increased diagnostic capability; and • Systems to control and log override actions. 	<p>Refer to Recommendation 1 – covering lifecycle management of SIFs.</p>

Buncefield Recommendation		Requirement for Project
9	<p>Operators of Buncefield-type sites should introduce arrangements for the systematic maintenance of records to allow a review of all product movements together with the operation of the overfill prevention systems and any associated facilities. The arrangements should be fit for their design purpose and include, but not be limited to, the following factors:</p> <ul style="list-style-type: none"> • The records should be in a form that is readily accessible by third parties without the need for specialist assistance; • The records should be available both on site and at a different location; • The records should be available to allow periodic review of the effectiveness of control measures by the operator and the Competent Authority, as well as for root cause analysis should there be an incident; • A minimum period of retention of one year. 	TQ Holdings to develop a system for maintaining a record of tank movements and operation of overfill protection systems.
10	The sector should agree with the Competent Authority on a system of leading and lagging performance indicators for process safety performance.	TQ should develop Process Safety leading and lagging indicators that are monitored and reported on regularly. KPIs are a requirement of the WHS regulations. This should be described in the MHF Safety Case.

Buncefield Recommendation		Requirement for Project
11	Operators of Buncefield-type sites should review the classification of places within COMAH sites where explosive atmospheres may occur and their selection of equipment and protective systems (as required by the Dangerous Substances and Explosive Atmospheres Regulations 2002). This review should take into account the likelihood of undetected loss of containment and the possible extent of an explosive atmosphere following such an undetected loss of containment. Operators in the wider fuel and chemicals industries should also consider such a review, to take account of events at Buncefield.	PKBLT should undertake a Hazardous Area Classification consistent with the requirements of the relevant Australian Standards. Equipment located within hazardous areas should be selected, installed and maintained in accordance the relevant standards. Hydrocarbon monitoring and alarm systems will be installed in gasoline tank bunds. Gasoline tanks will also have overflow piping to direct any overfill stream to grade and into the bund. This will eliminate the liquid cascade effect which encourages mixing with air and forming a flammable and potentially explosive cloud.
12	Following on from Recommendation 11, operators of Buncefield-type sites should evaluate the siting and/or suitable protection of emergency response facilities such as fire fighting pumps, lagoons or manual emergency switches.	Firewater storage, foam storage and firewater pumps are currently located on the north-west corner of Site 2. A manual fire call point system complying with AS 1670 will be provided along the wharf and escape routes to raise an alarm at FRNSW. The suitability of the location of firewater protection systems and ESD push buttons should be reviewed in the Fire Safety Study (FSS) and when developing the Emergency Response Plan (ERP).

Buncefield Recommendation	Requirement for Project
<p>13</p> <p>Operators of Buncefield-type sites should employ measures to detect hazardous conditions arising from loss of primary containment, including the presence of high levels of flammable vapours in secondary containment. Operators should without delay undertake an evaluation to identify suitable and appropriate measures. This evaluation should include, but not be limited to, consideration of the following:</p> <ul style="list-style-type: none"> • Installing flammable gas detection in bunds containing vessels or tanks into which large quantities of highly flammable liquids or vapour may be released; • The relationship between the gas detection system and the overfill prevention system. Detecting high levels of vapour in secondary containment is an early indication of loss of containment and so should initiate action, for example through the overfill prevention system, to limit the extent of any further loss; • Installing CCTV equipment to assist operators with early detection of abnormal conditions. Operators cannot routinely monitor large numbers of passive screens, but equipment is available that detects and responds to changes in conditions and alerts operators to these changes. 	<p>Means of detecting overfill of flammable liquid from tanks should be developed during the detailed design phase of the Project.</p>
<p>14</p> <p>Operators of new Buncefield-type sites or those making major modifications to existing sites (such as installing a new storage tank) should introduce further measures including, but not limited to, preventing the formation of flammable vapour in the event of tank overflow. Consideration should be given to modifications of tank top design and to the safe re-routing of overflowing liquids.</p>	<p>PKBLT is a new bulk petroleum liquids site. To reduce the risk associated with tank overfill leading to a Buncefield-type consequence, TQ Holdings has added ducted overflow piping within the tank design.</p> <p>This would safely direct an overflow from a floating roof tank to a safe location at grade, and eliminate the possibility of a large flammable cloud forming due to cascading flammable liquid and droplet formation.</p>

Buncefield Recommendation		Requirement for Project
15	The sector should begin to develop guidance without delay to incorporate the latest knowledge on preventing loss of primary containment and on inhibiting escalation if loss occurs. This is likely to require the sector to collaborate with the professional institutions and trade associations.	Not applicable to operator – industry wide requirement
16	Operators of existing sites, if their risk assessments show it is not practicable to introduce measures to the same extent as for new ones, should introduce measures as close to those recommended by Recommendation 14 as is reasonably practicable. The outcomes of the assessment should be incorporated into the safety report submitted to the Competent Authority.	Recommendation 14 has been incorporated in PKBLT tank design.

Buncefield Recommendation	Requirement for Project
<p>17</p> <p>The Competent Authority and the sector should jointly review existing standards for secondary and tertiary containment with a view to the Competent Authority producing revised guidance by the end of 2007. The review should include, but not be limited to the following:</p> <ul style="list-style-type: none"> • Developing a minimum level of performance specification of secondary containment (typically this will be bunding); • Developing suitable means for assessing risk so as to prioritise the programme of engineering work in response to the new specification; • Formally specifying standards to be achieved so that they may be insisted upon in the event of lack of progress with improvements; • Improving firewater management and the installed capability to transfer contaminated liquids to a place where they present no environmental risk in the event of loss of secondary containment and fires; • Providing greater assurance of tertiary containment measures to prevent escape of liquids from site and threatening a major accident to the environment. 	<p>TQ Holdings should apply the latest codes and standards relating to tank and bund design.</p>
<p>18</p> <p>Revised standards should be applied in full to new build sites and to new partial installations. On existing sites, it may not be practicable to fully upgrade bunding and site drainage. Where this is so operators should develop and agree with the Competent Authority risk-based plans for phased upgrading as close to new plant standards as is reasonably practicable.</p>	<p>TQ Holdings should apply the latest codes and standards to the design of the site.</p>

Buncefield Recommendation	Status at PKBLT
<p>19 The sector should work with the Competent Authority to prepare guidance and/or standards on how to achieve a high reliability industry through placing emphasis on the assurance of human and organisational factors in design, operation, maintenance, and testing. Of particular importance are:</p> <ul style="list-style-type: none"> • Understanding and defining the role and responsibilities of the control room operators (including in automated systems) in ensuring safe transfer processes; • Providing suitable information and system interfaces for front line staff to enable them to reliably detect, diagnose and respond to potential incidents; • Training, experience and competence assurance of staff for safety critical and environmental protection activities; • Defining appropriate workload, staffing levels and working conditions for front line personnel; • Ensuring robust communications management within and between sites and contractors and with operators of distribution systems and transmitting sites (such as refineries); • Prequalification auditing and operational monitoring of contractors' capabilities to supply, support and maintain high integrity equipment; • Providing effective standardised procedures for key activities in maintenance, testing, and operations; • Clarifying arrangements for monitoring and supervision of control room staff; and • Effectively managing changes that impact on people, processes and equipment. 	<p>TQ Holdings to develop Health Safety Environment Quality (HSEQ) Management Systems to address the following requirements:</p> <ul style="list-style-type: none"> • Identification of roles and responsibilities • Competence management system in place. • Adequate staffing arrangements including shift work. Shift work is adequately managed to control risks from fatigue • Operating procedures include shift handover, log books etc. • Active monitoring programme and a set of leading and lagging indicators. These should be developed as part of the MHF Safety Case.

Buncefield Recommendation		Status at PKBLT
20 - 22	Not applicable - Recommendations for the industry sector and competent authority	
23	The sector should set up arrangements to collate incident data on high potential incidents including overfilling, equipment failure, spills and alarm system defects, evaluate trends, and communicate information on risks, their related solutions and control measures to the industry.	Not applicable to operator – industry wide requirement
24	The arrangements set up to meet Recommendation 23 should include, but not be limited to, the following: <ul style="list-style-type: none"> • thorough investigation of root causes of failures and malfunctions of safety and environmental protection critical elements during testing or maintenance, or in service; • developing incident databases that can be shared across the entire sector, subject to data protection and other legal requirements. Examples exist of effective voluntary systems that could provide suitable models; • collaboration between the workforce and its representatives, duty holders and regulators to ensure lessons are learned from incidents, and best practices are shared. 	TQ Holdings to develop and implement a system for incident investigation.
25	In particular, the sector should draw together current knowledge of major hazard events, failure histories of safety and environmental protection critical elements, and developments in new knowledge and innovation to continuously improve the control of risks. This should take advantage of the experience of other high hazard sectors such as chemical processing, offshore oil and gas operations, nuclear processing and railways.	Refer to Recommendation 23.
2. Emergency Preparedness for, response to and recovery from incidents		
Assessing the potential for a Major Incident		

Buncefield Recommendation		Status at PKBLT
1	Operators of Buncefield-type sites should review their emergency arrangements to ensure they provide for all reasonably foreseeable emergency scenarios arising out of credible major hazard incidents, including vapour cloud explosions and severe multi-tank fires that, before Buncefield, were not considered realistically credible. The Competent Authority should ensure that this is done.	The ERP should be prepared in accordance with HIPAP 1 as part of the development approval process. As part of the MHF Safety Case process, the ERP should be reviewed with Fire and Rescue NSW (FRNSW) to ensure that all Major Incident scenarios have been considered in the ERP.
2 & 3	Not applicable - Action for the competent authority	
4	Operators should review and where necessary revise their on-site emergency arrangements to ensure that relevant staff are trained and competent to execute the plan and should ensure that there are enough trained staff available at all times to perform all the actions required by the on-site emergency plan.	Emergency exercises on a range of scenarios should be held regularly. Shift rosters will involve checks to ensure that there are sufficient trained personnel available onsite to execute the ERP. The ERP should account for potential changes in required resourcing in an emergency situation.
5	For Buncefield-type sites, operators should evaluate the siting and/or suitable protection of emergency response facilities such as the emergency control centre, fire fighting pumps, lagoons or manual switches, updating the safety report as appropriate and taking the necessary remedial actions.	Refer to Recommendation 12.
6	Operators should identify vulnerable critical emergency response resources and put in place contingency arrangements either on or off site in the event of failure at any time of the year and make appropriate amendments to the on-site emergency plan. This should include identifying and establishing an alternative emergency control centre with a duplicate set of plans and technical information.	Refer to Recommendation 12.
7	For COMAH sites, if the operator relies on an off-site Fire and Rescue Service to respond, the operator's plan should clearly demonstrate that there are adequate arrangements in place between the operator and the service provider. The Competent Authority will need to check that this is done	A Fire Safety Study should be prepared for PKBLT to determine the site firewater demand requirements. This is required as part of the post-development approval stage by NSW DPE and should be reviewed and approved by FRNSW. As part of the MHF Safety Case, TQ Holdings should submit the ERP to FRNSW for approval regarding appropriate support during Major Incident events. FRNSW should periodically attend the site for exercises and conduct annual audit of the site fire protection systems.

Buncefield Recommendation		Status at PKBLT
Warning and Informing the Public		
8	COMAH site operators should review their arrangements to communicate with residents, local businesses and the wider community, in particular to ensure the frequency of communications meets local needs and to cover arrangements to provide for dealing with local community complaints. They should agree the frequency and form of communications with local authorities and responders, making provision where appropriate for joint communications with those bodies.	This should be covered during the ERP development.
9 - 32	Not applicable to MHF operators	
Investigation of the Explosion Mechanism		
1 - 3	Not applicable to MHF operators	
Land use planning and the control of societal risk around major hazard sites		
1 - 18	Not applicable to MHF operators	

APPENDIX H. REFERENCES

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- 2 NSW Department of Planning (2011): *Hazardous Industry Planning Advisory Paper No. 4 – Risk Criteria for Land Use Safety Planning*.
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