PRELIMINARY HAZARD ANALYSIS,

PORT KEMBLA ETHANOL TERMINAL, NSW

MANILDRA

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14 May 2022

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Preliminary Hazard Analysis, Manildra, Port Kembla Ethanol Terminal

Disclaimer

Rev	Date	Description	Reviewed By
A	11/7/21	Draft for Comment	Manildra
B	7/8/21	Final Issue	Manildra
C	9/8/21	Table 1 Updated	Manildra
D	2/10/21	Updates with NSW Ports Comments	Manildra
E	5/10/21	Rev D Updates Accepted	Manildra
F	23/4/22	LPG Cylinders and Berth Fire Protection Included	Manildra
G	14/5/22	Appendices Updated	Manildra

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EXECUTIVE SUMMARY

The Manildra Group is a wholly Australian owned business and the largest processor of wheat in Australia. It manufactures a wide range of wheat-based products for food and industrial markets both locally and internationally.

The Manildra Group owns the Shoalhaven Starches factory located on Bolong Road, Bomaderry, which produces a range of products for the food, beverage, confectionary, paper and motor transport industries including starch, gluten, glucose and ethanol.

Manildra propose to construct a beverage grade ethanol storage and handling facility at Port Kembla, NSW. The beverage grade ethanol will be transferred via road tankers from the Bomaderry facility to the Port Kembla facility and stored within six tanks. The beverage grade ethanol can then be transferred to a ship, or to Isotanks and road tankers for delivery to the market.

As part of the project requirements, a Preliminary Hazard Analysis (PHA) is required.

The risks associated with the proposed ethanol terminal at the Manildra Port Kemba site have been assessed and compared against the Department of Planning risk criteria. The results show compliance with all HIPAP (Hazardous Industry Planning Advisory Paper) 4 risk criteria.

Societal risk, propagation risk, area cumulative risk and environmental risk is also concluded to be acceptable.

The primary reasons for the low risk levels from the terminal are that significant levels of radiant heat from potential fires are contained on-site and the relatively large separation distances between the potential hazardous event locations and the nearby industries and residential areas.

Based on the analysis in this PHA, there are no further recommendations made.

GLOSSARY

ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
AS	Australian Standard
BLEVE	Boiling Liquid Expanding Vapour Explosion
DG	Dangerous Good
DoP	NSW Department of Planning
HAZAN	Hazard Analysis
HIPAP	Hazardous Industry Planning Advisory Paper
HSE UK	Health and Safety Executive United Kingdom
ISGOTT	International Safety Guide for Oil Tankers and Terminals
LEL	Lower Explosive Limit
LPG	Liquefied Petroleum Gas
PHA	Preliminary Hazard Analysis
PLC	Programmable Logic Controller
QRA	Quantitative Risk Assessment
ROSOV	Remotely Operated Shut-off Valve
SEP	Surface Emissive Power
SEPP	State Environmental Planning Policy
UEL	Upper Explosive Limit

REPORT

1 INTRODUCTION

1.1 BACKGROUND

The Manildra Group is a wholly Australian owned business and the largest processor of wheat in Australia. It manufactures a wide range of wheat-based products for food and industrial markets both locally and internationally.

The Manildra Group owns the Shoalhaven Starches factory located on Bolong Road, Bomaderry, which produces a range of products for the food, beverage, confectionary, paper and motor transport industries including starch, gluten, glucose and ethanol.

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As part of the project requirements, a Preliminary Hazard Analysis (PHA) is required.

Manildra requested that Pinnacle Risk Management prepare the PHA for the proposed ethanol terminal. This PHA has been prepared in accordance with the guidelines published by the Department of Planning (DoP) Hazardous Industry Planning Advisory Paper (HIPAP) No 6 (Ref 1).

1.2 OBJECTIVES

The main aims of this PHA study are to:

- Identify the credible, potential hazardous events associated with the proposed terminal;
- Evaluate the level of risk associated with the identified potential hazardous events to surrounding land users and compare the calculated risk levels with the risk criteria published by the DoP in HIPAP No 4 (Ref 2);
- Evaluate the potential for propagation events;
- Review the adequacy of the proposed safeguards to prevent and mitigate the potential hazardous events; and
- Where necessary, submit recommendations to Manildra to ensure that the proposed terminal is operated and maintained at acceptable levels of safety and effective safety management systems are used.

1.3 SCOPE

This PHA assesses the credible, potential hazardous events and corresponding risks associated with the Port Kembla terminal with the potential for off-site impacts. This includes road transport and shipping.

1.4 METHODOLOGY

In accordance with the approach recommended by the DoP in HIPAP 6 (Ref 1) the underlying methodology of the PHA is risk-based, that is, the risk of a particular potentially hazardous event is assessed as the outcome of its consequences and likelihood.

The PHA has been conducted as follows:

- Initially, the proposed terminal and its location were reviewed to identify credible, potential hazardous events, their causes and consequences. Proposed safeguards were also included in this review;
- As the potential hazardous events are located at a significant distance from other sensitive land users, the consequences of each potential hazardous event were estimated to determine if there are any possible unacceptable off-site impacts;
- Included in the analysis is the risk of propagation both on and off-site; and
- If adverse off-site impacts could occur, assess the risk levels to check if they are within the criteria in HIPAP 4 (Ref 2).

2 SITE DESCRIPTION

The site for the proposed terminal is on Foreshore Road, Port Kembla (see Figure 1). This is currently a greenfield site adjacent to the harbour. The site is approximately 15,000 m^2.

The site is surrounding by the following land uses:

- The harbour to the north;
- A vacant Lot to the east;
- Ixom to the south. Ixom services at this site include:
  - Sulphuric acid manufacturing, recycling and supply services to the Australian oil refining industry via a purpose-designed spent acid regeneration plant;
  - Import / export and bulk supply of concentrated sulphuric acid to industrial and power generation customers both locally and overseas;
  - Manufacture of specific grades of sulphuric acid and sulphur-based chemicals for the water treatment industry;
- A sewerage pumping station to the immediate west of the site boundary; and
- Port Kembla train station and steel equipment suppliers further to the west.

A storm water channel runs along the western boundary to the harbour. The Lot to the west of this channel is currently vacant.

The nearest residential area is to the south-west at approximately 600 m from the terminal, i.e. the suburb of Port Kembla.

Security of the site will be achieved by a number of means. This will include site personnel and security patrols by an external security company. The site will operate 7 days per week (24 hours per day). Also, the site will be fully fenced and non-operating gates are locked. Security cameras will be installed for Shoalhaven Starches personnel to view site activities.

The site is planned to be unmanned except when the required maintenance activities are to be performed, Isotank loading and shipping operations. Road tankers drivers could be at the site 24/7.

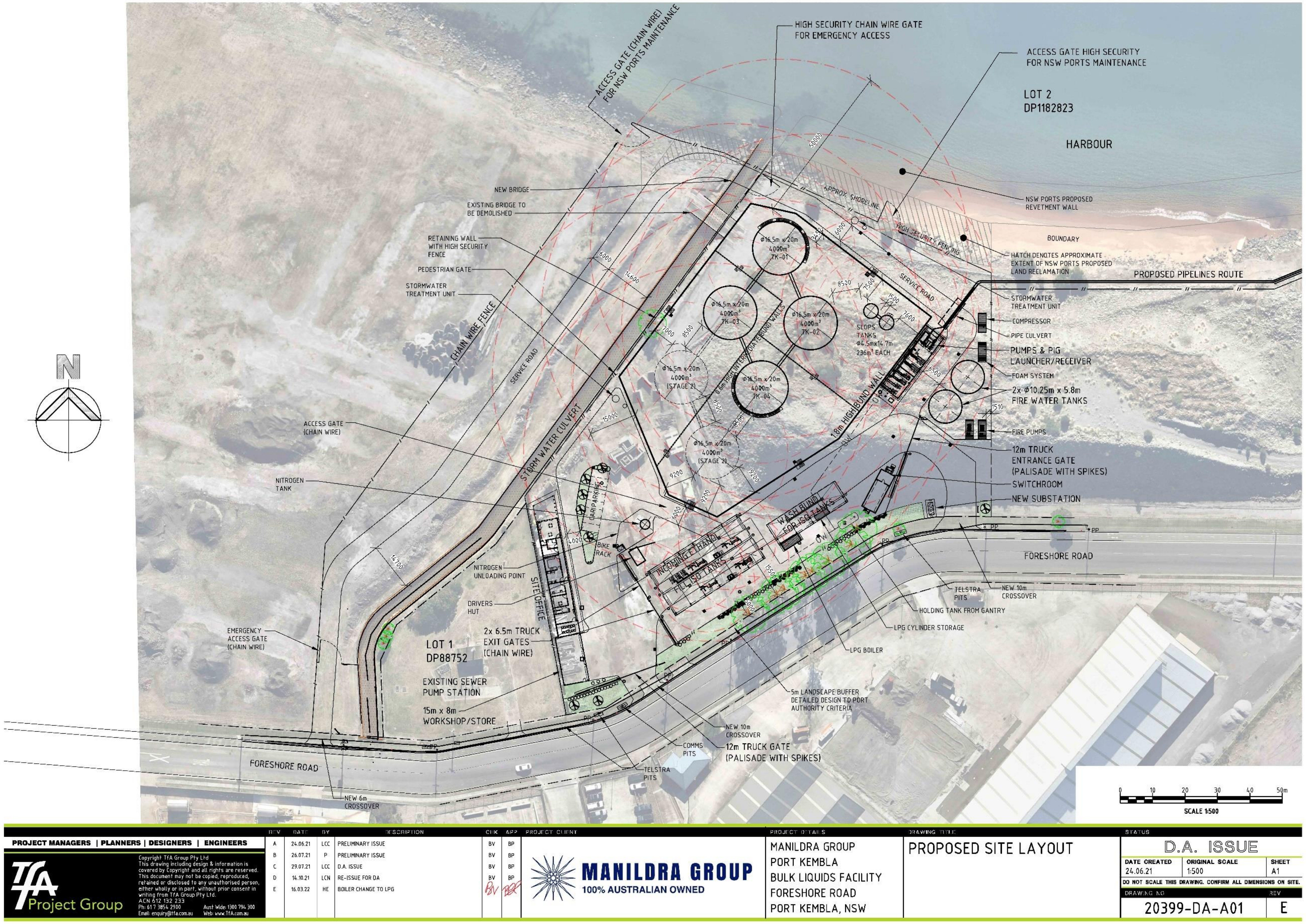
The main natural hazard for the site is flooding. This hazard is further detailed in Section 4.2. No other significant external events are considered high risk for this site.

A layout drawing showing the proposed terminal layout is shown in Figure 2.

Figure 1 - Site Location

Reference: Google Maps

Figure 2 - Site Layout



3 PROCESS DESCRIPTION

Ethanol is a Dangerous Good Class 3, Packing Group 2, flammable liquid.

The facility is to include the following:

- In-loading of beverage grade ethanol into the storage tanks from road tankers (singles and doubles);
- Ethanol storage in 6 x 4 ML stainless steel, fixed roof tanks;
- Ethanol loadout to vessels moored at berth 206 at approximately 1,000 m^3 per hour. Typical shipments are 5 ML to 10 ML;
- Flushing and pigging of the wharf supply and return pipelines to the slops tanks; and
- Outloading to Isotanks and road tankers for local markets at up to 100 m^3 per hour.

A process flow diagram is provided in Appendix A.

The road tanker in-loading will be automated so that truck drivers can operate the system. The road tanker drivers will be inducted and have swipe cards to enter the site through the automatic entrance gate. The road tankers will be parked at the dedicated in-loading bay. This will include containment (for at least the largest compartment), an automatic foam deluge system, a safety shower / eyewash station, dry-break couplings, a transfer control system with a 3 minute deadman's button and a Scully system for earthing.

When the required preparation requirements and interlocks are complete then the transfer pumps can be operated to transfer the ethanol into the storage tanks. Road tanker drive-away protection includes gates and a traffic light system (green / red lights for go / no-go indication for the driver).

The design of the storage tanks includes the following:

- 16.5 m diameter with a 20 m wall height (designed to API 620);
- Stainless steel construction (painted exterior);
- Frangible roofs;
- Pressure and vacuum relief valves plus emergency fire relief as per the requirements of AS1940;
- Nitrogen padding above the liquid to minimise the risk of an internal explosion. The nitrogen will be supplied from a cryogenic tank and vaporiser;
- Foam piped into the tanks above max liquid level, i.e. via foam pourers;

- Radar level gauge with an independent high level trip (to prevent overfill);
- All tank control functions will be PLC (programmable logic controller) controlled;
- The tanks will be designed to operate within the under/over pressure range -2.0/+1.85kpa; and
- Concrete bunding (capacity as per AS1940).

In addition to the six ethanol storage tanks, there will be two slops tanks. Slops (waste ethanol streams) can be generated during road tanker transfers, maintenance, Isotank cleaning and pigging the wharflines. The slops tanks will be smaller than the main storage tanks (4 m diameter and 18 m high) but similarly designed. The slops will be transferred to a road tanker and reprocessed at the Shoalhaven Starches facility at Bomaderry.

Ethanol can be pumped from the storage tanks to the road tanker and Isotank loadout facility or to a ship. Tank-to-tank transfers and tank recirculation are also potential modes of operation.

The Isotanks are cleaned using steam from a package boiler. The fuel for the boiler is proposed to be from (up to) five 210 kg LPG (liquefied petroleum gas) cylinders.

Out-loading to road tankers and Isotanks is performed in a dedicated transfer bay adjacent to the in-loading transfer bay. The out-loading transfer bay will include containment (for at least the largest compartment), an automatic foam deluge system, a safety shower / eyewash station, dry-break couplings, a transfer control system with a 3 minute deadman's button and a Scully system for earthing as per the in-loading bay. It will also include a vapour connection to a scrubber so that ethanol vapours are not released to the environment during out-loading. Effluent from the scrubber will be sent to the slops system.

As out-loading to an Isotank involves connecting transfer spool pieces and separate high level protection then this operation will be performed by a Manildra operator.

Outloading to ships will require additional operators, e.g. to supervise the terminal and berth operations as well as performing line walking to check for leaks. The ship export pumps will be variable speed drive and ramp up and down when starting and stopping. The transfers to the ship at the berth will be via hoses. To avoid any potential ethanol losses, a return wharfline will also be included in the design to return waste ethanol to the slops tanks.

The wharfline and return line will be pigged to ensure the lines rest on nitrogen. These lines will be 300 mm diameter. They will run along the wharf and adjacent to the harbour to connect to the site.

All equipment in contact with ethanol will be manufactured from stainless steel. Non-destructive testing will be performed on all critical pipes, e.g. the wharflines.

The terminal design includes actuated, fail closed valves on the inlet and outlet lines for all tanks. These close on a terminal emergency.

The proposed fire detection and protection systems include:

- Leak detection at the pumps and in the switchroom;
- Foam pourers to the tanks (above liquid level);
- Fire extinguishers and hose reels;
- Automatic foam deluge at the transfer bays and over the pumps; and
- Two firewater pumps, each supplied by a dedicated tank, supplying firewater to hydrants, monitors and water sprinklers as per the Australian Standards for terminals and berths.

The fire protection requirements for the berth (Ref 3) are proposed to be compliant to the Australian Standards and ISGOTT 6, i.e.:

1. 2 foam extinguishers;
2. 1 fixed and 1 portable water/foam monitors, one on either side of the shore manifold. Each monitor will be capable of supplying up to 2,700 L/min;
3. 4 new dual fire hydrants with isolation valves along the water main (every 90 m) with isolation valves downstream;
4. Foam concentrate storage requirements of 450L for initial response, 3,240 L for 60 minutes of operation and 8,100 L for reserve stocks (contingency for disaster combat); and
5. Foam proportioner up to 2,700 L/min.

To ensure adequate water supply to meet the above requirements, it is proposed to upgrade the current 2 x DN100 fire water mains currently on the jetty with:

1. A new DN200 fire water main aboveground along jetty from shore to berth; and
2. A new DN250 polyethylene underground water mains from the DN150 water supply connection point (provided by Sydney Water approximately 250 m from the jetty.

Firewater in the tank farm will be contained in the bunds and pumped to the slops tank for offsite disposal at the Shoalhaven Starches facility.

The potential transport movements are as follows:

- In-loading is approximately 250 million litres per year. If there is an average of 74,000 L per road tanker then this equates to approximately 3,380 loads into the facility per year or 65 loads per week;
- Isotanks and road tanker outloading is approximately 50 million litres per year or 1,000 loads out, i.e. approximately 20 loads per week; and
- A ship transfer every one to two weeks for the remaining ethanol (approximately 200 million litres per year).

4 HAZARD IDENTIFICATION

4.1 HAZARDOUS MATERIALS

The main hazardous material at the terminal is ethanol. There will also be some minor quantities of diesel (a combustible liquid), e.g. for the fire water pumps and package boiler.

Ethanol is a Dangerous Good Class 3 flammable liquid. It is soluble in water.

Ethanol's flammability limits are LEL (lower explosive limit) 3.5% and UEL (upper explosive limit) 19%. The control measures regarding safe handling and storage of ethanol are similar to other Class 3 materials, e.g. elimination of ignition sources, including static. It burns with a near colourless flame. The vapour is heavier than air and can accumulate in low points. Explosions of confined vapours are possible. Ethanol combustion produces carbon dioxide and carbon monoxide. Fires involving ethanol are normally extinguished with alcohol resistant foam.

LPG is also proposed to be stored in (up to) five 210 kg cylinders for the boiler. It is a Class 2.1 Dangerous Good (flammable gas).

When released from pressurised, ambient temperature storage to atmosphere, LPG will flash, generating larger volumes of vapour and some liquid which will evaporate quickly. The flammability range is typically 2% to 9.4% v/v in air. The vapours are heavier than air and may accumulate in confined, unventilated places (and thereby create a confined explosion hazard).

LPG ignition can lead to jet fires, flash fires or vapour cloud explosions (although unconfined explosions are not credible for this storage given the relatively small quantity stored in an open area). The LPG cylinders can BLEVE (boiling liquid expanding vapour explosion) when subjected to radiant heat from a nearby fire.

Products of combustion include carbon monoxide and carbon dioxide.

4.2 POTENTIAL HAZARDOUS INCIDENTS REVIEW

In accordance with the requirements of *Guidelines for Hazard Analysis*, (Ref 1), it is necessary to identify hazardous events associated with the facility's process operations. As recommended in HIPAP 6, the PHA focuses on "atypical and abnormal events and conditions. It is not intended to apply to continuous or normal operating emissions to air or water".

In keeping with the principles of risk assessments, credible, hazardous events with the potential for off-site effects have been identified. That is, "slips, trips and falls" type events are not included nor are non-credible situations such as an aircraft crash occurring at the same time as an earthquake.

The identified credible, significant process safety incidents (in particular, with the potential for off-site impacts) for the proposed modifications are summarised in the Hazard Identification Word Diagram following (Table 1).

This diagram presents the causes and consequences of the events, together with major preventative and protective features that are to be included as part of the design.

Table 1 – Hazard Identification Word Diagram

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
Terminal and Shipping				
1.	Loss of containment into the tanks' bunded area	Overfilling a tank. Tank failure, e.g. weld defect. Pipe failure, e.g. weld defect, flange failure. Drain valve left open or passing. Valve leak. Loss of containment from the scrubber system, e.g. due to overfilling	Pool fire if ignited. This can propagate to the adjacent tanks. Delayed ignition can result in a vapour cloud flash fire or explosion (if confinement exists). Impact to people (radiant heat) and property	Two level instruments installed on each tank to prevent overfill including an independent high level trip. These will trip a failed closed, actuated valve on the inlet to each tank. Tanks designed to API 620. Pipes designed to AS4041. Regular maintenance and inspection procedures. Tank and site fire protection facilities including foam pourers. Earthing of all tanks, no splash filling, hazardous area assessment and ignition control procedures, e.g. Authority to Work Permits - hot work permits. Training and procedures to ensure valves in the correct position following maintenance. Maintenance of all equipment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
2.	Tank top fire	Lightning strike, hot work	Tank top fire if ignited. This can propagate to the adjacent tanks. Impact to people (radiant heat) and property	Tanks designed to API 620. Tanks to have frangible roofs. Tanks to be nitrogen padded to lower the risk of an internal explosion with a subsequent tank top fire. Operator response to the low tank pressure alarm. Tank and site fire protection facilities including foam pourers. Earthing of all tanks, no splash filling and ignition control procedures, e.g. hot work permits
3.	On-site pipe failure external to the tanks' bunded area, e.g. failure of a pipe to the load-out gantry	Pipe defect, flange failure or impact	Spillage of ethanol. Fire if ignited. Impact to people (radiant heat) and property	Regular maintenance and inspection procedures. Emergency isolation valves. Firefighting system (including foam). Stainless steel pipes designed to AS4041. Pipes to be located on a piperack to avoid impact damage. Pipes to be fully welded where possible. Control of ignition sources, e.g. permits to work and hazardous area assessment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
4.	Leak during unloading or loading of a road tanker or Isotank	Failure of transfer hose. Leak from valves or fittings. Road tanker or Isocontainer overfill	Spillage of ethanol. Fire if ignited at the transfer bays. Impact to people (radiant heat) and property	High level of surveillance via cameras and use of flame detection and shutdown systems. Drivers are well trained (DG licenced) so as to minimise the chance of error and ensure quick response to leaks. Transfer bays fitted with automatic foam deluge system. Remote spill containment pit to avoid collection of flammables in the loading bay. Control of ignition sources, e.g. permits to work and hazardous area assessment. Scully truck and dedicated Isotank overfill shutdown systems. Manildra operators will perform the Isotank loading activity. All equipment including the transfer hoses (loading arms) will be included in the preventative maintenance system

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
5.	Road tanker drive-away incident (i.e. driver does not disconnect the hose and drives away from the loading bay)	Failure of procedures and hardware interlocks	Spillage of ethanol. Fire if ignited. Impact to people (radiant heat) and property	Driver training. Driver not in cab during filling. Gates and a traffic light system to be installed at each transfer bay. These systems will include interlocks with the Scully and hoses via position switches. Road tanker bays fitted with automatic foam deluge system. "Dry-break" hose couplings
6.	Leak at the ethanol pumps in the pump bunded area	Pump seal, shaft or casing failures (as well as the piping failures listed in Item Number 3 above)	Leak of ethanol in the pump bay. Fire if ignited. Impact to people (radiant heat) and property	Condition monitoring and preventative maintenance of the pumps. Leak detection system and alarm. Fire detection with automatic foam deluge over the pumps. Pumps in contained area to lower the likelihood of propagation

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
7.	Fire / explosion within the drainage system	Spill or release of ethanol with subsequent ignition	Potential for an internal explosion in the underground tanks (primarily TK-1601 as TK-1602 will be used for stormwater storage and handling). Potential for a flame to travel throughout the drainage piping system (this may result in multiple confined explosions in the drainage pipework)	Control of ignition sources, e.g. permits to work and hazardous area assessment. Flame arrestors to be installed on the underground tanks' vents. Flame traps to be installed in the drainage piping system
8.	Loss of containment of ethanol during pipeline pigging	Opening the pig hatch with too much ethanol inside. Leaving a pig hatch drain and/or vent valve open	The loss of containment could occur at the terminal or at the berth. Fire if ignited. Impact to people (radiant heat) and property. Environmental impact if ethanol is spilt into the harbour	The pig hatches and operations are to be as per industry good practice. Only appropriately trained operators will perform the pigging operations. Procedures for pigging to include the required sequence for valve operation to avoid leaving a drain or vent valve open. Control of ignition sources, e.g. permits to work and hazardous area assessment. The pig hatches will be bunded. Fire protection at the site and berth will include hydrants and extinguishers

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
9.	Loss of containment from the wharflines	Third Party interference. Pipe defect, flange failure or impact. Lightning strike Hammer / surge	The loss of containment could between the terminal and the berth, or at the berth. Fire if ignited. Impact to people (radiant heat) and property. Environmental impact if ethanol is spilt into the harbour or to the ground	The wharflines will be cleared of ethanol using pigs and they will rest on nitrogen. Line-walking during wharfline transfers. Regular maintenance and inspection procedures. Emergency isolation valves and operator response, e.g. closing the shore isolation valves. Mobile firefighting equipment in a trailer (to be positioned at the berth during ship transfers) . Stainless steel pipes designed to AS4041 and AS2885. Pipes to be fenced and barriers installed to avoid impact damage. Pipes to be fully welded where possible. Surge study to be performed on the wharflines, e.g. to ensure the actuated valves do not close too quickly. Control of ignition sources, e.g. permits to work, pipeline earthing and hazardous area assessment. Emergency response include spill equipment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
10.	Loss of containment from the ship transfer system	Ship hose failure, e.g. due to wear and tear. Ship pulls away from the berth. Ship transfer hoses flanges not adequately connected. Leak when using the stripping pump for clearing the ship's hoses	Potential for a loss of containment into the harbour hence environmental impact and fines. As ethanol is miscible with water, it will not pool on top of the water so a floating fire is not credible as is the case for petroleum products such as gasoline. If ethanol is released onto the berth then there is the potential for a fire if ignited. Impact to people (radiant heat) and property	Shipping hoses to be included in the hose register for routine testing and inspection. Standard international good practice for berthing a ship, e.g. securing the ship to the berth using ropes. Hoses inspected and pressure tested prior to ethanol transfer. Emergency response by the supervisors using radios and the process shutdown button. Trained personnel. Hoses to be included in the preventative maintenance system for routine pressure and electrical continuity tests. Emergency response includes firewater protection at the berth and a mobile trailer with equipment response equipment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
11.	Potential damage to equipment due to flooding	Storm event	Potential for flotation of structures. If this occurs and the structures, e.g. tanks, are damaged then a release of ethanol or diesel could occur, i.e. impact to the environment and possible fire (although the flood water will mitigate this risk through dilution)	The site will be raised/filled to ensure that all buildings including the workshop, offices load in/out gantry and wash bund will have finished surface levels above the 1% Annual Exceedance Probability flood level (3.0 m above the Australian Height Datum – the recommended worst-case for design purposes), thereby protecting major equipment and buildings and achieving an adequate degree of flood immunity. The main tank compound floor is anticipated to be approximately 3.0 m above the Australian Height Datum and protected by the proposed 1.8 m high bund wall which will prevent any flood waters from entering the tank compound

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
Boiler				
12.	Explosion within the boiler	LPG continues to flow when the burners are offline and the furnace is still hot	Buildup of flammable vapour in the furnace. If ignited, there is the potential for an internal explosion, i.e. damage to the furnace and boiler	Burner management system will be certified to Australian Standards which will include the need for adequate LPG isolation and air purging prior to startup
13.	Loss of containment of LPG from the supply pipe or cylinders	Corrosion or weld defect, gasket failure, valve leak, impact	If ignited, potential for a flash and/or jet fire which can impact personnel and equipment. A release from a 25 mm hole occurs (largest pipe size and assuming 25C saturated pressure), if ignited, will result in a jet fire of approximately 26 m, i.e. insufficient length to reach the ethanol tanks or the nearest adjacent property. If a jet fire impinges on the LPG cylinders or there is excessive radiant heat from an ethanol pool fire then the cylinders can BLEVE. Historically, this is a low likelihood event. For example, Ref 4 quotes a BLEVE likelihood of 5×10^{-7} times per year.	The piping and equipment items are to be compliant with the Australian Standards, e.g. AS1596. The LPG pressure will be reduced (via a regulator) at the cylinders and the supply pipe will be relatively small, i.e. 25 mm diameter (limits the flowrate if a release occurs). The LPG cylinders are to be located in an open area away from potential vehicle impacts and also in an area were the potential radiant heat from an ethanol pool fire is less than 10 kW/m^2. The LPG supply pipe is to be pressure tested following construction and protected against corrosion by painting. Control of ignition sources, e.g. permits to work and hazardous area assessment

Event Number	Hazardous Event	Causes	Consequences	Existing Safeguards - Prevention Detection Mitigation
14.	Boiler rupture	Low level, loss of boiler feed water pump / supply, failure of level control, control valve stuck closed	Catastrophic failure of the boiler, i.e. equipment damage and injury to on-site personnel if steam is released externally to the boiler	Australian Standard compliant low level protection, low and low-low level alarms, boiler trip on low-low level, maintenance on the valves and instruments, operator checks on the boiler sight glass
15.	High pressure within the furnace	Tube failure within the furnace	Potential for flames to be emitted from the furnace openings and hence injure on-site personnel and damage equipment	Preventative maintenance on the tubes (annual inspection), furnace trip logic to prevent high pressure, common alarm sounds on high pressure, fan maintenance
16.	Boiler rupture	Corrosion, e.g. poor boiler feed water chemistry. Erosion, e.g. from two phase flow	Catastrophic failure of the boiler, i.e. equipment damage and injury to on-site personnel	Water softeners on the boiler feedwater supply, routine water sampling, routine equipment inspections (weekly, monthly and yearly)

5 RISK ANALYSIS

The assessment of risks to both the public as well as to operating personnel around the proposed facility requires the application of the basic steps outlined in Section 1. As per HIPAP 6 (Ref 1), the chosen analysis technique should be commensurate with the nature of the risks involved. Risk analysis could be qualitative, semi-quantitative or quantitative.

The typical risk analysis methodology attempts to take account of all credible hazardous situations that may arise from the operation of processing plants etc.

Having identified all credible, significant incidents, risk analysis requires the following general approach for individual incidents:

Risk = Likelihood x Consequence

The risks from all individual potential events are then summated to get cumulative risk.

For QRA (quantitative risk analysis) and hazard analysis, the consequences of an incident are calculated using standard correlations and probit-type methods which assess the effect of fire radiation, explosion overpressure and toxicity to an individual, depending on the type of hazard.

In this PHA, however, the approach adopted to assess the risk of the identified hazardous events is scenario-based risk assessment. The reason for this approach is the distances from the proposed facility to residential and other sensitive land users are large and hence it is unlikely that any significant consequential impacts, e.g. due to radiant heat from fires, from the facility will have any significant contribution to off-site risk.

The risk criteria applying to developments in NSW are summarised in Table 2 on the following page (from Ref 2).

Table 2 - Risk Criteria, New Plants

Description	Risk Criteria
Fatality risk to sensitive uses, including hospitals, schools, aged care	0.5×10^{-6} per year
Fatality risk to residential and hotels	1×10^{-6} per year
Fatality risk to commercial areas, including offices, retail centres, warehouses	5×10^{-6} per year
Fatality risk to sporting complexes and active open spaces	10×10^{-6} per year
Fatality risk to be contained within the boundary of an industrial site	50×10^{-6} per year
Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 kW/m^2 at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year	50×10^{-6} per year
Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure	10×10^{-6} per year
Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community	50×10^{-6} per year
Propagation due to Fire and Explosion – exceed radiant heat levels of 23 kW/m^2 or explosion overpressures of 14 kPa in adjacent industrial facilities	50×10^{-6} per year

As discussed above, the consequences of the potential hazardous events are initially analysed to determine if any events have the potential to contribute to the above-listed criteria and hence worthy of further analysis.

5.1 POOL FIRE MODELLING

The following pool fire scenarios have been assessed:

- Bund fire (compound and an intermediate bunded area);
- Road tanker transfer bay fires;
- Pump and pig hatch bund fire; and
- Representative tank top fires.

There are no toxic gas emissions from this proposed terminal or credible explosion events with adverse off-site impacts. As ethanol is a flammable liquid then pool fires are the credible hazardous events with the potential for off-site impact.

Fires at the berth are not modelled as there is a generous separation distance to the land users (i.e. no credible risk of adverse radiant heat impact from a berth fire). Any ethanol that is potentially released into the harbour during ship transfers will immediately mix and dilute with the water, i.e. a floating pool fire scenario is not credible.

Potential fires associated with releases from the wharflines are not modelled as the likelihood of these events is very low given that these pipelines will contain nitrogen for the majority of the time (see the analysis in Section 5.9.3).

Therefore, the credible hazardous events associated with the proposed terminal are largely pool fires due to potential losses of containment being ignited. The potential pool fire events associated with the equipment, tanks and bunds are detailed in Table 3. This data is used in the fire modelling. A discussion on burndown rates and surface emissive powers (SEP) is given below.

Burndown Rates:

For burning liquid pools (Ref 5), heat is transferred to the liquid via conduction, radiation and from the pool rim.

Wind can also affect the burning rate (experiments have shown both an increase and decrease in burning rates due to the effects of wind) but also can affect flame stability (and hence average flame emissive power) (Ref 6). Therefore, average reported values for burndown rates are used in this study.

For very large pool fires with diameters greater than 5 to 10 m, there is some evidence of a decrease in burning rate.

Experimental data for the ethanol burndown rate is 1 mm/min (Refs 6 and 7).

The burning rate is used in the determination of flame height. Normally, the higher the burning rate, the higher the estimated flame height.

Surface Emissive Power:

Surface emissive power can be either derived by calculation or by experimentation. Unfortunately, experimental values for surface emissive powers are limited.

When calculated, the results can be overly conservative, particularly for large diameter fires, as it is assumed that the entire flame is at the same surface emissive power. This is not the case for large diameter fires as air entrainment to the centre of the flame is limited and hence inefficient combustion occurs.

For ethanol, a literature search (Refs 8 and 9) indicates the following data:

SEP's of 50kW/m^2 for large fires (pool diameter => 25 m) and 60 kW/m^2 for pool fires less than 25 m in diameter appear reasonable.

The distances to specified radiant heat levels for the potential fire scenarios are shown in Table 3. The distances were calculated using the View Factor model for pool fires (Refs 6 and 7). Graphical representations of the estimated radiant heat contours are shown in Appendix B.

Table 3 – Fire Scenarios Calculation Data and Results

Note that "Eq. D" is the equivalent diameter of the fire (4 x the fire area / the fire perimeter) and "SEP" is the surface emissive power (i.e. the radiant heat level of the flames).

Item No.	Item Description	Width, m	Length, m	Eq. D, m	Tank Height, m	Liquid Density, kg/m^3	SEP, kW/m^2	Distance to Specified Radiant Heat Level, m (from base of flame)				Maximum Ground Level Radiant Heat, kW/m^2 (for tank fires only)
								23 kW/m^2	12.6 kW/m^2	4.7 kW/m^2	3 kW/m^2	
1	Compound fire	-	-	74	-	790	50	5	18	46	64	-
2	Intermediate Bund Fire (for comparison to the compound fire) – Bund Closest to the Fire Water Tanks	-	-	41	-	790	50	4	12	21	43	-
3	Fire at the road tanker transfer bay (Note 2)	7	25	7	-	790	60	3	5	10	14	-
4	Fire at the pump and pig hatch bund (Note 2)	4	30	4	-	790	60	2	3	7	9	-
5	Tank top fire	-	-	16.5	20	790	60	4	8	18	25	Less than 3 kW/m^2
6	Slops tank top fire	-	-	4.5	14.7	790	60	2	4	7	10	Less than 3 kW/m^2

Notes for Table 3:

1. The bund fires include releases from piping leaks which ignite as well as releases from tank failures.
2. Modelled as a channel fire, i.e. flame height estimated based on width.
3. Modelling performed at low wind speed.

The values of interest for radiant heat (DoP, HIPAP No. 4 and ICI HAZAN Course notes) are shown in Table 4.

Table 4 - Radiant Heat Impact

HEAT FLUX (kW/m^2)	EFFECT
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-30 seconds and second degree burns after 30 seconds. Glass breaks
12.6	30% chance of fatality for continuous exposure. High chance of injury Wood can be ignited by a naked flame after long exposure
23	100% chance of fatality for continuous exposure to people and 10% chance of fatality for instantaneous exposure Spontaneous ignition of wood after long exposure Unprotected steel will reach thermal stress temperatures to cause failure
35	25% chance of fatality if people are exposed instantaneously. Storage tanks fail
60	100% chance of fatality for instantaneous exposure

For information, further data on tolerable radiant heat levels is shown in Table 5.

Table 5 – Layout Considerations – Tolerable Radiant Heat Levels

Plant Item	Tolerable Radiant Heat Level, kW/m^2	Source
Drenched Storage Tanks	38	Ref 7
Special Buildings (Protected)	25	Ref 7
Cable Insulation Degrades	18-20	Ref 7
Normal Buildings	14	Ref 7
Vegetation	12	Ref 7
Plastic Melts	12	Ref 7
Escape Routes	6	Ref 7
Glass Breakage	4	Ref 10
Personnel in Emergencies	3	Ref 7
Plastic Cables	2	Ref 7
Stationary Personnel	1.5	Ref 7

5.2 VAPOUR CLOUD EXPLOSIONS DUE TO TANK OVERFILLS

Explosions involving the vapours from flammable liquids are possible. Two notable incidents involving releases of flammable liquids that have resulted in unconfined vapour explosions are detailed below.

One incident occurred at the fuel storage facility at Buncefield, UK. In the early hours of Sunday 11th December 2005, a number of explosions occurred at Buncefield Oil Storage Depot, Hemel Hempstead, Hertfordshire. At least one of the initial explosions was of massive proportions and there was a large fire, which engulfed a high proportion of the site. Over 40 people were injured; fortunately there were no fatalities. The explosion was the result of a large loss of containment of flammable liquid.

Another similar incident occurred at the Texaco Newark storage facility, January 7 (i.e. during winter again), 1983. The tanks involved here had little level protective instrumentation; tank level was primarily achieved via frequent dipping with subsequent checklist completion. The material was super unleaded gasoline. During a transfer operation, one tank overflowed at approximately midnight and a vapour cloud formed. It travelled approximately 300 metres towards an incinerator (most likely source of ignition given eye-witness reports) and then exploded. There was one fatality and twenty four people injured.

Issues in common with two events are:

- Overflow from height, spraying of the flammable liquid causing a mist;
- Cold ambient temperatures (Buncefield approximately -2 deg Cel, similarly for Newark);
- Low wind speeds (e.g. Buncefield - Pasquill stability class F);
- Rolling mist (e.g. Buncefield - 5 to 7 metres high mist with confinement, i.e. between buildings and amongst trees);
- Delayed ignition; and
- Large amounts lost - Buncefield approximately 300 tes and Newark approximately 450 tes.

The following summarised recommendations are from the Buncefield Safety Task Group's investigation. Comment is included on their applicability to the Manildra Port Kembla ethanol tank storage area.

- The overall systems for tank filling control need to be of high integrity, with sufficient independence to ensure timely and safe shutdown to prevent tank overflow and the overall systems for tank filling control meet AS 61511. *This will be achieved via tank radar level gauge with alarm and a high level trip on the tank feed pumps. There will also be an independent high level switch which also stops the ethanol feed to the tanks.*

- Management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. *Manildra has an existing safety management system which includes equipment item maintenance, including instrumentation testing requirements*. *The equipment at this new facility will be included in the maintenance system for the site.*

- Fire-safe shut-off valves should be used and remotely operated shut-off valves (ROSOVs) should be installed on tank outlets. *Manildra plan to use fire-safe valves and install ROSOVs on the tanks' inlet and outlet lines.*

- Bunds are to be leak tight and the bund compliant with AS1940. *These recommendations are consistent with the proposed Manildra bund designs*.

- Site-specific planning of firewater management and control measures should be undertaken. *Firewater containment will be afforded by the tank bunds and on-site waste water containment facilities. Beyond these measures, further emergency response will be required.*

- Procedures exist for defining roles, responsibilities and competence, staffing and shift work arrangements (e.g. managing fatigue), shift handover, organisational change and management of contractors, performance evaluation and process safety performance measurement including procedures for investigation of incidents and near misses, and auditing. *Manildra has an existing safety management system which includes these requirements*. *This system will be implemented, with appropriate modification, at the Port Kembla facility.*

- Emergency procedures exist inclusive of firefighting requirements. *Manildra has emergency response plans for their existing sites and will develop a site specific plan for Port Kembla*.

In summary, unconfined vapour cloud explosions resulting from the spillage of a hydrocarbon at ambient temperature and below its boiling point are rare (Ref 11). If enough hydrocarbon is spilt, particularly from height with low wind speeds to minimise dilution, then a vapour cloud is possible.

Importantly for this site, the volumes released at Buncefield and Newark from tank overflows will not be possible at Port Kembla as the tanks are filled by road tankers, i.e. an overfill is limited to the maximum capacity of a road tanker.

Given the measures proposed at the Manildra Port Kembla site, the expected likelihoods for these types of events are still expected to be rare and therefore do not pose significant off-site risks.

5.3 PROPAGATION RISK ANALYSIS

There are design and safety management system controls (summarised in Table 1) that are designed to prevent hazardous events occurring. These include designing to Australian and international standards and codes, hazardous area assessments and controls of ignition sources, e.g. permits to work. Should these prevention controls fail and an incident occur then propagation is possible for some events.

Given the types of potential hazardous events that can occur at the terminal, the main risk of propagation is from pool fires.

Propagation of a fire event can occur if equipment is subjected to approximately 23 kW/m^2 or higher for a prolonged exposure period, i.e. the exposed equipment could fail due to high temperature creep, typically after at least 10 minutes of exposure.

Given the radiant heat contours shown in Appendix B then no off-site propagation is expected as the 23 kW/m^2 contour does not encroach onto any neighbouring facilities. Therefore, off-site propagation risk is deemed acceptable.

For on-site propagation, historical evidence shows that tanks fires in terminals can propagate from tank-to-tank even when the separation distances are compliant with the relevant codes and standards. One reference (Ref 12) quotes a study on large diameter, external floating roof tanks (wind speed of 4 m/s) and the estimated average time for the fire to propagate from one tank to an adjacent tank (see Table 6).

Table 6 – Tank Fires Propagation Time

Intertank Separation	Propagation Time (Hours)
0.5 Tank Diameter	1.5 (Note 1)
1.0 Tank Diameter	3.0
2.0 Tank Diameter	17

Note 1: The propagation time will increase to 2.8 hours when there is no wind or when water sprays are used on the tank at risk.

Others notes for the above table include:

- Smaller diameter tanks at normal separations are at greater risk of propagation than larger diameter equivalent tanks; and
- Lower volatility fuels allow more response time for fire fighters

The risk of tank-top fires propagation at the terminal will be reduced by the following controls:

- Nitrogen padding to prevent an internal explosion (which can lead to a tank-top fire);
- Foam pourers to installed within each tank;
- Tank cooling water to be supplied via sprinklers; and
- Tank spacing as per the Australian Standards.

A compound or intermediate bund fire will pose propagation risks, in particular to the equipment within the bund. As shown in Table 9, the likelihood of these events is acceptably low (approximately 5.5×10^{-6} times per year).

Fires at the other areas of the terminal, i.e. the transfer bays, and the pump and pig hatch bund, are not expected to pose propagation risks given the generous site layout and separation distanced.

As the boiler will be designed, operated, maintained and certified to the Australian Standards, e.g. AS1596 for the industry standard cylinders, then this ensures the risk of incidents achieves ALARP (as low as reasonably practicable).

Given the analysis performed in this PHA then there are no events posing high propagation risk levels.

5.4 CUMULATIVE RISK

As the 12.6 kW/m^2 contours do not encroach onto any adjacent facilities then the proposed facility does not increase the existing risk levels in the area. Therefore, cumulative area risk is deemed acceptable.

5.5 ROAD TRANSPORT

Ethanol transported by road will be transported in accordance with the Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref 13).

If a road tanker or Isotank carrying ethanol is involved in an accident and the vessel integrity is lost then there is the potential for serious injury and fatality for people involved in the accident or those nearby if the ethanol ignites.

The expected frequency and vehicle movements to/from the site is given in Table 7.

Table 7 – Ethanol Road Transport Frequencies

Material Transported	Nominal Site Delivery Frequency	Nominal Annual Volume
Road Tankers Delivering Ethanol to the Site	65 Loads per Week (74,000 L each) or 13 per Day	250,000,000 L
Road Tankers and Isotanks Supplying the Market, i.e. leaving the site	20 Loads per Week (50,000 L each) or 4 per Day	50,000,000 L

Given the expected approximate transport frequencies in Table 7 then there will be an additional 85 loads carrying ethanol per week. This is above the SEPP 33 (State Environmental Planning Policy) (Ref 14) criterion of 45 loads per week for a Dangerous Good 3, Packing Group II, flammable liquid such as ethanol. Therefore, it was recommended in earlier versions of this PHA that the project should include an assessment of the anticipated roads that will be used for ethanol transport with respect to transport risk and the preferred roads to use. This study has been completed (Ref 15). The preferred route from Shoalhaven Starches to the Port Kembla facility is via the A1 and Five Islands Road.

5.6 Site Location Checklist

The site has been assessed with regard to exposure to the following external hazards:

Subsidence	Landslide
Burst dam	Earthquake
Storm and high winds	Rising water courses
Flood	Storm water runoff
Lightning	Forest fire
Vermin/insect infestation	Security

The risk controls for flooding events are detailed in Table 1. Given the current proposed location, there are no obvious other significant hazards amongst this list that could result in on-site events leading to serious off-site impacts.

5.7 HIPAP 4 COMPLIANCE CHECK

The risk criteria applying to developments in NSW are summarised in Table 2. The results in Table 3 are analysed as follows to check compliance with the HIPAP 4 risk criteria.

For assessment of the effects of radiant heat, it is generally assumed that if a person is subjected to 4.7 kW/m^2 of radiant heat and they can take cover within approximately 20 seconds then no serious injury, and hence fatality, is expected. However, exposure to a radiant heat level of 12.6 kW/m^2 can result in fatality for some people for limited exposure durations.

The 4.7 kW/m^2 contour extends off-site for the large bund fire scenario (this is common for these types of facilities). The 4.7 kW/m^2 contour is for injury risk at residential areas, i.e. from HIPAP 4 “incident heat flux radiation at residential areas should not exceed 4.7 kW/m^2 at frequencies of more than 50 chances in a million per year”. Whilst technically roads and footpaths are not residential areas, the risk is still acceptable given that the large bund fire likelihood is approximately $5.5x10^{-6}$ times per year (see Section 5.3). As this value is less than 50 x 10^{-6} per year then the risk is acceptable and no further controls for the large bund fire scenario are warranted, in particular, given that the terminal will be designed to AS1940.

The effect of heat radiation on a person can be calculated from the probit equation below and the probability of fatality predicted by transforming the probit. The probit equation is based on thermal dose.

$$\text{Probit} = -36.38 + 2.56 \ln(tQ^{1.33}) \text{ (Ref 6)}$$

t exposure time (sec)

Q heat flux (W/m^2)

Note that this probit is only valid for very short exposure durations (less than 1 minute). For the purposes of this assessment it is assumed a person has 20 seconds to escape from heat radiation (i.e. an exposure duration of 20 seconds).

For the radiant heat levels of interest, the probability of fatality from the above probit is shown in the following table.

Table 8 – Probability of Fatality from Radiant Heat

Radiant Heat, kW/m^2	Probability of Fatality
4.7	0.0
12.6	0.07
23	0.72

Therefore, the radiant heat level of 12.6 kW/m^2 is taken to be the approximate lower limit for fatality from radiant heat for short durations.

For information, representative likelihoods of potential pool fires are summarised in Table 9.

Table 9 – Pool Fires' Likelihoods

Scenario	Likelihood times per year	Reference
Bund fires	$5.5x10^{-6}$	Thomas, Historical Fire Incident Data Use & Sources, June 2003
Flammable liquids pump fires	10^{-4} to 10^{-5}	Lees (Ref 7)
Tank top fires (fixed roof tanks)	$2.9x10^{-4}$	Lees (Ref 7)

Given the radiant heat contours in Appendix B and the above-stated event likelihoods then the analysis with respect to compliance with the HIPAP 4 risk criteria is shown in Table 10.

Table 10 – HIPAP 4 Risk Criteria Compliance

Description	Risk Criteria	Comments
Fatality risk to sensitive uses, including hospitals, schools, aged care	0.5 x 10^{-6} per year	There are no sensitive land users in the nearby area, in particular, within the 4.7 kW/m^2 radiant heat contour. Therefore, this fatality risk criterion is satisfied
Fatality risk to residential and hotels	1 x 10^{-6} per year	There are no residential areas or hotels in the nearby area, in particular, within the 4.7 kW/m^2 radiant heat contour. Therefore, this fatality risk criterion is satisfied
Fatality risk to commercial areas, including offices, retail centres, warehouses	5 x 10^{-6} per year	There are no commercial areas in the nearby area, in particular, within the 4.7 kW/m^2 radiant heat contour. Therefore, this fatality risk criterion is satisfied
Fatality risk to sporting complexes and active open spaces	10 x 10^{-6} per year	There are no sporting complexes or active open spaces in the nearby area, in particular, within the 4.7 kW/m^2 radiant heat contour. Therefore, this fatality risk criterion is satisfied
Fatality risk to be contained within the boundary of an industrial site	50 x 10^{-6} per year	The 12.6 kW/m^2 radiant heat contour remains on-site for all scenarios except the large compound fire case (the contour extends over the beach). This event has a likelihood of approximately 5.5x10^{-6} times per year. Therefore, this fatality risk criterion is satisfied
Injury risk – incident heat flux radiation at residential areas should not exceed 4.7 kW/m^2 at frequencies of more than 50 chances in a million per year or incident explosion overpressure at residential areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year	50 x 10^{-6} per year	The 4.7 kW/m^2 radiant heat contour does not encroach onto residential areas. There are no credible explosion events that could cause an overpressure of 7 kPa or more at residential areas. Therefore, this injury risk criterion is satisfied

Toxic exposure - Toxic concentrations in residential areas which would be seriously injurious to sensitive members of the community following a relatively short period of exposure	10×10^{-6} per year	There are no toxic substances proposed to be stored or handled at this site. Therefore, this toxic exposure risk criterion is satisfied
Toxic exposure - Toxic concentrations in residential areas which should cause irritation to eyes or throat, coughing or other acute physiological responses in sensitive members of the community	50×10^{-6} per year	There are no toxic substances proposed to be stored or handled at this site. Therefore, this toxic exposure risk criterion is satisfied
Propagation due to Fire and Explosion – exceed radiant heat levels of 23 kW/m^2 or explosion overpressures of 14 kPa in adjacent industrial facilities	50×10^{-6} per year	The 23 kW/m^2 radiant heat contour does not encroach onto adjacent industrial facilities. There are no credible explosion events that could cause an overpressure of 14 kPa or more at adjacent industrial facilities. Therefore, this propagation risk criterion is satisfied

5.8 SOCIETAL RISK

The criteria in HIPAP 4 for individual risk do not necessarily reflect the overall risk associated with any proposal. In some cases, for instance, where the 1 pmpy contour approaches closely to residential areas or sensitive land uses, the potential may exist for multiple fatalities as the result of a single accident. One attempt to make comparative assessments of such cases involves the calculation of societal risk.

Societal risk results are usually presented as F-N curves, which show the frequency of events (F) resulting in N or more fatalities. To determine societal risk, it is necessary to quantify the population within each zone of risk surrounding a facility. By combining the results for different risk levels, a societal risk curve can be produced.

In this study of the proposed Port Kembla terminal, the risk of off-site fatality at neighbouring facilities is below the HIPAP 4 risk criteria. Also, as the nearest house is approximately 600 m away, the concept of societal risk applying to populated areas is therefore not applicable for this project.

5.9 RISK TO THE BIOPHYSICAL ENVIRONMENT

The main concern for risk to the biophysical environment is generally with effects on whole systems or populations. For this site, it is suitably located away from residential areas. However, due to the nature of the activities, there are operations, e.g. ship transfers and road tanker or tank filling, where losses of containment can potentially impact the environment.

5.9.1 Solid and Gaseous Effluents

For the proposed terminal, there are no solid effluents that could significantly impact the environment. Significant gaseous emissions containing ethanol could emanate from tank or vehicle filling, and pipeline pigging activities. Manildra propose to install a scrubber to prevent impact to the environment from these vapour streams containing ethanol.

5.9.2 Terminal Liquid Effluent

Potential spills of ethanol from the tanks, adjacent piping and equipment, pumps, pig hatches and vehicle transfer bays are to be contained in the bunds and sumps. The bunded areas are to be sized to contain in excess of the entire contents of the single tank so that a total loss of contents does not spill over the bund (as per AS1940). Any ethanol that enters these contained areas will be pumped to the slops tanks and returned to the Shoalhaven Starches facility for reprocessing.

Stormwater that falls onto paved areas that are not directed to the slops tanks will pass through a stormwater holding tank (which can be sampled) prior to release to the harbour.

5.9.3 Wharfline Releases

Outside of the terminal, ethanol releases are possible from the wharflines and shipping transfers.

Data for pipeline failure is available from a number of sources but one of the most recent, comparable data sets is from the United Kingdom's Health and Safety Executive (HSE) (Ref 16).

The HSE have researched pipeline releases in the United Kingdom over a 45 year period and determined a current failure rate of approximately 2.8×10^{-5}/year.km. This is for small, medium and large releases. Note the HSE data assumes the pipelines are in use 100% of the time. However, the supply wharfline will be empty for the majority of the time (resting on nitrogen). The return wharfline is primarily for nitrogen and ethanol vapour streams returning to the scrubber and is unlikely to be full with liquid ethanol at any stage in the operations.

The time that the wharfline is in use is approximated as follows (pigging time not included as this is a relatively quick process):

- The ship transfer pumps are to be sized for approximately 1,000 m^3/hour;
- There will be approximately 200,000 m^3 of liquid ethanol transferred to a ship per year; and
- The total time that the supply wharfline has ethanol is estimated as 200,000 m^3 / 1,000 m^3/hr = 200 hours

Therefore, the likelihood of a release that could impact the environment is:

L = 2.8×10^{-5}/yr.km x 200 hours / 8,760 hours per year x 0.9 km (wharfline length) = 6×10^{-7}/yr

The above low likelihood for a release supports the anecdotal evidence in Australia that liquid lines built to the Australian Standards, e.g. AS2885, have a low failure rate. The low likelihood of a release plus construction to recognised codes confirms that the ALARP principle is met.

5.9.4 Releases from the Ship Transfer Hoses

Releases into the harbour are possible from the ship transfers due to hose failures. The reported failure frequency for shipping hoses vary, however, a typical value is 9×10^{-8} per hour of operation (Ref 17). This is for a range in spill sizes.

If the total transfer time is taken to be 200 hours per year then the approximate release likelihood for a loss of containment from the hoses is 9×10^{-8} per hour of operation x 200 hours = 2×10^{-5} per year, i.e. a relatively low value.

Whereas any adverse effect on the environment is obviously undesirable, the results of this study show that the risk of losses of containment is broadly acceptable.

6 CONCLUSION AND RECOMMENDATIONS

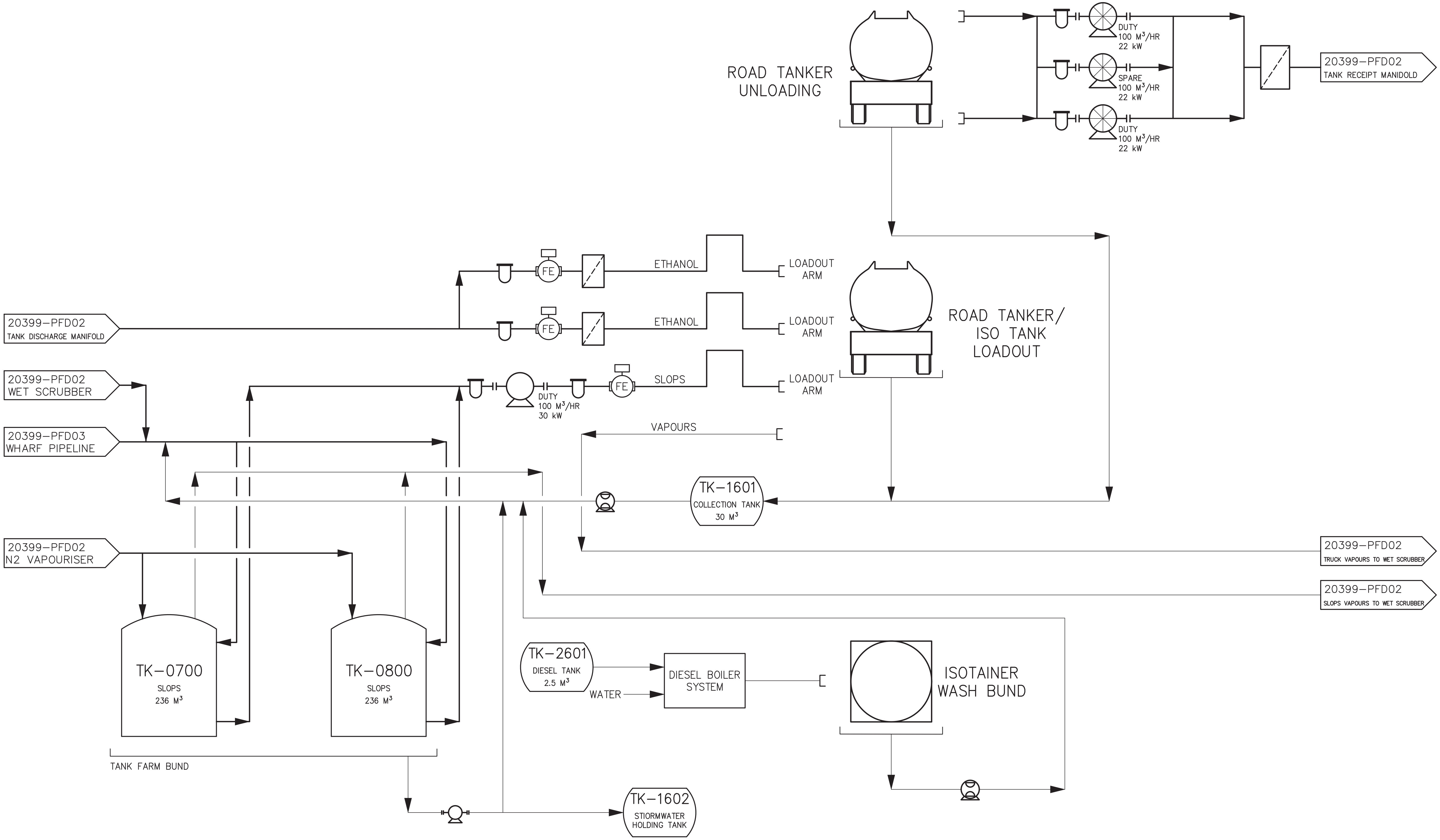
The risks associated with the proposed ethanol terminal at the Manildra Port Kemba site have been assessed and compared against the Department of Planning risk criteria. The results show compliance with all HIPAP 4 risk criteria.

Societal risk, propagation risk, area cumulative risk and environmental risk is also concluded to be acceptable.

The primary reasons for the low risk levels from the terminal are that significant levels of radiant heat from potential fires are contained on-site and the relatively large separation distances between the potential hazardous event locations and the nearby industries and residential areas.

Based on the analysis in this PHA, there are no further recommendations made.

7 APPENDIX A – PROCESS FLOW DIAGRAMS



PROJECT MANAGERS | PLANNERS | DESIGNERS | ENGINEERS

TfA Project Group

DRAWING ISSUE APPROVAL

NAME: DATE:

PROFESSIONAL QUALIFICATION:

SIGNATURE:

Head office - Brisbane Ph: 61 7 3854 2900
166 Knapp Street, Fortitude Valley QLD 4006 Australia
Email: enquiry@tfa.com.au Aust Wide: 1300 794 300

REV	DATE	BY	DESCRIPTION	CHK	APP
A	26.05.21	HE	INITIAL ISSUE		
B	07.06.21	HE	GENERAL REVISION		
C	23.07.21	HE	REVISED POST HAZOP 1	BV	

PROJECT DETAILS

MANILDRA GROUP
SHOALHAVEN STARCHES
PORT KEMBLA SITE
FORESHORE ROAD
PORT KEMBLA, NSW

DRAWING TITLE

PROCESS FLOW DIAGRAM
SHEET 1

STATUS

PRELIMINARY

DATE CREATED	ORIGINAL SCALE	SHEET
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DO NOT SCALE THIS DRAWING. CONFIRM ALL DIMENSIONS ON SITE.

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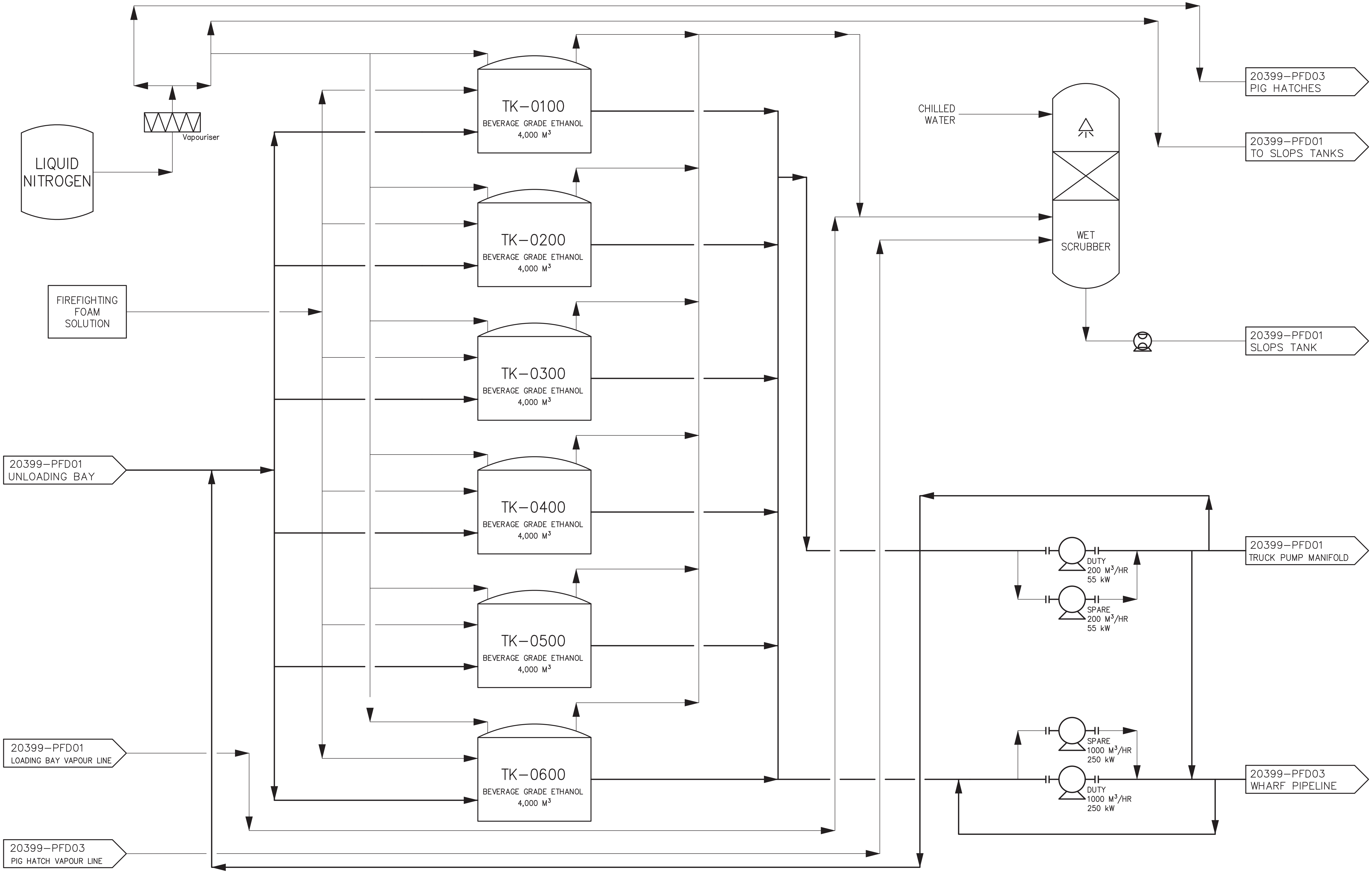
20399-PFD01	C



PROJECT MANAGERS | PLANNERS | DESIGNERS | ENGINEERS

TfA Project Group

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C	23.07.21	HE	REVISED POST HAZOP 1	BV	

PROJECT DETAILS

MANILDRA GROUP
SHOALHAVEN STARCHES
PORT KEMBLA SITE
FORESHORE ROAD
PORT KEMBLA, NSW

DRAWING TITLE

PROCESS FLOW DIAGRAM
SHEET 2

STATUS

PRELIMINARY

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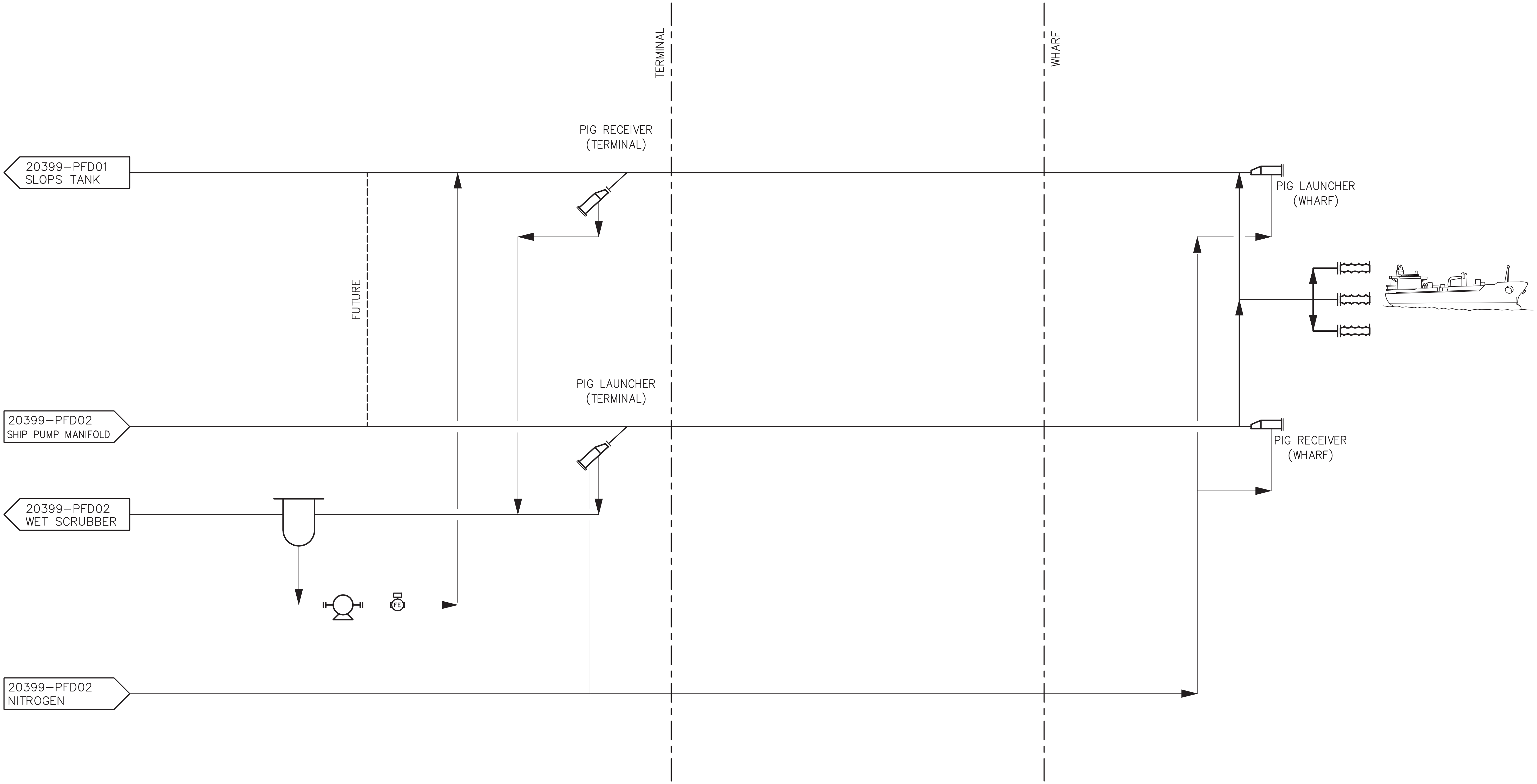

PROJECT MANAGERS | PLANNERS | DESIGNERS | ENGINEERS

TfA Project Group

DRAWING ISSUE APPROVAL

NAME: DATE:

PROFESSIONAL QUALIFICATION:

SIGNATURE:

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REV	DATE	BY	DESCRIPTION	CHK	APP
A	26.05.21	HE	INITIAL ISSUE		
B	07.06.21	HE	GENERAL REVISION		
C	23.07.21	HE	REVISED POST HAZOP 1	BV	

PROJECT DETAILS

MANILDRA GROUP
SHOALHAVEN STARCHES
PORT KEMBLA SITE
FORESHORE ROAD
PORT KEMBLA, NSW

DRAWING TITLE

PROCESS FLOW DIAGRAM
SHEET 3

STATUS

PRELIMINARY

DATE CREATED	ORIGINAL SCALE	SHEET
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DO NOT SCALE THIS DRAWING. CONFIRM ALL DIMENSIONS ON SITE.

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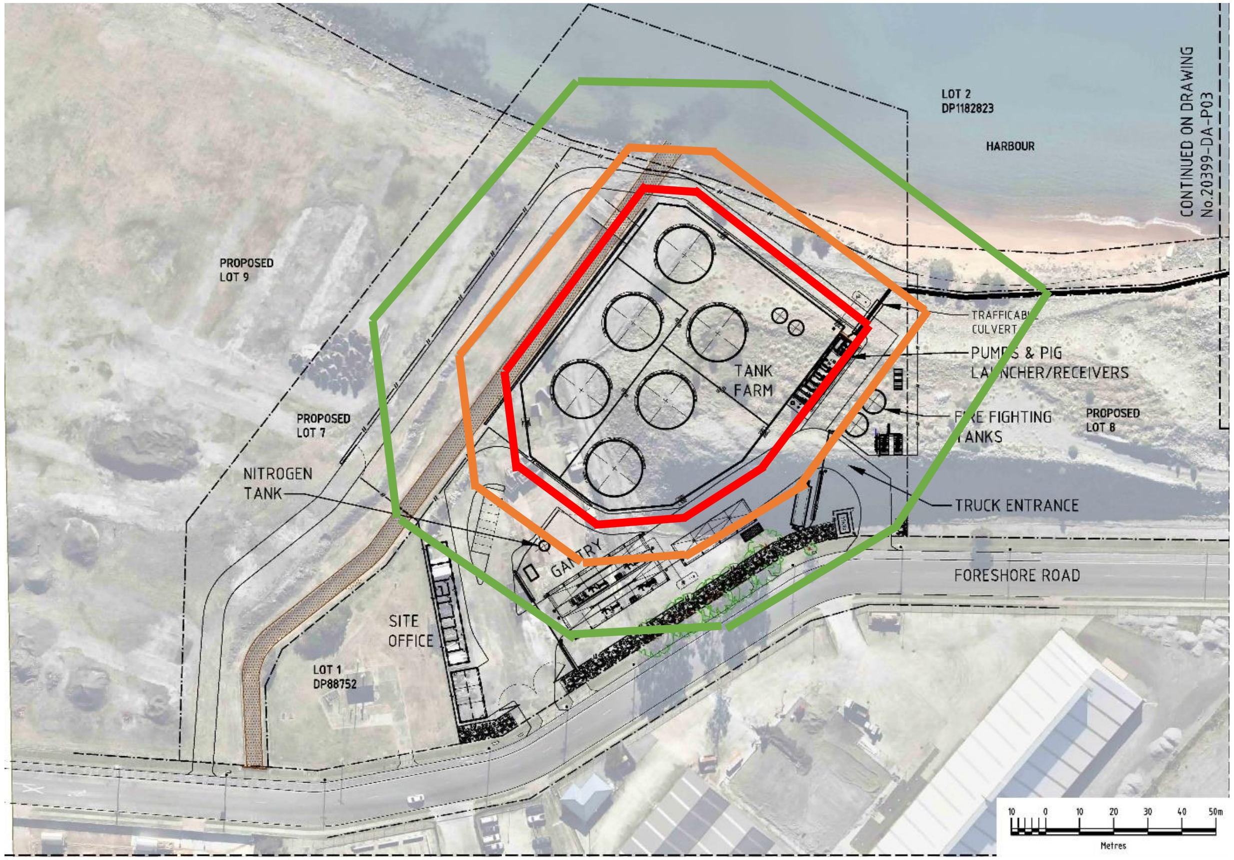
8 APPENDIX B - RADIANT HEAT CONTOURS

Appendix B - Radiant Heat Contours

Scenario 1: Compound Fire

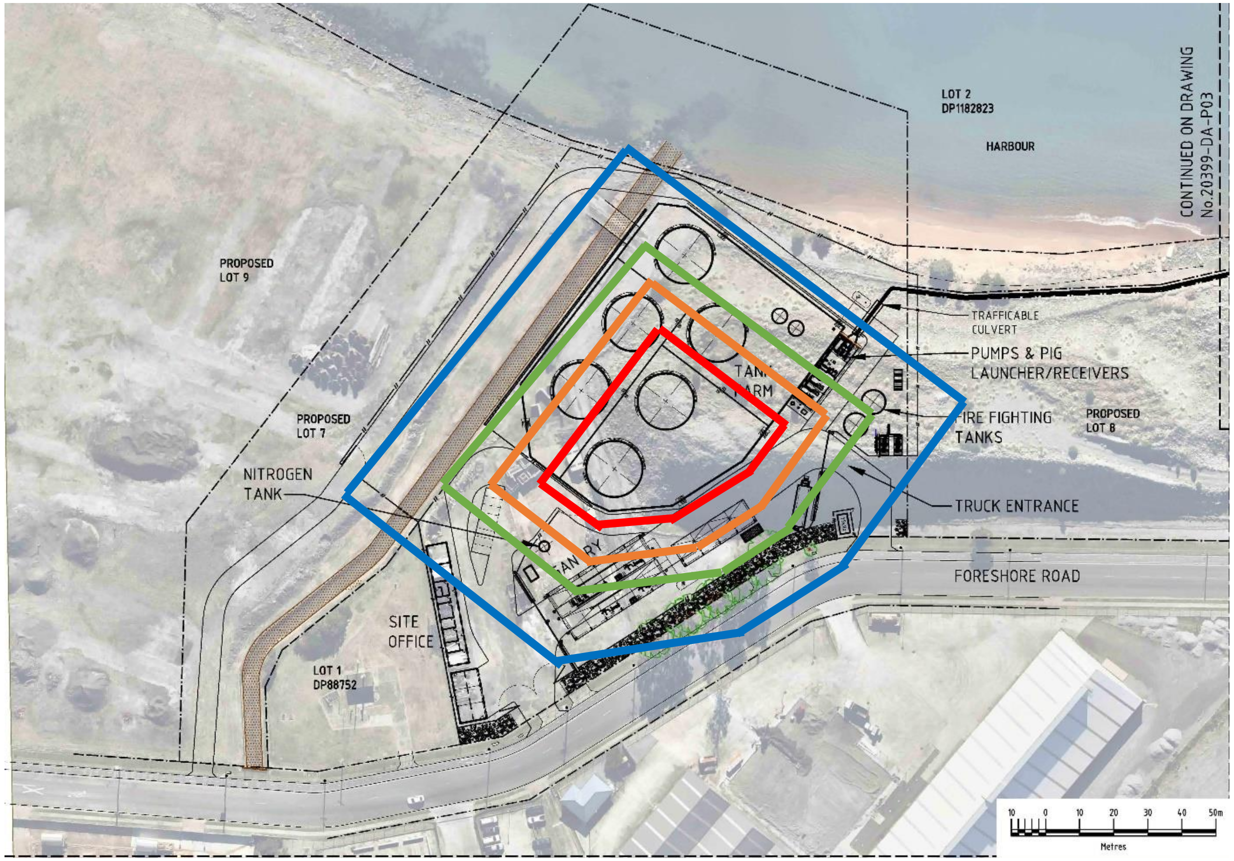


Key:

Red line	**23 kW/m²**
Orange line	**12.6 kW/m²**
Green line	**4.7 kW/m²**

Note: The radiant heat contours are approximate due to the irregular shape of the bund and the 3 kW/m² contour is not shown as the 4.7 kW/m² contour essentially covers the site.

Scenario 2: Bund Fire (representative case is the bund closest to the fire water tanks)

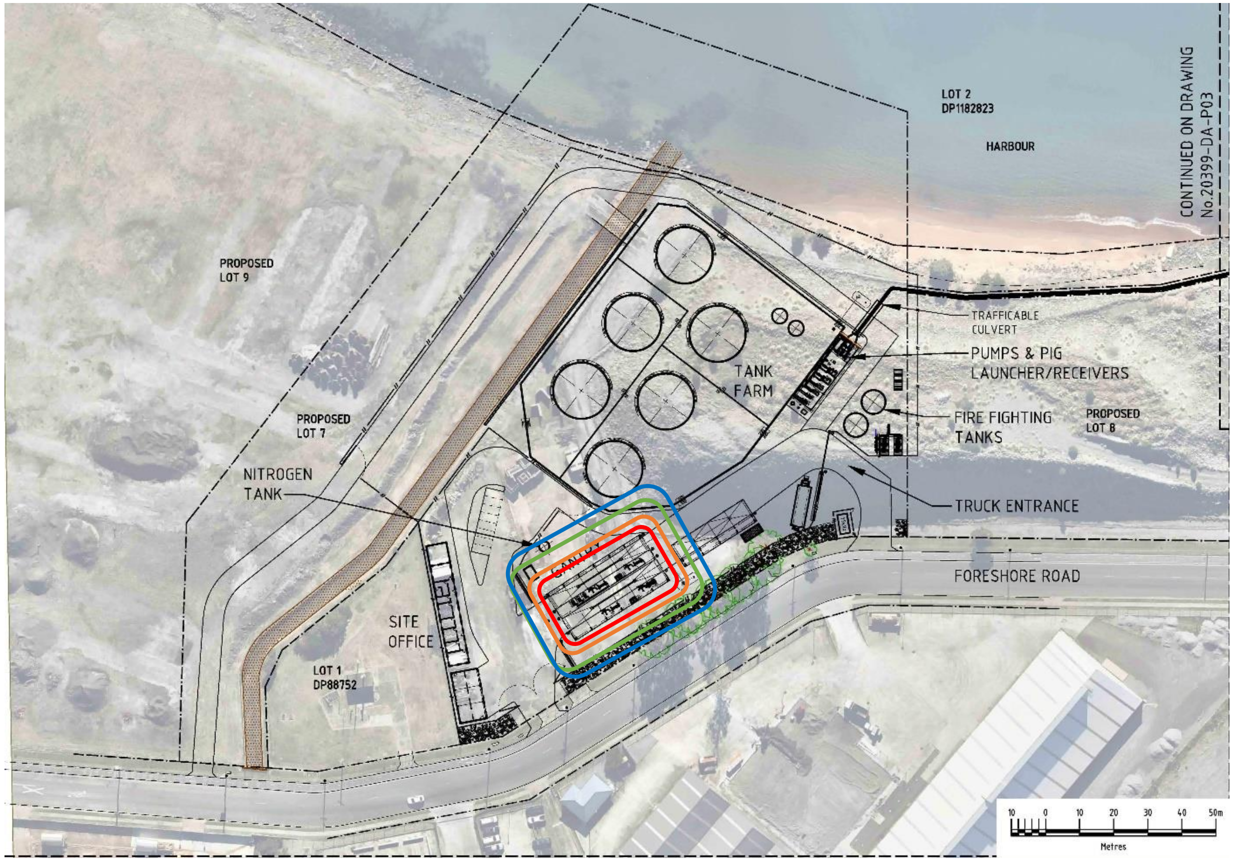


Key:

- 23 kW/m^2
- 12.6 kW/m^2
- 4.7 kW/m^2
- 3 kW/m^2

Note: The radiant heat contours are approximate due to the irregular shape of the bund.

Scenario 3: Road Tanker Transfer Bay Fire

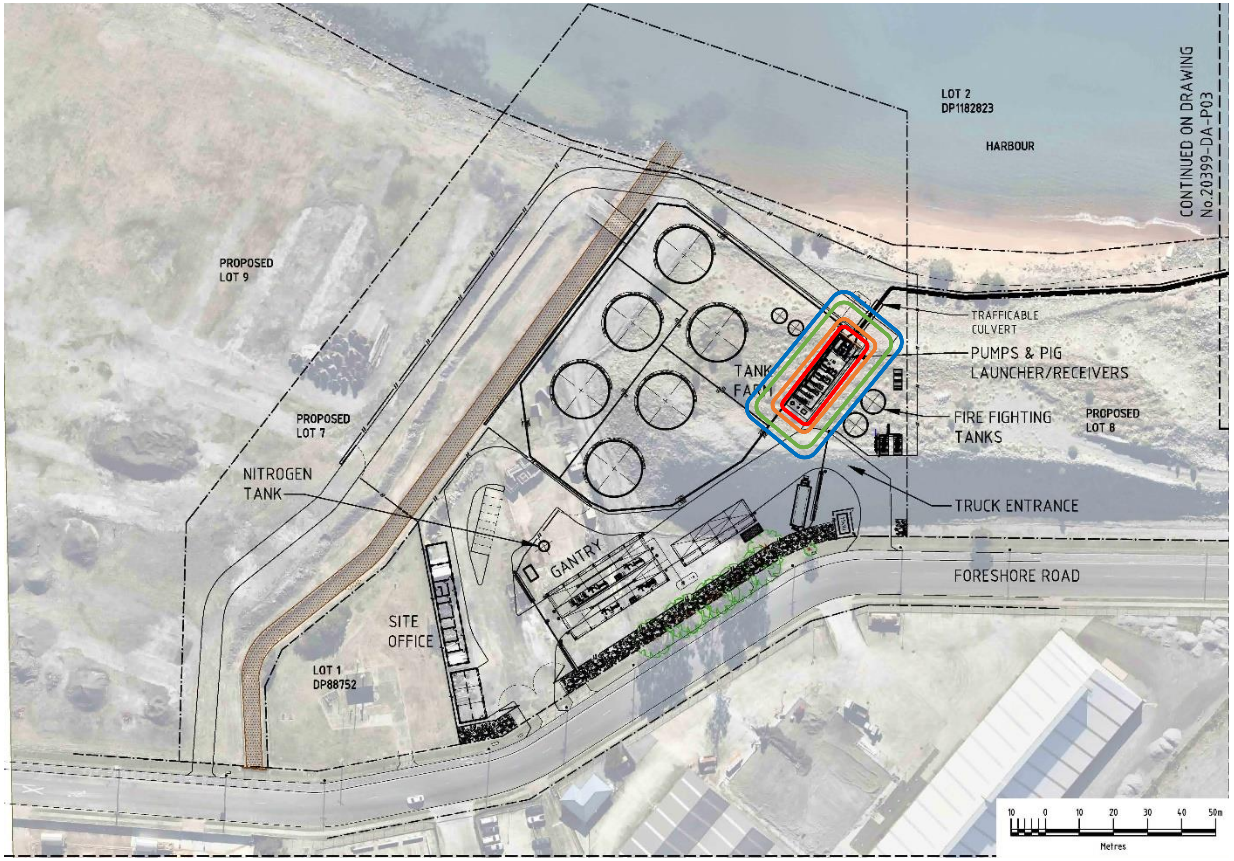


Key:

Red line	**23 kW/m²**
Orange line	**12.6 kW/m²**
Green line	**4.7 kW/m²**
Blue line	**3 kW/m²**

Note: The radiant heat contours are shown for a fire in either transfer bay.

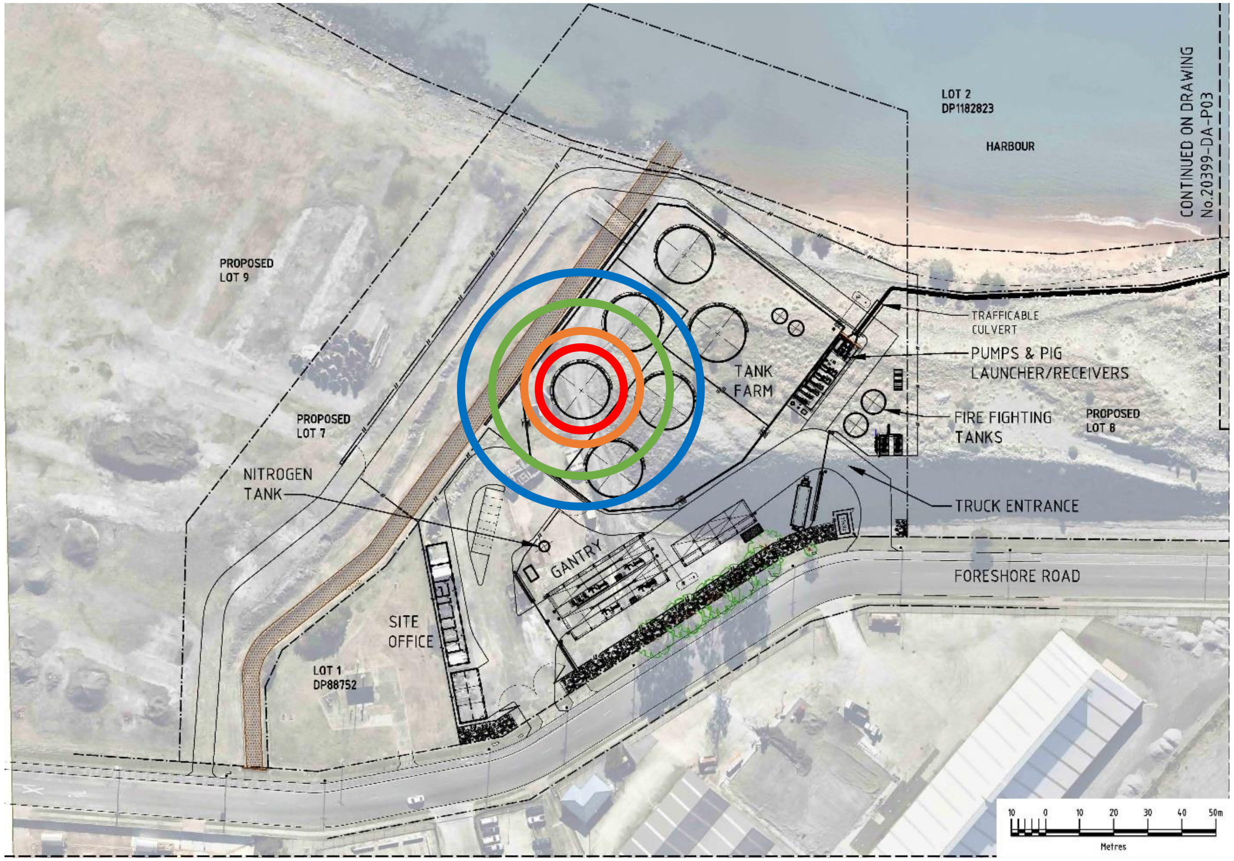
Scenario 4: Pump Bund Fire



Key:

red line	**23 kW/m²**
orange line	**12.6 kW/m²**
green line	**4.7 kW/m²**
blue line	**3 kW/m²**

Scenario 5: Tank Top Fire

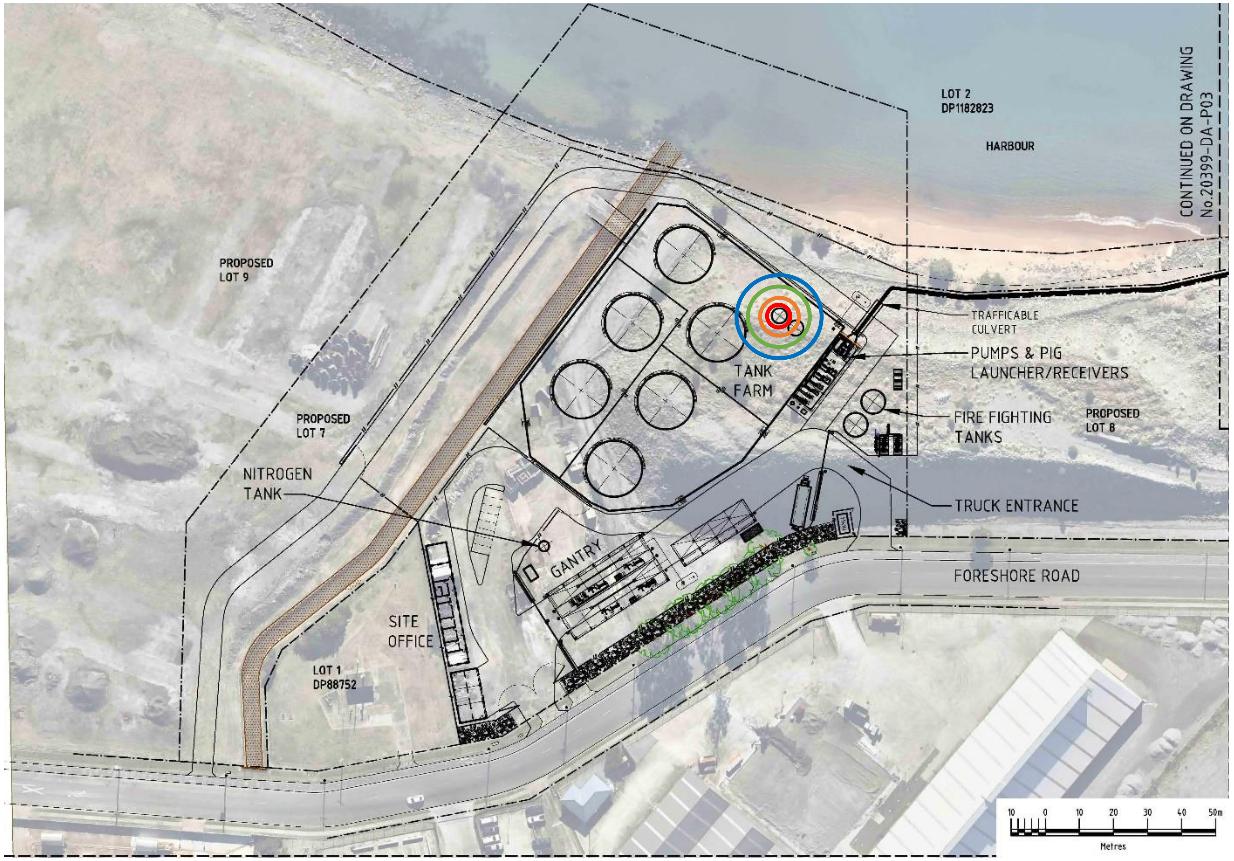


Key:

Red	**23 kW/m^2**
Orange	**12.6 kW/m^2**
Green	**4.7 kW/m^2**

Note: The radiant heat contours are at tank-top height.

Scenario 6: Slops Tank Top Fire



Key:

Red line	**23 kW/m²**
Orange line	**12.6 kW/m²**
Green line	**4.7 kW/m²**

Note: The radiant heat contours are at tank-top height.

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