Fire Safety Study

Oakdale West 1A, Kemps Creek

Confidential Applicant
Document No. RCE-19039_CA_FSS_Final_31Jul20_Rev(0)
Date 31/07/2020

Fire Safety Study

Oakdale West 1A, Kemps Creek

Confidential Applicant

Prepared by

Riskcon Engineering Pty Ltd
Unit 19/5 Pyrmont Bridge Road
Camperdown, NSW 2050
www.riskcon-eng.com
ABN 74 626 753 820

Quality Management

Rev	Date	Remarks	Prepared By	Reviewed By
A	2 July 2020	Draft issue for comment	Jason Costa	Renton Parker
0	31 July 2020	Issued Final		

Executive Summary

Background

Goodman Property Services (Aust) Pty Limited (Goodman) proposes to develop a new warehouse for a Confidential Applicant (CA) within the Oakdale West Industrial Estate to be located at Oakdale South Building 1A in Kemps Creek, NSW. The project will comprise an automated warehousing system with hardstand and awnings, including the provision for offices and other ancillary areas. The facility will store a range of Dangerous Goods (DGs) across all classes of DGs.

A review of the application guide to State Environmental Planning Policy No. 33 (SEPP33, Ref. [1]) indicates the facility would exceed the threshold criteria for the storage of DGs. As part of the Conditions of Consent, it is a requirement to prepare a Fire Safety Study (FSS) per the requirements of the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 (Ref. [2]) to meet the requirements of Fire & Rescue NSW (FRNSW). In addition, the condition requires FRNSW to be consulted with regards to fire safety in terms of both the fire and life safety systems.

Richard Crookes Constructions (RCC), on behalf of Goodman, has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare an FSS for the facility. This document represents the FSS for the warehouse at Kemps Creek.

Conclusions

A Fire Safety Study per the HIPAP No. 2 guidelines was prepared for the CA site as required by Condition 3.1.2 of the Conditions of Consent. In addition, the FSS assessed all incidents that could occur at the site and the recommendations made in the PHA were reviewed as required by Condition 3.1.2

The analysis performed in the FSS was based on the credible fire scenarios to assess whether the protection measures at the site were adequate to combat the hazards associated with the quantities and types of commodities being stored. Based on the assessment, it was concluded that the designs and existing fire protection adequately managed the risks.

Recommendations

Based on the analysis, the following recommendations have been made:

- All site personnel are to be trained in specific site procedures, emergency and first aid procedures and the use of fire extinguishers and hose reels.
- A storm water isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course.
- 9 kg dry powder fire extinguishers shall be located no closer than 2 m and no further than 10 m from manual DG storage locations.
- A spill kit suitable for the commodities being stored shall be provided for the DG store and a separate spill kit provided for the forklift transport areas.
- The warehouse and/or site boundaries shall be capable of containing 653.4 m^3 which may be contained within the warehouse footprint, site stormwater pipework and any recessed docks or other containment areas that may be present as part of the site design.

- Site management to prepare and maintain operational procedures to minimise the number of hazardous incidents and accidents on site and to mitigate the consequences of incidents regarding the handling of dangerous goods and chemicals.
- A site Emergency Response Plan per the requirements of HIPAP No. 1 shall be prepared and shall include measures to advise neighbouring premises in the event of an emergency with potential offsite impacts.
- Emergency response procedures shall be developed in conjunction with CA and the automation supplier (Witron) to ensure that all areas within the system can be accessed to facilitate FRNSW intervention as required.
- A person knowledgeable in the emergency response shall be on shift at all times such that FRNSW may be guided through the system to undertake intervention activities when required.
- CA shall engage with local FRNSW stations to undertake training and familiarisation of the automated system at a minimum of once (1) per year.
- A hazardous area classification in accordance with AS/NZS 60079.10.1:2009 shall be prepared to identify where hazardous areas may exist.
- Where electrical equipment is installed within a hazardous area, the equipment shall comply with AS/NZS 60079.14:2017.
- DG documentation shall be prepared as required by the Work Health and Safety Regulation 2017 to demonstrate the risks associated with the storage and handling of DGs has been assessed and minimised.
- The DG storages shall be appropriately placarded per the requirements of the Work Health and Safety Regulation 2017.

Table of Contents

List of Figures

List of Tables

List of Appendix Figures

List of Appendix Tables

procedures

Abbreviations

Abbreviation	Description
ADG	Australian Dangerous Goods Code
AS	Australian Standard
BLEVE	Boiling Liquid Expanding Vapour Explosion
CBD	Central Business District
CCPS	Centre for Chemical Process Safety
DA	Development Application
DGs	Dangerous Goods
DGS	Dangerous Goods Store
DPE	Department of Planning and Environment
FER	Fire Engineering Report
FRNSW	Fire and Rescue New South Wales
HIPAP	Hazardous Industry Planning Advisory Paper
LPG	Liquefied Petroleum Gas
PHA	Preliminary Hazard Analysis
RDC	Retail Distribution Centre
SEP	Surface Emissive Power
SEPP	State Environmental Planning Policy
SMSS	Storage Mode Sprinkler System
SSC	Spread Sheet Calculator
VF	View Factor

1.0 Introduction

1.1 Background

Goodman Property Services (Aust) Pty Limited (Goodman) proposes to develop a new warehouse for a Confidential Applicant (CA) within the Oakdale West Industrial Estate to be located at Oakdale South Building 1A in Kemps Creek, NSW. The project will comprise an automated warehousing system with hardstand and awnings, including the provision for offices and other ancillary areas. The facility will store a range of Dangerous Goods (DGs) across all classes of DGs.

A review of the application guide to State Environmental Planning Policy No. 33 (SEPP33, Ref. [1]) indicates the facility would exceed the threshold criteria for the storage of DGs. As part of the Conditions of Consent, it is a requirement to prepare a Fire Safety Study (FSS) per the requirements of the Hazardous Industry Planning Advisory Paper (HIPAP) No. 2 (Ref. [2]) to meet the requirements of Fire & Rescue NSW (FRNSW). In addition, the condition requires FRNSW to be consulted with regards to fire safety in terms of both the fire and life safety systems.

Richard Crookes Constructions (RCC), on behalf of Goodman, has commissioned Riskcon Engineering Pty Ltd (Riskcon) to prepare an FSS for the facility. This document represents the FSS for the warehouse at Kemps Creek.

1.2 Objectives

The objectives of the FSS are to;

- Review the site operations and DG storages for the potential to initiate or become involved in a fire including flammable materials which may be present at the site.
- Identify heat radiation impacts from potential fire sources at the site and determine the potential impacts on the surrounding areas and fire protection system, and
- Review the proposed fire safety features and determine the adequacy of the fire safety systems based on the postulated fires.

1.3 Scope of Services

The scope of work is for the preparation of an FSS for the facility to assess the potential hazards at the site to ensure the fire protection systems are commensurate with the identified hazards. This document follows the methodology recommended in HIPAP No.2 (Ref. [2]).

The FSS focuses on the storage of commodities associated with the new development at the site in addition to the existing operations at the site as required by HIPAP No. 2. A review of the following components of the FSS are within the scope of work;

- Determination of risk and consequences from fire or explosion scenarios throughout the facility;
- The preparation of a report on fire prevention, fire detection, fire alarm and fire suppression systems for the site;
- Firewater storage capacity for compliance with Australian Standards and Regulations and relevant NFPA standards;
- Hydrant hydraulic design screening calculations for the fire water system including the fire main sizing;

- External fire hydrant configuration and locations; and
- Recommendations based upon the study for implementation in the final design.

2.0 Methodology

2.1 Fire Safety Study Approach

The following methodology was used in the preparation of the FSS for the facility. The methodology is to follow items required by HIPAP No. 2 (Ref. [2]).

- The fire hazards associated with the facility were identified to determine whether there were any fire or explosion hazards that may impact offsite or result in a potential to escalate. Where fire hazards with the potential to impact offsite or escalate were identified, these were carried forward for consequence assessment.
- The heat radiation impacts or overpressure impacts (consequences) from each of the postulated incidents from the proposed equipment were then estimated and potential impacts on surrounding areas assessed.
- Impacts of the fires from the proposed equipment were plotted on a layout plan of the proposed facility, to determine whether heat radiation impacts any critical areas (i.e. adjacent storage areas, fire services, safety systems, etc.) and whether such impact affected the ability of fire fighters to respond to the postulated fire. The heat radiation impact from incidents at adjacent sites on the buildings and structures at the facility were then assessed against the maximum permissible levels in HIPAP No. 4 (Ref. [3]).
- The firefighting strategies were then assessed to determine whether these strategies require update in light of the location of the proposed equipment and storage areas.
- The response times for FRNSW in the immediate vicinity were assessed. In addition, further out lying FRNSW stations were included to provide a 'back-up plan' in the event that the closest fire brigades were unable to attend.
- A report was then developed for submission to the client and the regulatory authority.

2.2 Limitations and Assumptions

In this instance, the FSS is developed based on applicable limitations and assumptions for the development which are listed as follows:

- The report is specifically limited to the project described in **Section 2.1**.
- The report is based on the information provided.
- The report does not provide guidance in respect of incidents that relate to sabotage or vandalism of fire safety systems.
- The assessment is limited to the objectives of the FSS as provided in the guidelines issued as HIPAP No. 2 (Ref. [2]) and does not consider property damage such as building and contents damage caused by fire, potential increased insurance liability and loss of business continuity.
- Malicious acts or arson with respect to fire ignition and safety systems are limited in nature and are outside the scope of this report. Such acts can potentially overwhelm fire safety systems and therefore further strategies such as security, housekeeping and management procedures may better mitigate such risks.

- This report is prepared in good faith and with due care for information purposes only and should not be relied upon as providing any warranty or guarantee that ignition or a fire will not occur.

3.0 Site Description

3.1 Site Location

The site is located at Building 1A, Oakdale West Industrial Estate, Kemps Creek, which is approximately 44 km west of the Sydney Central Business District (CBD). **Figure 3-1** shows the regional location of the site in relation to the Sydney CBD. Provided in **Figure 3-2** is the layout of the site in Kemps Creek.

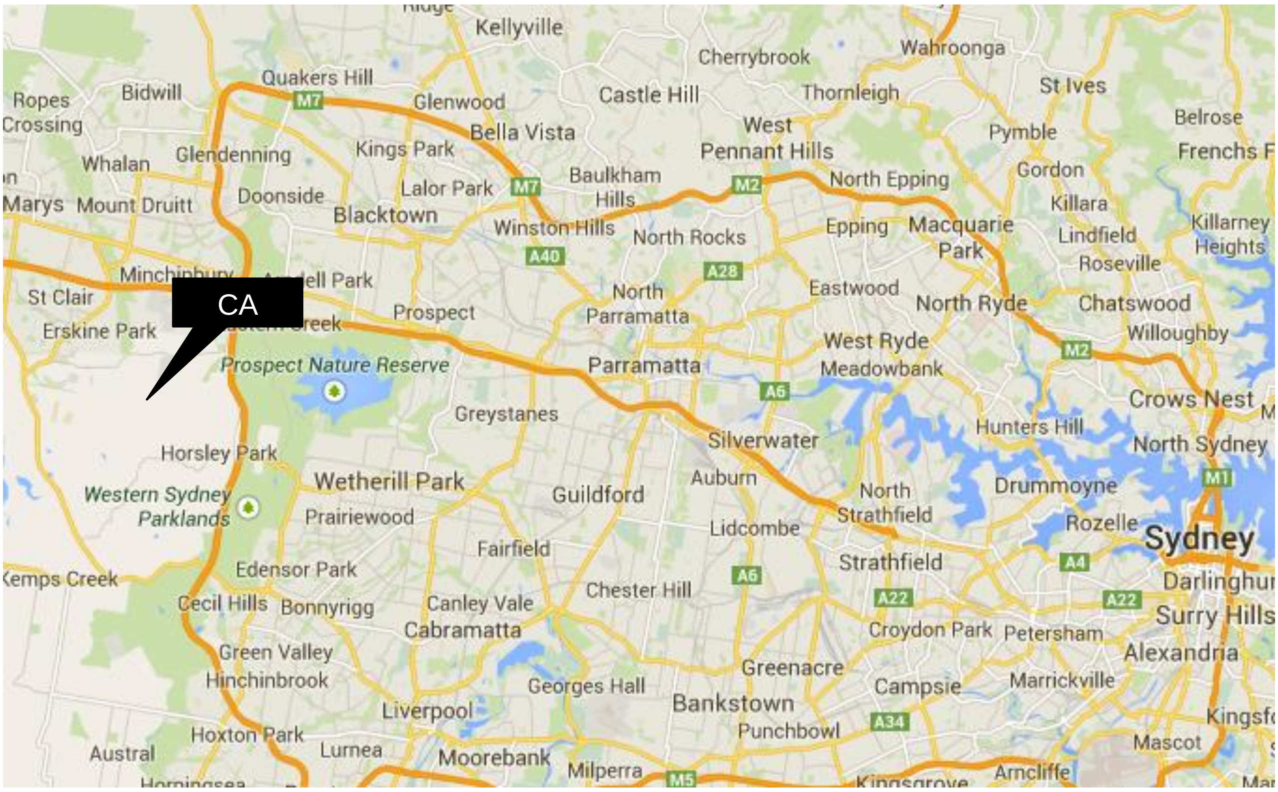


Figure 3-1: Site Location

3.2 Adjacent Land Uses

The land is located in an industrial area surrounded by the following land uses, which are adjacent to the site:

- North – Industrial warehousing
- South – Industrial warehousing
- East – Industrial warehousing
- West – Industrial warehousing

3.3 Warehouse Detailed Description

The warehouse will utilise an automated storage system which takes delivered pallets and stores them in high bay racking until required. The system stores products in a unique location which is tracked to allow accurate retrieval of products. Pallets can be collected from within the high bay storage and separated to form composite pallets containing numerous products for delivery to retail stores.

The warehouse will store a range of DGs in retail packages and the facility will be designed to comply with AS/NZS 3833:2007 (Ref. [4]). Specifically, the facility will comply with the Retail Distribution Centre (RDC) section of the standard which accounts for the reduced risk posed by packages stored in restricted small volumes.

The warehouse will be protected by a bespoke automatic sprinkler system involving both ceiling mounted and in-rack sprinklers depending on commodities stored. The sprinklers which will activate upon fire detection will suppress and control any fire that may occur. The warehouse will be air conditioned for occupation purposes which will provide adequate ventilation flow for preventing accumulation of any vapours released from packages in storage as required by AS/NZS 3833:2007 (Ref. [4]).

All DG products will be protected by base building specified Storage Mode Sprinkler System (SMSS) sprinklers and the aerosols will be protected by in-rack sprinklers scheme A sprinkler systems designed according to FM Global Data Sheet 7-31 (Ref. [5]).

The whole site will be capable of containing at least 90 minutes of potentially contaminated fire water as required by AS/NZS 3833:2007 (Ref. [4]) and the NSW "*Best Practice Guidelines for Contaminated Water and Retention Systems*" (Ref. [6]). The water will be contained via isolation of the stormwater system which is performed by the actuation of a penstock valve upon fire detection.

The site will be subject to a hazardous area classification per AS/NZS 60079.10.1:2009 (Ref. [7]) and any electrical equipment within the hazardous zone will be compliant per AS/NZS 60079.14:2017 (Ref. [8]) to minimise the potential for ignition of flammable vapours which may be released during storage.

The different classes of DGs will require separation per AS/NZS 3833:2007 (Ref. [4]) which will be configured within the logic of the automated system. DGs will be stored throughout the warehouse in addition to dispersed throughout the warehouse as required (in lesser quantities).

3.4 Flow of DGs Through the Automated System

All the DGs listed (with the exception of class 3 greater than 60ml) will initially be stored as pallets in the ground level locations of the High Bay Warehouse (HBW). When required in the AIO section, the pallets will be conveyed to Decant and the cartons will be taken off the pallets and placed into totes. These totes will be conveyed to the All-In-One (AIO) for storage and picking. DG's will either be picked from totes at one of three fixed workstations in the DPS aisle, or sent to the OPS workstation for picking, then sent back to reserve storage in the AIO racking.

A store order tote containing picked DG items will be temporarily stored in the AIO racking until all totes on the pallet are ready, then they will be sent to the palletiser for stacking and wrapping. All totes containing DG items will be stacked onto a minimum number of pallets. E.g. If a store order contains enough totes for 4 full pallets, the system will stack the totes containing DG items onto a single pallet, rather than spreading them across multiple pallets.

When a pallet is received which contains Class 3 DG items with a sales unit which is greater than 60ml, it will be immediately conveyed to an outfeed conveyor near the pallet returns area. From here, it will be picked up by a fork lift truck and taken immediately to the manual DG store. It will be placed into reserve storage, then replenished to the picking location when required. These items will be manually picked into totes and taken to the AIO infeed conveyor at the appropriate time (when this store order is nearing completion). These totes will be stacked onto a pallet with the other totes containing DG items, again, with the aim of minimising the number of pallets containing DGs. Pallets containing DGs will be stored in the bottom level of the Despatch Buffer. All other movements and locations used for DGs to be classed as Transient.

Cooking oils will be stored in the HBW in ground level locations under barrier boards and picked in one half of the last aisle of the CPS, again under barrier boards. Motor oils will be stored in the HBW in ground level locations under barrier boards and then replenished to the manual racking to the north of the CPS for further reserve storage, or picking from this racking location.

The cooking oils, or motor oils will be picked onto a pallet with other non-oil items, then wrapped and placed onto conveyor, where it is conveyed to the Despatch buffer for short term storage before being loaded onto the trailer for despatch to stores.

3.5 Quantities of Dangerous Goods Stored and Handled

The dangerous goods stored at the warehouse are for various customers and may fluctuate with customer requirements. The classes and quantities to be approved in the facility are summarised **Table 3-1**. The location of the DGs within the warehouse are shown in **Figure 3-2.**

Table 3-1: Maximum Classes and Quantities of Dangerous Goods Stored

Class	Description	Packing Group	Quantity (kg)
1.4s	Explosives	n/a	20,000
2.1	Flammable gas (LPG)	n/a	7,500 L / 4,125
2.1	Flammable gas (LPG) – Kitchen	n/a	450 L / 247.5
2.1	Flammable gas (aerosols)	n/a	70,000*
2.2	Non-flammable, non-toxic gas (aerosols)	n/a	25,000
3	Flammable liquids	II & III	300,000
4.1	Flammable solids	III	24,000
5.1	Oxidising agents	III	25,000
6.1	Toxic substances	III	45,000
8	Corrosive substances	II & III	60,000
9	Miscellaneous Dangerous Goods	III	105,000
C1/C2	Combustible Liquids	n/a	1,100,000

*Note: This refers to the quantity of LPG within the aerosols and not the total package weight. The LPG content within the cannisters is typically around 25% of product weight.

3.6 Aggregate Quantity Ratio

Where more than one class of dangerous goods are stored and handled at the site an AQR exists. This ratio is calculated using **Equation 3-1:**

$$AQR = \frac{q_x}{Q_x} + \frac{q_y}{Q_y} + [\dots] + \frac{q_n}{Q_n}$$ **Equation 3-1**

Where:

x,y […] and n are the dangerous goods present

q_x, q_y, […] and q_n is the total quantity of dangerous goods x, y, […] and n present.

Q_x, Q_y, […] and Q_n is the individual threshold quantity for each dangerous good of x, y, […] and n

Where the ratio AQR exceeds a value of 1, the site would be considered a Major Hazard Facility (MHF). The threshold quantities for each class is taken from Schedule 15 of the Work Health and Safety (WHS) Regulation 2017 (Ref. [9]). These are summarised in **Table 3-2** noting Class 1.4s, 2.2, 4.1(II & III), 8, 9 and combustible liquids are not subject to MHF legislation.

Table 3-2: Major Hazard Facility Thresholds

Class	Packing Group	Threshold (tonnes)	Storage (tonnes)
2.1	n/a	200	74.37
3	II & III	50,000	300
5.1	I & II	200	25
6.1	III	200	45

A review of the thresholds and the commodities and packing groups listed in **Table 3-1** indicates only Class 2.1, 3, 5.1 and 6.1 are assessable against the MHF thresholds. Therefore, substituting the storage masses into **Equation 3-1** the AQR is calculated as follows:

$$AQR = \frac{74.37}{200} + \frac{300}{50000} + \frac{25}{200} + \frac{45}{200} = 0.728$$

The AQR is less than 1; hence, the facility would not be classified as a MHF.

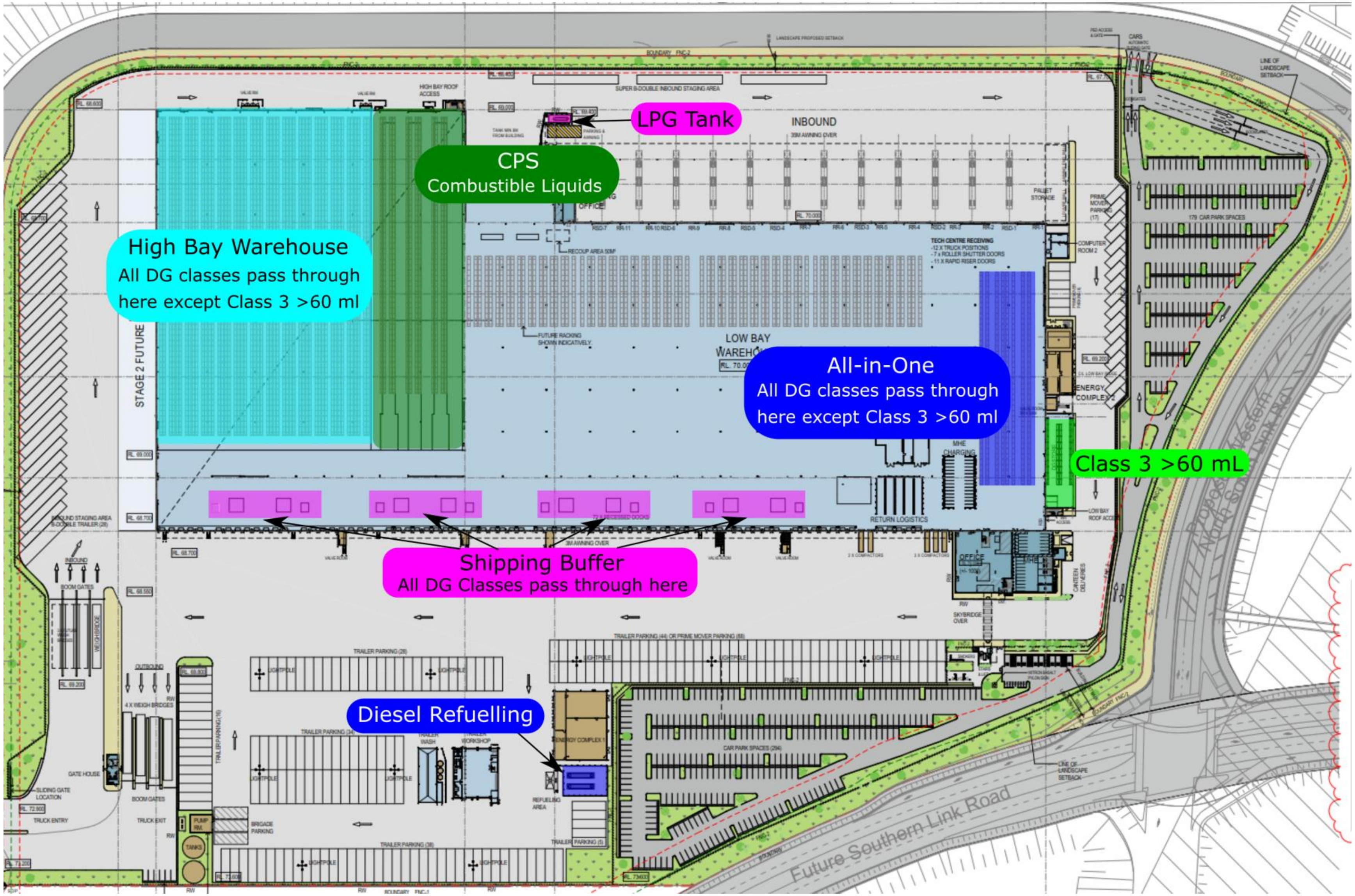


Figure 3-2: Site Layout

4.0 Hazard Identification

4.1 Introduction

A hazard identification table has been developed and is presented at **Appendix A**. Those hazards identified to have a potential fire or explosion impact are assessed in the following sections of this document.

4.2 Properties of Dangerous Goods

The type of DGs and quantities stored and used at the site has been described in **Section 3**. **Table 4-1** provides a description of the DGs stored and handled at the site, including the Class and the hazardous material properties of the DG Class.

Table 4-1: Properties* of the Dangerous Goods and Materials Stored at the Site

Class	Hazardous Properties
1.4s – Explosives	Class 1.4s are a sub-designation of explosives which covers explosive products which include blasting caps, small arms, ammunition. Essentially, Class 1.4s contains explosives with relatively low risk (compared to other explosives) they are not shock sensitive and are contained within enclosed products. Products likely to be stored in the facility include party poppers, sparklers, etc.
2.1 – Flammable Gas	Class 2.1 includes flammable gases which are ignitable when in a mixture of 13 per cent or less by volume with air or have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit. Ignited gas may result in explosion or flash fire. Where gas released under pressure from a hole in a pressurised component is ignited, a jet fire may occur.
2.2 – Non-Flammable, Non-Toxic Gases	Class 2.2 includes non-flammable and non-toxic gases which are asphyxiant (dilute or replace the oxygen normally in the atmosphere).
3 – Flammable Liquids	Class 3 includes flammable liquids which are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc.) which give off a flammable vapour at temperatures of not more than 60°C closed-cup test or not more than 65.6°C open-cup test. Vapours released may mix with air and if ignited, at the right, concentration will burn resulting in pool fires at the liquid surface.
4.1 – Flammable Solids	Flammable solid materials are materials that may burn when exposed to an ignition source, examples of flammable solids include matches and some waxes.
5.1 -Oxidising Agents	Class 5.1 materials will not combust but these materials include substances which can in a fire event, liberate oxygen and could accelerate the burning of other combustible or flammable materials. Releases to the environment may cause damage to sensitive receptors within the environment.
6.1 – Toxic Substances	Substances liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact.
8 – Corrosive Substances	Class 8 substances (corrosive substances) are substances which, by chemical action, could cause damage when in contact with living tissue (i.e. necrosis), or, in case of leakage, may materially damage, or even destroy, other goods which come

Class	Hazardous Properties
	into contact with the leaked corrosive material. Releases to the environment may cause damage to sensitive receptors within the environment.
9 – Miscellaneous DGs	Class 9 substances and articles (miscellaneous dangerous substances and articles) are substances and articles which, during transport present a danger not covered by other classes. Releases to the environment may cause damage to sensitive receptors within the environment.
C1/C2	C1/C2 products are not classified as a DGs; however, they are combustible liquids. Therefore, it may sustain combustion although initial ignition is difficult due to the high flash point of the material. Combustible liquids do not generate flammable vapours which eliminates the potential for flash fire or explosions to occur when confined.

* The Australian Code for the Transport of Dangerous Goods by Road and Rail (Ref. [10]

4.3 Hazard Identification

Based on the hazard identification table presented in **Appendix A**, the following hazardous scenarios have been developed:

- Flammable liquid or gas release, delayed ignition and flash fire or explosion.
- Flammable material spill, ignition and racking fire.
- LPG release (from aerosol), ignition and racking fire.
- Full warehouse fire and radiant heat.
- Full warehouse fire and toxic smoke emission.
- Dangerous goods liquid spill, release and environmental incident.
- Warehouse fire, sprinkler activation and potentially contaminated water release.
- LPG release, ignition and pool fire.
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire.
- LPG release and ignition causing flash fire or explosion.
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire and impact on LPG delivery tanker and Boiling Liquid Expanding Vapour Explosion (BLEVE).
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire and impact on LPG tank and BLEVE.
- Diesel tank, damage and release, ignition and fire.
- Diesel tank, damage and release to environment.
- LPG cylinder release, ignition, and flash fire or explosion.

Each identified scenario is discussed in further detail in the following sections.

4.4 Flammable Liquid or Gas Release, Delayed Ignition and Flash Fire or Explosion

As noted in **Section 3.0**, flammable liquids will be held at the site for storage and distribution. There is potential that a flammable liquid spill could occur in the warehouse area due to an accident (packages dropped from forklift, punctured by forklift tines) or deterioration of packaging. If a flammable liquid spill occurred, the liquid may begin to evaporate (depending on the material flashpoint and ambient temperature). Where materials do evaporate, there is a potential for accumulation of vapours, forming a vapour cloud above the spill.

If the spill is not identified, the cloud may continue to accumulate, eventually contacting an ignition source. If the cloud is confined (i.e. pallet racking and stored products) the vapour cloud may explode if ignited, or, if it is unconfined, it may result in a flash fire which would burn back to the flammable liquid spill, resulting in a pool fire.

A similar scenario could occur with the release of Liquefied Petroleum Gas (LPG) from an aerosol; however, the formation of a gas cloud would occur immediately as the LPG would instantly flash to gas following release from the canister. It is noted that the potential for a release of LPG is low as aerosol canisters are pressure tested during manufacture and filling, hence, release would predominately result from damaged product rather than deterioration.

A review of the product list to be stored indicates the products are small retail packages as defined by AS/NZS 3833:2007 (Ref. [4]). Therefore, the release from a single flammable liquid container would result in a release <20 L. For flammable gas canisters, the quantity of flammable gas released would be <1 L in the worst-case release. The associated vapour cloud formed by the release of gas or flammable liquid would be insufficient to result in offsite impacts from ignition.

Packages are inspected for damage upon receipt at the loading dock before they are transported into the warehouse. This minimises the likelihood a damaged package is incorrectly stored. Once stored inside the warehouse, deterioration or damage are unlikely to occur.

To minimise the likelihood a flammable vapour cloud may contact an ignition source, the electrical equipment within the DG store hazardous zone will be installed according to the requirements of AS/NZS 60079.14:2017 (Ref. [8]).

It has been proposed to seek approval to operate the site 24 hours a day 7 days a week however the site will be unlikely to be used for these proposed hours of operation. Therefore, if a spill occurred, it would be identified by personnel working in the warehouse where it could be immediately cleaned up. To ensure appropriate cleaning equipment is available, the following recommendation has been made:

- Multiple spill kits be provided around the DG storage areas to ensure spills can be cleaned up immediately following identification.

Explosives will be stored at the site which will be Class 1.4S which is a subclassification of explosives covering ammunition, blasting caps, etc. These products are finished products that contain small quantities of explosives. In this case these products will consist of sparklers and party popper type products. As the products contain only small quantities of explosives a large explosion would not occur. Rather, if exposed to heat (i.e. from a fire) the packaging will burn exposing the explosives which will then ignite resulting in a more aggressive fire. The combustion profile of these products would be similar to ignition of aerosols (i.e. constant flames from combustion of packaging punctuated by the increase burning rate of the LPG when the can ruptures). Nonetheless, combustion of such products would not be expected to result in a pressure wave as there is insufficient explosive mass in a dense form.

Based on the warehouse design (controlled ignition sources, etc.), operation practices and the storage of small packages, the risk of a vapour cloud being generated that is large enough to ignite and impact over the site boundary, by way of a vapour cloud explosion or a flash fire, is considered to be low (if not negligible); hence, this hazard has not been carried forward for further analysis.

4.5 Flammable Material Spill, Ignition and Racking Fire

As noted in **Section 4.4**, it is considered that there is a low potential for a package to leak resulting in a flammable material spill and there are several controls in place to minimise the likelihood of a damaged container entering the warehouse and additional controls to minimise the potential that ignition of a flammable material spill could occur.

If a flammable material spill was to occur (e.g. dropped pallet or package during handling) and it was ignited (e.g. by the forklift), the fire would initially be small due to the majority of packages stored being 20 L or less. While a fire would be limited in size, heat generated may impact adjacent packages which may deteriorate and release their contents contributing additional fuel to the fire. As the fire grows Storage Mode Sprinkler System (SMSS) would activate controlling the fire within the sprinkler array and cooling adjacent packages preventing deterioration and reducing the potential for fire growth.

Based on the limited fire size, the design of the warehouse and the installed fire systems, the risks of this incident impacting over the site boundary are considered to be low. Notwithstanding this, this incident has been carried forward for further analysis to demonstrate that the likely impact of an SMSS controlled fire is within the site boundary.

4.6 LPG Release (from Aerosol), Ignition and Racking Fire

As noted in **Section 4.4**, the potential for release of LPG from an aerosol is considered low due to the quality assurance testing on aerosol canisters during the filling process. The release of LPG would likely result from damage to aerosols during transport and storage rather than from deterioration. Packages are inspected upon delivery and an accident involving aerosols would trigger an additional inspection to verify that damage had not occurred prior to storage within the warehouse.

Notwithstanding this, there is the potential for a release of LPG to occur within the storage racking. Due to the hazardous area rated equipment within the area and protocols, it is considered unlikely for an ignition to occur; however, in the event that an ignition of an LPG release did occur a fire could result.

The fire would consume the packaging with the generated heat impacting the adjacent aerosols. As the LPG within the adjacent aerosols expands the canisters may rupture releasing LPG which would ignite and rocket the canister throughout the aerosol cage potentially spreading the fire.

As the fire grows, the SMSS is expected to activate to suppress the fire and cool adjacent packages to minimise the potential for aerosol rupture and rocketing. Activation of this system would control the fire within the sprinkler array.

A sprinkler-controlled fire within the aerosol racking would be unlikely to impact over the site boundary; notwithstanding this, this incident has been carried forward for consequence analysis.

Notwithstanding the above, the following recommendation has been made:

- Aerosols shall be stored in a dedicated storage area which prevents rocketing cans from escalating the incident (i.e. storage in an aerosol cage, separate storage area, or in palletised aerosol cages).

4.7 Full Warehouse Fire and Radiant Heat

There is potential that if a fire occurred and the fire protection systems failed to activate, a small fire may escalate as radiant heat impacts adjacent packages resulting in deterioration and release of additional fuel. While it is considered unlikely for a fire to occur simultaneously with the sprinkler system failing to operate there is the potential for this scenario to occur. Therefore, this incident has been carried forward for further analysis.

4.8 Full Warehouse Fire and Toxic Smoke Emission

As discussed in **Section 4.7** there is the potential for a full warehouse fire to occur in the event of sprinkler failure. During combustion toxic products of combustion may be generated which will be dispersed in the smoke plume which may impact downwind from the site. Depending on the toxicity of the bi-products, this may result in injury or fatality. Therefore, this incident has been carried forward for further analysis.

4.9 Dangerous Goods Liquid Spill, Release and Environmental Incident

There is potential that a spill of the liquid DGs (Class 3, 4.1, 5.1, 6.1, 8 and 9, and C1/C2) could occur at the site which if not contained could be released into the public water course resulting in a potential environmental incident.

To prevent spills escaping from the site per the requirements of AS/NZS 3833:2007 (Ref. [4]) the following recommendation has been made:

- The site shall be designed to contain any spills or contaminated water from a fire incident within the boundaries of the site.

The site will also be designed to prevent the release of any spills from the site, including potentially contaminated water. Therefore, the potential for a release is considered unlikely as this is expected to be contained within the footprint of the warehouse. Nonetheless, in the event of a catastrophic scenario and spills are released from the footprint of the warehouse, it will be necessary to prevent this from being released into the public water course. Therefore, the following recommendation has been made:

- A storm water isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course.

As noted, the volumes of the packages are small (< 20 L) and the site will be designed with a drain isolation system, allowing the containment of any spills within the premises; hence, in the event of a release the full volume will be contained within the warehouse area. As a spill would be contained within the bund/site drainage there is no potential for an environmental incident to occur; hence, this incident has not been carried forward for further analysis.

4.10 Warehouse Fire, Sprinkler Activation and Potentially Contaminated Water Release

In the event of a fire, the SMSS will activate discharging fire with water to control and suppress the fire. Contact of the fire water with DGs may result in contamination which, if released to the local watercourse, could result in environmental damage. The SMSS system delivers approximately 5 m^3/min of water which, if operated for a long period, may result in overflow of site bunding and potential release. The facility has been designed to be able to contain all DG spills and liquid effluent resulting from the management of an incident (i.e. fire) within the premises.

The site will hold 60 minutes of water storage on site as required by FM Global standards; hence, to allow for additional conservatism, following a risk assessment methodology as outlined by the Department of Planning document "*Best Practice Guidelines for Potentially Contaminated Water Retention and Treatment Systems"* (Ref. [6]), an allowance of 90 minutes of potentially contaminated water has been selected noting this includes all sources of application (i.e. onsite storage and towns mains) thus far exceeding the 60 minute on site storage. In a DG fire scenario, the following protection systems are likely to be discharging:

- SMSS at 5 m^3/min.
- 3 hydrant hoses at 1.8 m^3/min.

The total water discharge would be 6.8 m^3/min. Therefore, operation for 90 minutes would result in a total discharge of 612 m^3. The following recommendation has been made:

- The warehouse and/or site boundaries shall be capable of containing 612 m^3 which may be contained within the warehouse footprint, site stormwater pipework and any recessed docks or other containment areas that may be present as part of the site design.
- The civil engineers designing the site containment shall demonstrate the design is capable of containing at least 612 m^3.

As noted in **Section 4.9**, an automatic isolation valve has been recommended to be incorporated into the design to prevent the release of potentially contaminated water. Therefore, the volume within the stormwater system can also be used in calculation total volume contained.

Based on the design and containment for the premises, there is adequate fire water retention to meet the '*Best Practice Guidelines for Contaminated Water Retention and Treatment Systems*" (Ref. [6]), hence, this incident has not been carried forward for further analysis.

4.11 LPG Release, Ignition and Pool Fire

In the event of a small leak from a vessel or pipework a pool of LPG may form when the rate of evaporation of LPG is less than the flow rate of LPG from the leak. If the pool were to ignite a LPG pool fire would occur which may impact over the site boundary.

A leak sufficient to cause a release that exceeds the evaporation rate to develop a pool large enough to ignite (noting the area is zoned per the requirements of AS/NZS 60079.10.1:2009, Ref. [7]) and the subsequent fire to impact over the site boundary is very low. This is substantiated by numerous similar sized LPG tanks installed throughout Australia with very low incidences of leaks and fires occurring from such installations.

As the potential for a leak and LPG pool and subsequent ignition to occur is incredibly low, this incident has not been carried forward for further analysis.

4.12 LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire

As the site LPG is depleted, it will be refilled by a delivery tanker at the site. During loading of the tank there is the potential for the hose to rupture which may be the result of a puncture of the hosing or deterioration through general wear and tear. It has been assumed the hoses are inspected monthly and pressure tested annually in accordance with the Australian Dangerous Goods Code (ADG, Ref. [11]).

Notwithstanding this, there is the potential for a hose to become damaged between inspection and test periods which may lead to sufficient deterioration resulting in a hose rupture when transferring pressurised LPG. Excess flow and non-return valves will isolate the flow of LPG; however, if these fail in addition to a hose rupture, LPG will be released resulting in an LPG vapour cloud. The operator may be able to respond and isolate the LPG transfer by activating an emergency stop button located on the tanker.

If the operator is incapacitated or unable to stop the transfer, the LPG will continue to flow developing a substantial cloud which may contact an ignition source and ignite which would result in a flash fire or explosion which would burn back to the release point and subsequent jet fire. It is noted the area is unconfined; hence, an explosion is unlikely to occur and would likely result in a flash fire.

The potential for a fatality to occur as a result of a flash fire is not considered credible as the mechanism for a fatality to occur from a flash fire is via combustion of flammable vapours at head height which results in oxygen within the lungs being consumed as the fuel burns. The impacted person will involuntarily inhale, as low oxygen is detected, resulting in inhalation of hot combustion products which burn the sensitive lining of the lungs. As LPG is a dense gas, any release will spread along at ground level and due to the open nature of the site it will not accumulate to a level where a person offsite will be fully engulfed; hence, a fatality is unlikely to occur.

While a flash fire may not be expected to cause significant harm, the impacts from a jet fire are likely to be substantial and would impact over the site boundary; hence, this incident has been carried forward for further analysis.

4.13 LPG Release and Ignition Causing Flash Fire or Explosion

In the event of an LPG release, LPG will vapourise forming a flammable atmosphere which may ignite. A review of the area indicates the tank will not be stored in an area where confinement will occur; hence, the atmosphere would not ignite as an explosion but would rather result in a flash fire.

As noted in **Section 4.12**, the mechanism for a fatality to occur from a flash fire is inhalation of hot combustion products when a person is fully engulfed in a vapour cloud when ignition occurs. As LPG is a dense gas it will spread out at ground level as there is no confinement to allow the gas to accumulate at height; therefore, it is unlikely that a vapour cloud would form to allow a person to be fully engulfed; hence, a fatality would be unlikely to occur.

Furthermore, AS/NZS 1596:2014 (Ref. [12]) has been developed with reference to the likely impact scenarios from storage of LPG in various tank sizes. Review of Table 6.1 of AS/NZS 1596:2014 (Ref. [12]) indicates for a 7.5 kL tank the separation distance to a protected place is approximately 6 m. Therefore, the standard would consider that in open air, events resulting from a release from the tank would be unlikely to significantly impact >6 m.

A catastrophic failure of an LPG tank (i.e. rupture and full release of LPG) is considered incredible due to the manufacturing and regular testing of pressure vessels according to AS 1210:2010 (Ref. [13]).

As the area is unconfined and the location of the tank provides adequate separation to the site boundary and protected places it is considered that a fatality would not result from this incident; hence, this incident has not been carried forward for further analysis.

4.14 LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire and Impact on LPG Delivery Tanker and BLEVE

Similarly, to the scenario described in **Section 4.13** the hose may rupture resulting in a jet fire. If this jet fire were aimed at the delivery tanker, the tanker shell would begin to heat, transferring the heat into the LPG within the tank which would begin to vaporise and increase the pressure within the tanker. At the design pressure of the tank, the pressure relief valve will begin to lift to relieve pressure within the tanker.

As the liquid level within the tanker drops, the impact zone of the jet fire may impact the vapour space in the tanker. The vapour will absorb less energy than the liquid which will result in localised heating of the tanker shell at the point of the jet fire impact. This may compromise the structural integrity of the tanker shell which may rupture resulting in a blast overpressure as the vessel fails and formation of an LPG vapour cloud which may also ignite resulting in a vapour cloud explosion known as a Boiling Liquid Expanding Vapour Explosion (BLEVE). This incident has been carried forward to assess the potential impact zone.

4.15 LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire and Impact on LPG Tank and BLEVE

Similarly, to the scenario described in **Section 4.13** the hose may rupture resulting in a jet fire. If this jet fire were aimed at the tank, the tank shell would begin to heat, transferring the heat into the LPG within the tank which would begin to vaporise and increase the pressure within the tank which may result in a BLEVE as described in **Section 4.14**. Hence this incident has been carried forward for further analysis.

4.16 Diesel Tank, Damage and Release, Ignition and Fire

Diesel will be stored in a small integrally bunded tanks for to be used in a generator set. The tank will be designed according to Clause 5.9 of AS 1940:2017 (Ref. [14]); hence, the tank will be capable of containing the full volume of the liquid within the separate tanks, should deterioration of the internal tank occur.

There is potential for overfilling to occur if the overfill sensors and alarms fail and the operator fails to respond to an overfill which may result in a spill. However, diesel is classified as a combustible liquid; hence, it does not emit flammable vapours at ambient temperatures and subsequently it is difficult to ignite.

Finally, a release may occur if a vehicle were to impact the tanks as this may damage both the primary and secondary tanks. The diesel tanks will be protected by impact protection which will prevent any wayward vehicles from contacting the tank; hence, catastrophic damage is unlikely to occur.

As the tanks have been designed to fully contain failure of the internal tank, the potential for releases externally to the tank is considered to be low. In addition, the potential for diesel to ignite is very low due to the high flash point; therefore, this incident has not been carried forward for further analysis.

4.17 Diesel Tank, Damage and Release to Environment

As discussed in **Section 4.16**, the potential for diesel to spill externally to the tank is low due to the double skinned nature of the tanks, the overfill protections, trained operators being present during transfers and impact protection. Therefore, a major release of diesel is not considered a credible event and is not carried forward for further analysis.

4.18 LPG Cylinder Release, Ignition, and Flash Fire or Explosion

An LPG cylinder will be provided to provide gases for the onsite kitchen. The cylinders may be damaged during transport or installation, alternatively, the valve or pipework may deteriorate resulting in minor cracks and subsequent gas releases which may accumulate within the area which if ignited could result in a flash fire or explosion.

A review of the quantity of gas indicates the storage would be classified as a minor storage per AS 4332-2004 (Ref. [15]) which indicates the storage quantity is relatively minor. The cylinders would be located externally to the building and would therefore be adequately ventilated preventing the accumulation of gases.

In addition, the area will be subject to a hazardous area classification ensuring any electrical equipment located near the cylinders would be compliant with AS/NZS 60079.14:2017 (Ref. [8]) minimising the potential for an ignition.

Finally, as the store is small, any release would be unlikely to result in sufficient accumulation that the vapour cloud would impact over the site boundary (i.e. for flash fire) or sufficient mass in the vapour cloud that if it did explode the overpressure would impact over the site boundary. Further, the potential for an explosion is incredibly low as there is insufficient confinement as the cylinders are located externally.

As it is considered that the potential for an offsite incident to occur isn't credible this incident has not been carried forward for further analysis.

5.0 Consequence Analysis

The following incidents were identified to have potential to impact off site:

5.1 Incidents Carried Forward for Consequence Analysis

The following incidents were identified to have potential to impact off site:

- Flammable material spill, ignition and racking fire.
- LPG release (from aerosol), ignition and racking fire.
- Full warehouse fire and radiant heat.
- Full warehouse fire and toxic smoke emission.
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire.
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire and impact on LPG delivery tanker and Boiling Liquid Expanding Vapour Explosion (BLEVE).
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire and impact on LPG tank and BLEVE.

Each incident has been assessed in the following sections.

5.2 Flammable Material Spill, Ignition and Racking Fire

There is the potential for a fire to develop involving flammable material stored within the warehouse resulting in a racking fire. As the fire grows the SMSS would activate suppressing and controlling the fire while cooling adjacent packages minimising the potential for lateral spread due to radiant heat. A detailed analysis has been conducted in **Appendix B** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-1**.

Table 5-1: Heat Radiation from a Flammable Liquid Racking Fire

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	4.6	8.5
23	5.6	10.3
12.6	7.5	13.7
4.7	12.0	22.2
3.0	14.9	27.5

A review of the 23 kW/m^2 impact distance indicates an offsite impact would not occur as neither contour for base case nor sensitivity case impact over the site boundary. Therefore, it is not considered that a propagation risk is present based on the radiant heat levels observed for this fire scenario. In addition, the flammable liquids are contained within an enclosure with a FRL 240/240/240 separating the DG store from the main warehouse; hence, it is considered should a fire occur within the bunker and the sprinkler systems fail to suppress and control the fire, it will not propagate into the main warehouse area.

A review of the 3.0 kW/m^2 contour indicates critical fire fighting infrastructure (i.e. hydrants, pump house, boosters, etc.) would be unaffected; hence, would be accessible by FRNSW. As noted, the flammable liquid DGs are held within a fire rated enclosure providing containment of any out of control fire.

Based upon a review of the consequence impacts, it is considered that the fire protection (i.e. in-rack sprinklers, ceiling mounted sprinklers, fire rated enclosure, and hydrant system) provides a high level of protection against fire scenarios originating within the DG bunker.

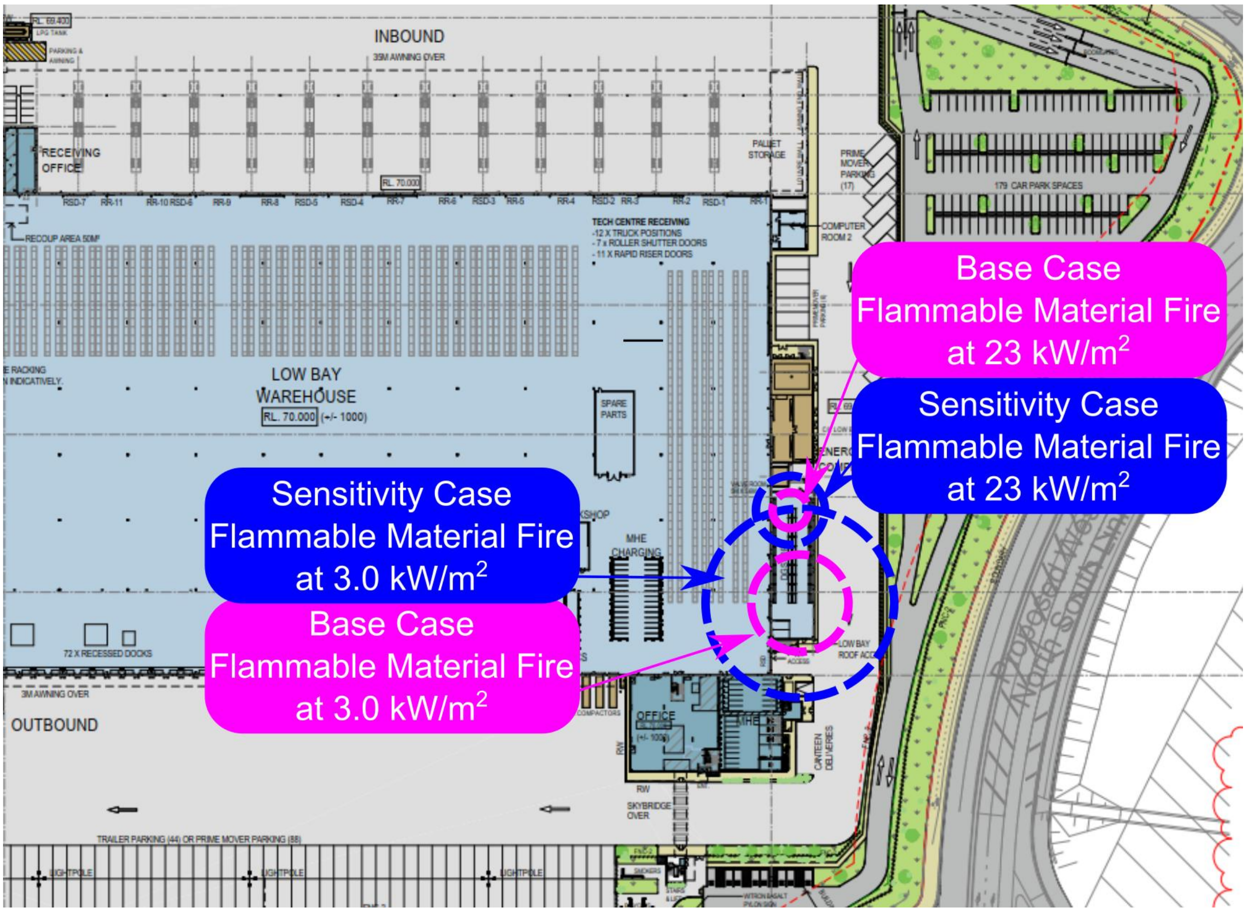


Figure 5-1: Sprinkler Controlled Flammable Material Fire Radiant Heat Contours

5.3 LPG Release (from Aerosol), Ignition and Racking Fire

A damaged aerosol canister could result in the release of LPG which if ignited may result in a fire. As the fire grows the radiant heat may impact adjacent aerosol storage heating the LPG within aerosol cans which may rupture rocketing the canisters around the aerosol store. The heat generated from the fire will activate the SMSS which will suppress and control the fire while cooling adjacent packages minimising the potential for lateral fire spread due to radiant heat. A detailed analysis has been conducted in **Appendix B** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-2**.

Table 5-2: Heat Radiation from an Aerosol Racking Fire

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	5.4	10.1

23	6.5	12.1
12.6	8.6	15.9
4.7	13.7	25.5
3.0	16.9	31.5

A review of the 23 kW/m^2 impact distance indicates an offsite impact would not occur as neither contour for base case nor sensitivity case impact over the site boundary. Therefore, it is not considered that a propagation risk is present based on the radiant heat levels observed for this fire scenario.

A review of the 3.0 kW/m^2 contour indicates critical fire-fighting infrastructure (i.e. hydrants, pump house, boosters, etc.) would be unaffected; hence, would be accessible by FRNSW. As noted, the aerosols are held within a fire rated enclosure providing containment of any out of control fire.

Based upon a review of the consequence impacts, it is considered that the fire protection (i.e. in-rack sprinklers, ceiling mounted sprinklers, fire rated enclosure, and hydrant system) provides a high level of protection against fire scenarios originating within the facility.

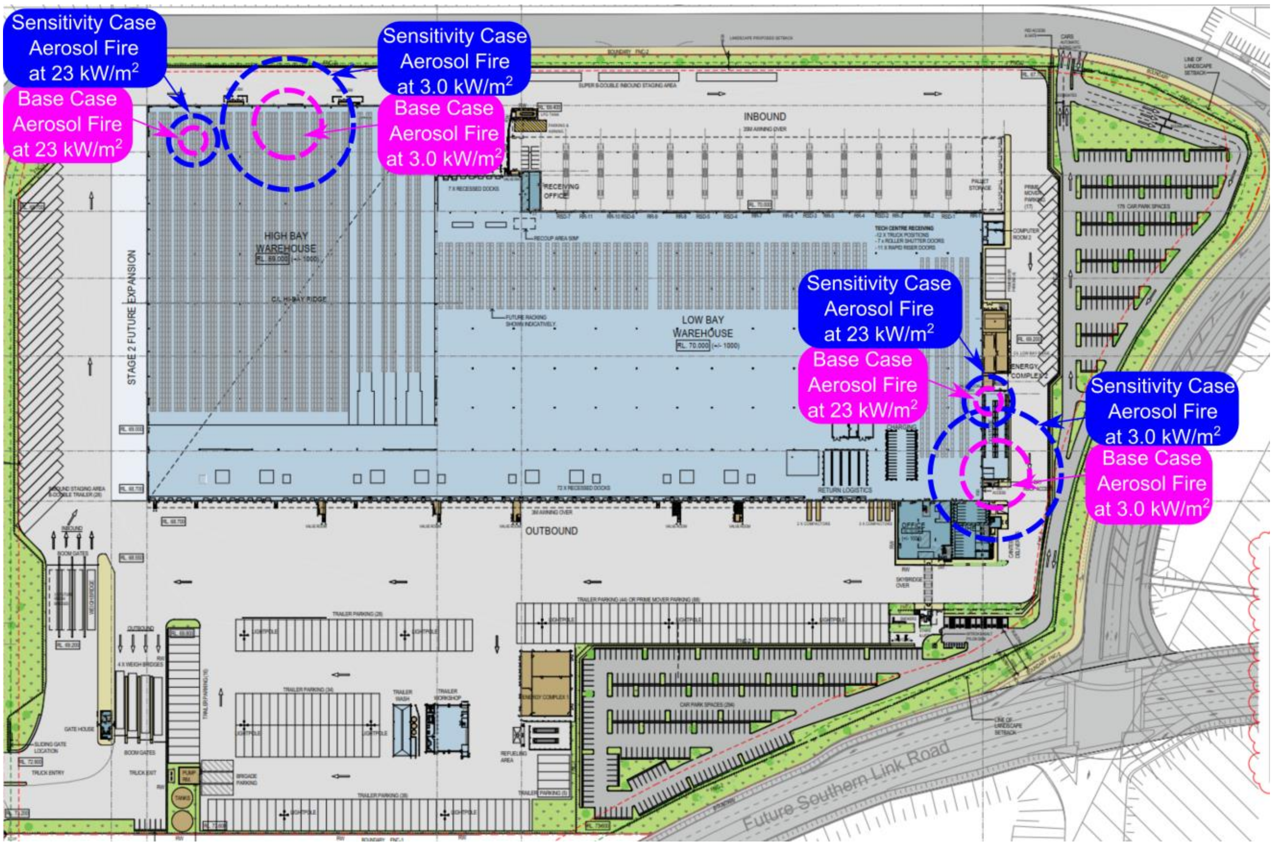


Figure 5-2: Sprinkler Controlled Aerosol Fire Radiant Heat Contours

5.4 Full Warehouse Fire and Radiant Heat

If a fire occurs within the DG store and the sprinkler systems fail to activate, the fire will spread throughout the warehouse and is unlikely to be contained and would likely consume the entire warehouse. A detailed analysis has been conducted in **Appendix B** and the radiant heat impact distances estimated for this scenario are presented in **Table 5-3**.

Table 5-3: Radiant Heat Impact Distances from a Full Warehouse Fire

Heat Radiation (kW/m^2)	Distance (m)
35	Maximum heat flux is 20*
23	Maximum heat flux is 20*
12.6	46.0
4.7	104.0
3.0	142.0

*Based on the research by Mudan & Croche reported in Lees (Ref. [16]) & Cameron/Raman (Ref. [17])

As shown in **Figure 5-3**, the radiant heat impacts at 3.0 kW/m^2 have an extensive impact from the warehouse; however, it must be noted that the analysis is based upon the full warehouse containing representative DG products with burning rates above those of normal products. It also assumes that the entire footprint is composed of combustible materials; hence, the true impact would likely be less than that shown.

Regardless, a full warehouse fire would likely render all protection systems impacted by a 3.0 kW/m^2 which would prevent FRNSW intervention based upon their accessibility criteria. Nonetheless, the warehouse has been designed using FM Global protection systems designed specifically for use in the configuration proposed for this warehouse. Therefore, a full warehouse fire is not expected to occur based upon the reliability of the sprinkler systems installed.

It is noted that due to the fire size there will be considerable smoke emitted which would obscure the flame surface reducing the average surface emissive power (SEP) and subsequently it would not exceed 23 kW/m^2. In addition, the distance to the closest buildings is 23 m which would allow attenuation of radiant heat from luminous spots and would not result in sustained radiant heat such that propagation to adjacent facilities would not occur.

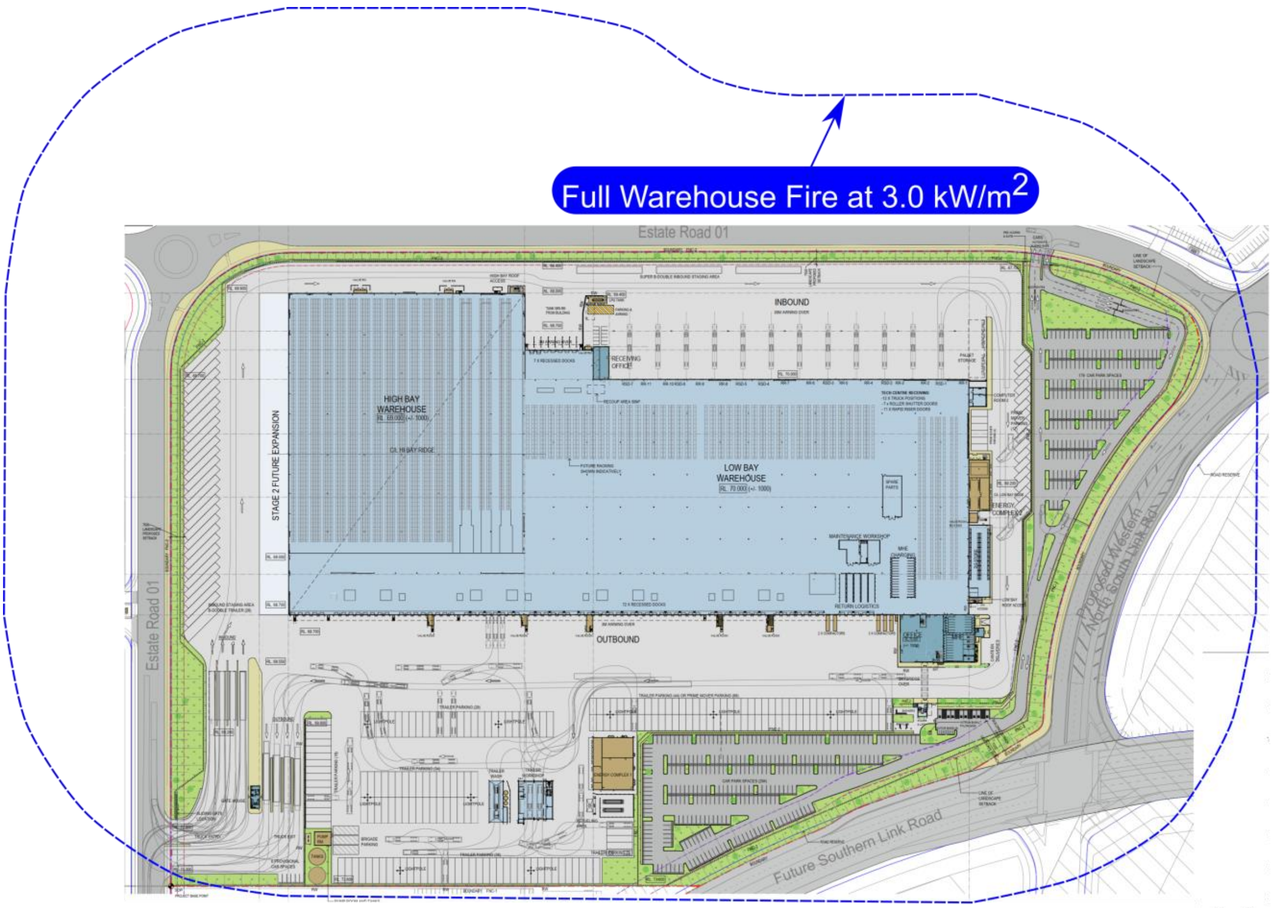


Figure 5-3: Full Warehouse Fire Radiant Heat Contours

5.5 Full Warehouse Fire and Toxic Smoke Emission

A detailed analysis has been performed in **Section B9** of **Appendix B** to estimate the impact of toxic products of combustion on the surrounding area. In addition, it was concluded that due to the relatively low quantity of toxic products that may be stored in the warehouse, and a substantial portion of toxic products involved in a fire will actually be combusted, the results generated from the assessment of toxic bi-products would provide a conservative analysis when applied to uncombusted toxic products.

Provided in **Table 5-4** is a summary of several toxic products of combustion which may be present in the smoke plume and their acceptable concentration of exposure for the Acute Exposure Guideline Levels (AEGL). These levels provide guidance on exposure concentrations for general populations, including susceptible populations over a range of exposure times to assist in the assessment of releases which may result in a toxic exposure.

Provided below is a summary of the AEGL tiers of exposure:

- **AEGL-3** is the airborne concentration, expressed as parts per million (ppm) or milligrams per cubic meter (mg/m^3), of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.
- **AEGL-2** is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

- **AEGL-1** is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

Selection for fatality or serious injury is based on an AEGL-3 values with injury values selected as those based on AEGL-2. It is noted the report AEGL values are based on 30-minute exposure.

Table 5-4: Concentrations of Toxic Products of Combustion from a Smoke Plume

Pollutant	Fatality or Serious Injury (ppm)	Injury (ppm)	Concentration (ppm)
Carbon monoxide	600	150	14.0
Nitric Dioxide	25	15	13.0
Hydrogen cyanide	21	10	14.5
Hydrogen chloride	210	43	10.7
Sulphur dioxide	30	0.75	6.1

The analysis indicates all quantities are below the AEGL-3 values. It is noted the analysis conducted is based on the primary toxic bi-product (carbon monoxide) which forms at rates higher than other toxic bi-products. Therefore, application of this result to other components is considered conservative. As these concentrations are taken at the point of release, they will disperse downwind resulting in substantially lower concentrations at the residential areas.

With reference to injury, all values except for hydrogen cyanide and sulphur dioxide are below the AEGL-2 concentration. Similar to the above discussion, the concentrations are likely to disperse substantially prior to impacting the residential populations; hence, an injury is unlikely to occur.

Based on the analysis conducted, it is considered that the concentrations at the residential area are likely to be lower than the fatality and injury concentration levels based on the comparison to the fatality and injury targets at the point of release (i.e. worst-case concentration). Notwithstanding this, as there is the potential for a toxic DG to be involved in the fire, the toxicity impacts may exceed those estimated for the toxic products of combustion analysis. Therefore, this incident has been carried forward for further analysis.

5.6 LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire

There is the potential for a hose to rupture and release high pressure LPG if the excess flow valve on the tanker fails and operator intervention does not occur. If this stream ignited, a jet fire could occur. A detailed analysis has been conducted in **Appendix B10** for this scenario which indicates the jet fire would have an impact of distance of 38 m. The impact distances for this incident are shown in **Figure 5-4**.

There are several protection systems to prevent hose rupture including hose pressure testing and inspections, non-return valves on the tank and vehicle, excess flow valves on the tanker, earthing connections, ignition source controls. Therefore, it is unlikely that a release of LPG would occur and subsequent ignition. In addition, the area has been subject to a hazardous area classification in accordance with AS/NZS 60079.10.1:2009 (Ref. [7]) to ensure ignition sources are controlled within the vicinity to control the risk of ignition.

Based upon the protection systems incorporated into tanker trucks, the ignition source controls within the area, a scenario which escalates into a jet fire scenario from the tanker truck is not expected to occur.

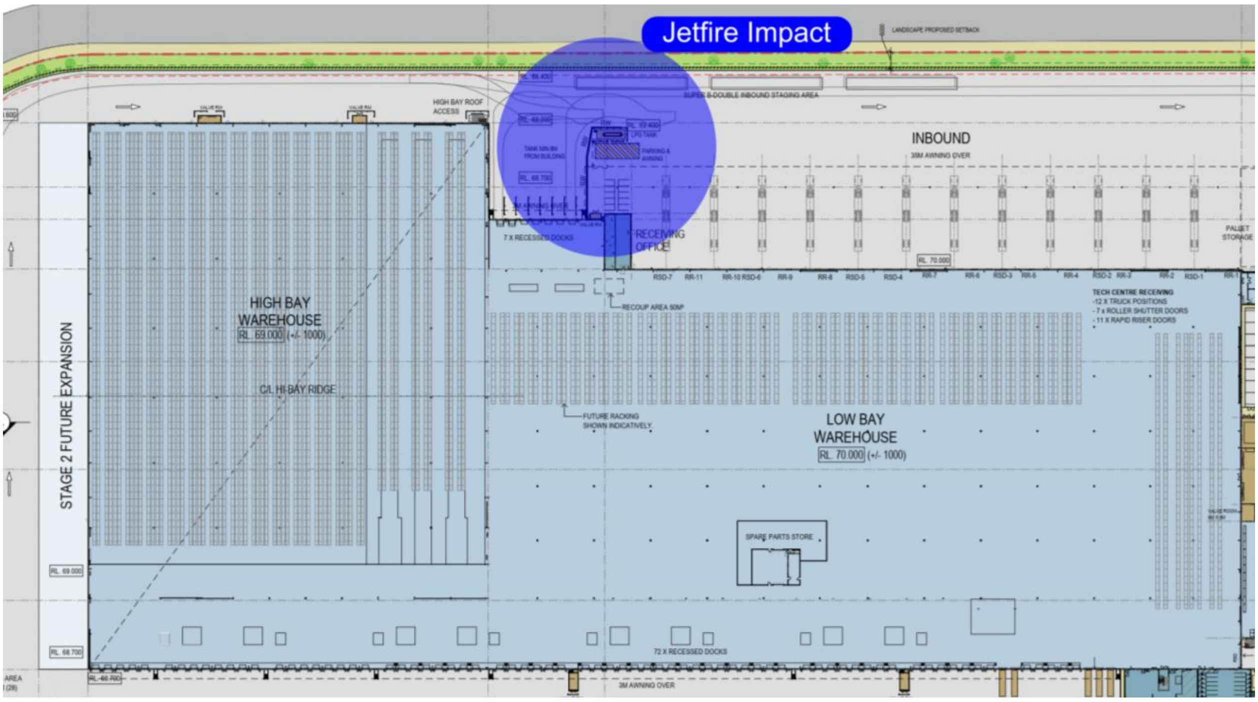


Figure 5-4: Impact from a Jet Fire

5.7 LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire and Impact on LPG Delivery Tanker and BLEVE

In the event of a jet fire and impingement on the delivery tanker there is potential for the LPG in the tanker to boil escalating to a BLEVE if intervention measures fail. A detailed analysis has been conducted in **Appendix B11** which indicates the diameter of the BLEVE would be 63.9 m and would last for 5.0 seconds. The impact distances for this incident are shown in **Figure 5-5**.

Similarly, to the jet fire scenario, several layers of protection are required to fail before the initiating event could occur. In addition, the jet fire would need to be impinged on the tanker before it could BLEVE which takes considerable time as the LPG must boil off such that the liquid level is below the impact point.

It is noted that a BLEVE scenario is a highly unlikely eventuality as it requires a jet fire scenario to occur with the associated impingement of the jet flame onto the tanker. Based upon the protections to prevent a jet fire, escalation to a BLEVE is unlikely. Nonetheless, for the scenario to further escalate where the BLEVE occurs, considerable time must pass which provides substantial potential for intervention which would include cooling of the impinged vessel.

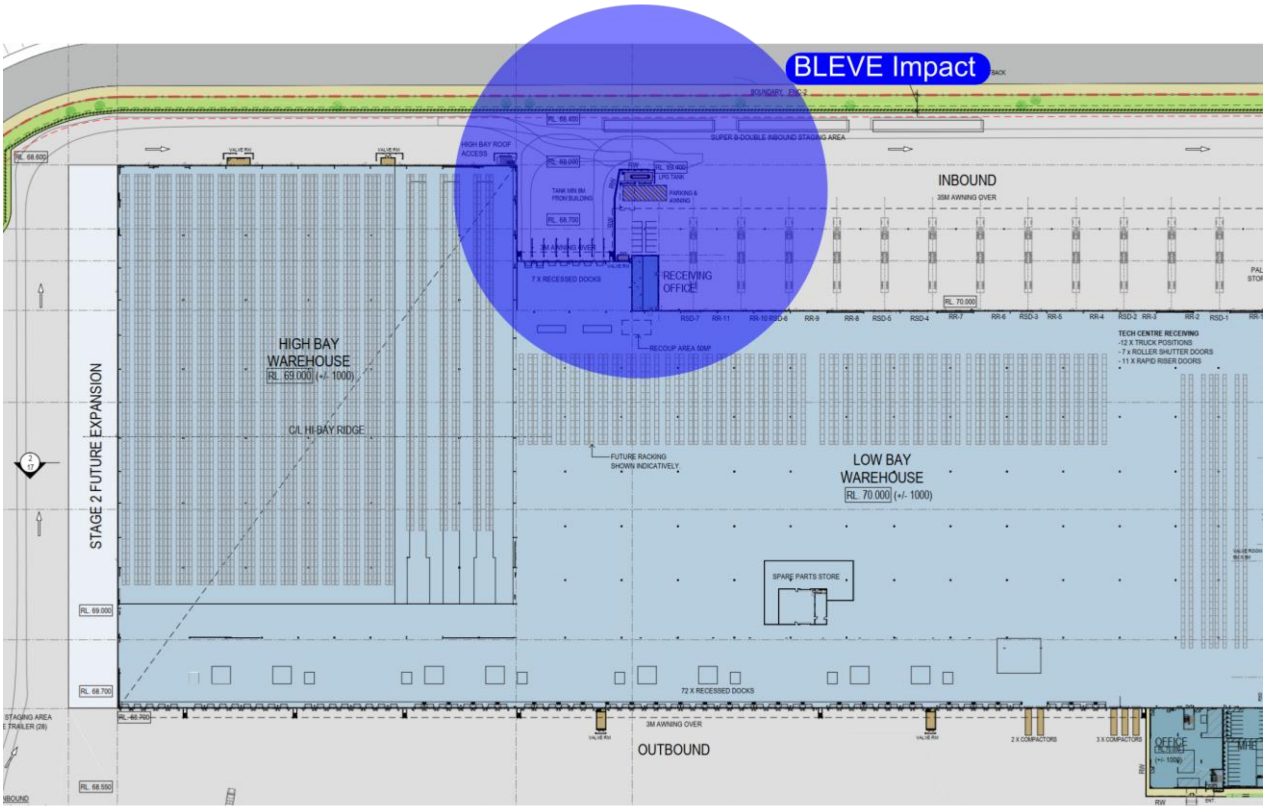


Figure 5-5: BLEVE Impact

5.8 LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire and Impact on LPG Tank and BLEVE

In the event of a jet fire and impingement on the LPG tank there is potential for the LPG in the tank to boil escalating to a BLEVE if intervention measures fail. A detailed analysis has been conducted in **Appendix B12** which indicates the diameter of the BLEVE would be 63.9 m and would last for 5 seconds. The impact distances for this incident are shown in **Figure 5-5** as this has the same fuel profile as the tanker scenario.

The eventuality of this scenario is the same as that analysed in **Section 5.7**, in that the initiating events are unlikely to occur, escalation takes time which allows substantial time for intervention should this unlikely event occur.

6.0 Details of Prevention, Detection, Protection and Mitigation Measures

The fire safety systems at the site can be split into four main categories:

- **Fire Prevention** – systems, installed to prevent the conditions that may result in initiating fire.
- **Fire Detection** – systems installed to detect fire and raise alarm so that emergency response can be affected (both evacuation and firefighting)
- **Fire Protection** – systems installed to protect against the impacts of fire or explosion (e.g. fire walls)
- **Fire Mitigation** – systems installed to minimise the impacts of fire and to reduce the potential damage (e.g. fire water application)

Each category has been reviewed in the following sections, with respect to the existing systems incorporated into the design and those to be provided as part of the recommendations herein.

6.1 Fire Prevention

This section describes the fire prevention strategies and measures that will be undertaken at the site.

6.1.1 Control of Ignition Sources

The control of ignition sources reduces the likelihood of igniting a release of material. The site has a number of controls for ignition sources. These include controls for fixed potential ignition sources and controls for introduced ignition sources.

- A permit to work or clearance system will be used - hot work will be controlled as part of the permit to work system.
- Hazardous area classification for areas containing flammable liquids or combustible dusts per the requirements of AS/NZS 60079.10.1:2009 (Ref. [7]).
- Electrical equipment selected for the classified hazardous area. Equipment is installed per the requirements of AS/NZS 60079.14:2017 (Ref. [18]).
- Designated smoking areas within the site (i.e. external from warehouse areas).

Table 6-1 presents the potential ignition sources and incidents for the facility which may lead to ignition and fire. The table also summarises the controls that will be used to reduce the likelihood of these potential sources of ignition and incidents resulting in a fire.

Table 6-1: Summary of Control of Ignition Sources

Ignition Source	Control
Smoking	No smoking policy for the site (i.e. within the warehouse) including processing and storage areas. Note: A designated smoking area is provided.
Housekeeping	The site will operate a housekeeping procedure to ensure accumulation of dust in delivery and processing areas does not occur. Limiting the accumulation of dust is an important method for minimising the potential for fires or dust dispersions.

Ignition Source	Control
Electrical	Fixed electrical equipment to be designed and installed to AS/NZS 3000:2007 (Ref. [19]). Equipment in hazardous areas installed per AS/NZS 60079.14:2017 (Ref. [18]).
Arson	The site will have a security fence and will be staffed during business hours.
Hot Work	A permit to work system and risk assessment prior to starting work will be provided for each job involving the introduction of ignition sources.

6.1.2 Separation of Incidents

The separation of incidents is used to minimise the impacts of a hazardous incident on the surrounding operations or the generation of potential "domino" effects. The storage locations of products have been designed based upon whether a product can be adequately protected by the fire protection system.

The majority of products can be protected by the sprinkler systems installed; however, some products (i.e. flammable liquids >60 mL) cannot be adequately protected. Therefore, these products present a higher fire risk and have been separated from the main warehouse by a wall with an FRL of 240/240/240.

Should the protection systems fail to control and suppress an incident, the passive protection of the bunker will prevent escalation of the incident into the main warehouse.

6.1.3 Housekeeping

The risk of fire can be significantly reduced by maintaining high standards of housekeeping. The site shall maintain a high housekeeping standard, ensuring all debris (e.g. waste packaging, etc.) that is released during transport, storage and processing is cleaned up and removed from the areas.

6.1.4 Work Practices

The following work practices will be undertaken to reduce the likelihood of an incident. They include;

- DG identification
- Placarding & signage within the site
- Forms of chemical and DG information
- Availability of Safety Data Sheets
- HAZCHEM code adherence
- Procedures for unlabelled containers
- Procedures for reporting damaged goods/accidents
- Safe work practices adhered to
- Personal Protective Equipment
- Emergency response plan and procedures
- First aid fire equipment

- Personal hygiene requirements
- Security
- Training of personnel
- Compatibility, segregation and safe storage of Dangerous Goods
- Hazardous area dossier (detailing zones, equipment, protection types and certification, etc.)
- Compliance with the Work Health and Safety Regulation 2017 (Ref. [9]).

6.1.5 Emergency Plan

An emergency plan, prepared in accordance with HIPAP No. 1 – Industry Emergency Planning Guidelines (Ref. [20]), will be developed for the site as required by the Work Health and Safety Regulations 2017 (Ref. [9]). The emergency plan will clearly identify potential hazardous fire or explosion incidents and develop fire response procedures. The plan will also include evacuation procedures and emergency contact numbers as well as an onsite emergency response structure with allocated duties to various personnel on site. This will provide readiness response in the unlikely event of an incident at the site.

6.1.6 Site Security

Maintaining a secure site reduces the likelihood either of a fire being started maliciously by intruders or by accident. Access to the site will be restricted at all times and only authorised personnel will be permitted within the site.

6.2 Detection Procedures and Measures

This section discusses the detection and protection from fires for the hazardous incidents previously identified. These include detection of fire pre-conditions, detection of a fire suppression activated condition and prevention of propagation. This assessment includes identification of the detection and protection systems required.

6.2.1 Detection of Leaks

All products are inspected for damage upon arrival at the site. Where damage is identified, these products are quarantined and not permitted to enter the Witron system. Once loaded onto the Witron system, products are not expected to be damaged based upon the highly sophisticated and calibrated system. Should a leak occur, ignition sources are not present within the bulk of the Witron system (i.e. fork lifts, personnel, etc.); hence, ignition is not expected to occur. In addition, the high risk flammable products are separated into a separate area from the main warehouse by a wall with an FRL of 240/240/240.

6.3 Fire Protection

The required fire protection systems have been outlined in Section 6 of the Fire Engineering Report (FER) produced by Core Engineering. These requirements are summarised below:

6.3.1 Fire Hydrants

A fire hydrant system shall be installed in accordance with Clause E1.3 of the BCA, and the relevant provisions of AS 2419.1:2005, except:

- External hydrant valves are permitted to apply the concession for the radiant heat shields in sprinkler protected buildings as detailed in the Performance Solution and AS 2419.1:2017.
- Dual hydrant valves external to the building envelope but positioned under the awning shall be treated as external hydrants for the purpose of coverage. They are to be provided with permanent all-weather fade resistant signs which state in text not less than 25 mm in height:
    - "External Hydrant – 2 Hose Lengths Required"
- When internal hydrants are required for coverage as per Clause 3.2.3.3 of AS 2419.1:2005 the hydrants shall be positioned to allow progressive movement of fire fighters from at least one entry point. Spacing shall be not more than 50 metres from an external hydrant, and then not more than 25 m to the next hydrant.
- When internal hydrants are provided a localised block plan should be provided at every hydrant pictorially and numerically illustrating the location of the next available additional hydrant. These localised block plans should be at least A4 size and be of all-weather fade resistant construction.

All hydrant valves shall possess a forging symbol and manufacturers mark and shall comply with Fire & Rescue NSW Fire Safety Guideline Technical Information (D15/45534).

6.3.2 Fire Hose Reels

A fire hose reel system shall be installed in accordance with Clause E1.4 of the BCA, and the relevant provisions of AS 2441:2005. However, due to the automated system access to areas with hose reel coverage may be difficult; hence, it has been proposed to use fire extinguisher coverage in lieu of fully compliant hose reel coverage as this is not a prescriptive requirement.

6.3.3 Portable Fire Extinguishers

Portable fire extinguishers shall be installed in accordance with Clause E1.6 of the BCA, and the relevant provisions of AS 2444:2001.

In the warehouse ABE type portable fire extinguishers are to be provided on each forklift or other manually operated piece of picking machinery or equipment.

6.3.4 Fire Sprinkler System

A sprinkler system in accordance with Building Code of Australia (NCC Vol. 1) Clause E1.5 and AS 2118.1:2017. The sprinkler system shall meet the following performance criteria:

- The sprinkler response time index (RTI) is to be no greater than $50m^{0.5}s^{0.5}$.
- Sprinkler activation temperature no greater than 68°C (below the ceiling) in the office. Higher temperature sprinkler heads are permitted directly below the roof covering in these areas as stipulated in AS 2118.1:2017.
- Early suppression fast response (ESFR) sprinklers with activation temperature no greater than 101°C (below the ceiling) in the warehouse.
- A gas suppression system is proposed for the communications room in the office(s) if required in accordance with AS 2118.1:2017.

6.3.5 Building Occupant Warning System

A building occupant warning system in accordance with Building Code of Australia (NCC Vol. 1) Clause E2.2 and AS1670.1:2015.

The evacuation signal 1 shall include the words such as “Fire” and “Evacuate” inserted in the time period provided in ISO 8201, or a site-specific voice message as provided for in AS 4428.16.

6.3.6 Smoke Hazard Management

An aspirated smoke detection system (e.g. VESDA) complying with AS 1670.1:2015 is to be provided within the Server and Communications Rooms.

The smoke hazard management system is comprised of an automatic system segmented into two (2) zones named Zone A and Zone B. The smoke management system shall:

- Incorporate fans designed to operate at 200°C for a period no less than 60-minutes and fire rated cabling; and
- The capacity shall be per Appendix M of the FER:
    - Zone A (low bay section): 210,000 L/s
    - Zone B (high bay section): 101,200 L/s
- Shall be initiated by manual controls. The controls together with operating instructions for use by emergency personnel must be provided adjacent to the fire indicator panel in accordance with the requirements of clauses 4.11 and 4.13 of AS/NZS 1668.1; and
- Have fans positioned at natural collection points for the hot smoky gases, having due regard to the ceiling/roof geometry and its effect on the migratory path of the smoke; and
- Discharge directly to outdoor with a velocity of not less than 5 m/s, at a point not less than 6 m from any exit;
- Make up air for each warehouse is to be provided by permanent openings or by way of louvres or roller shutters that automatically open on fire detection.

6.3.7 Emergency Lighting and Exit Signs

Emergency lighting and exit signs shall be installed in accordance with Clauses E4.2, E4.4, E4.5, E4.6 and E4.8 of the BCA, and the relevant provisions of AS 2293.1:2005.

6.3.8 Perimeter Access

Gates and security checkpoints in the emergency vehicle travel path are to be secured with a loose chain and 003 type padlock or be provided with locking devices that can be unlocked by key (i.e. provided to the two nearest local fire stations) and be manually released or operated onsite (i.e. manual override). Pedestrian access for fire fighters is to be provided around the perimeter of the site, with personal access gates located generally in accordance.

A designated hardstand area shall be provided adjacent to the fire sprinkler tank suction connections in accordance with FRNSW Policy Guide Sheet No. 5.

All drawings associated with the fire protection systems are provided in **Appendix D**.

6.4 Fire Mitigation

6.4.1 Fire Water Supply

The street mains will provide fire water supply to the hydrant ring main and the onsite fire water tanks. The onsite fire water tank is filled directly from the street mains. The sprinkler system will be serviced by an onsite pump set which consists of 2 diesel pumps operating with a primary duty pump and a secondary standby pump. The location of the hydrant main, fire hydrants and hose reels are shown in the drawing package attached to the report submission.

Pumps are started monthly and a complete test of the hydrants, pumps and sprinklers systems is conducted each year and a fire safety statement is to be produced in accordance with Environmental Planning and Assessment Regulation 2000 (Ref. [21]).

7.0 Local Brigade Access and Egress

7.1 Overview

In order to assess the likely fire brigade response times an indicative assessment of fire brigade intervention has been undertaken based on the methods defined in the Fire Brigade Intervention Model (FBIM, Ref. [22]). **Figure 7-1** illustrates the building layout with entry points to the site and fire services infrastructure. These are further explored in the Fire Engineering Report (FER) produced by Core Engineering.

To ensure consistency between the FER and the FSS, the analysis conducted by Core Engineering has been reproduced within this report.

The building is located within the Fire and Rescue New South Wales (FRNSW) jurisdictional turnout area. The closest two fire stations to the site that are provided with permanent staff are located in Huntingwood and Bonnyrigg Heights, which are approximately 8.5 km and 14 km from the site respectively and the expected routes from these stations to the project site are illustrated in Figure D-1.

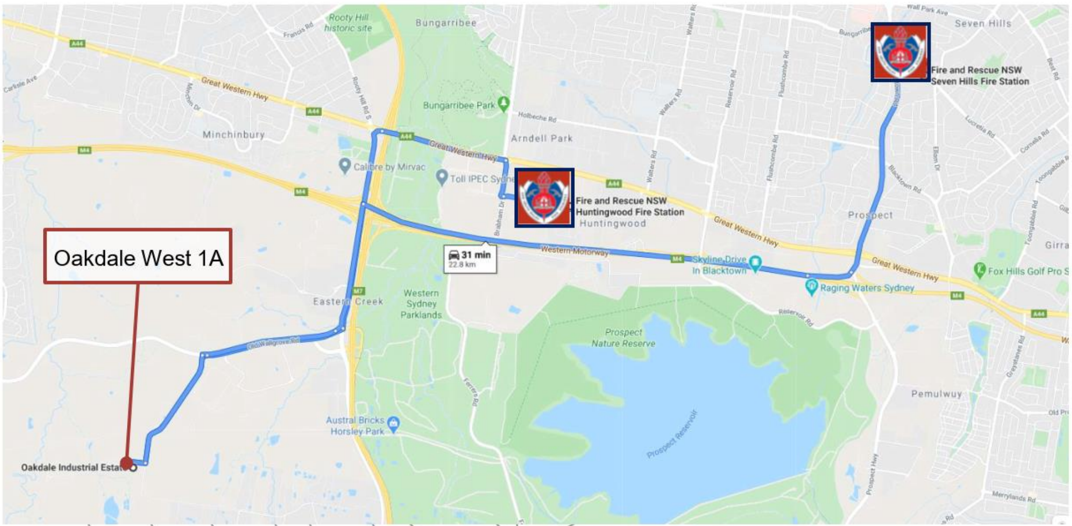


Figure D-1: Location of Site with Respect to Closest FRNSW Stations **www.google.com.au/maps**

Due to the nature of the Fire Brigade Intervention Model (FBIM), it is necessary to justify the results through the inclusion of assumptions. The accuracy of results weighs heavily upon the measure of which assumptions are made and the sources from which they are derived. The model produced details the time it will take for brigade personnel within the aforementioned location to receive notification of a fire, time to respond and dispatch resources, time for resources to reach the fire scene, time for the initial determination of the fire location, time to assess the fire, time for fire fighter travel to location of fire, and time for water setup such that suppression of the fire can commence. The following are details of the assumptions utilised in this FBIM:

Location of Fire

- This FBIM will only be an indicative model of one fire scenario within the building. For conservative purposes, the FBIM will consider a fire in the furthest habitable location from the point of entry.

Time between Ignition and Detection

- It is assumed that the initial brigade notification is via the activation of the smoke detection system at 60 s. The activation time calculated has considered a fire with an ultra-fast growth rate, which is expected to be indicative of the rate of growth expected in an area of such use.

Time for Initial Brigade Notification

- Fire brigade notification is expected to occur via a direct monitored alarm.
- Time for alarms/fire verification and any notification delays is 20 seconds based on Table B of the Fire Brigade Intervention Model [13].
- Therefore, the time from ignition at which the fire brigade will be notified is (60 + 20) = 80 seconds

Time to Dispatch Resources

- The two fire stations are assumed to be manned at the time of the fire.

Time for fire fighters to respond to dispatch call and leave fire station is included in the travel time for fire brigade in NSW [13]).

Time for Resources to Reach Fire Scene

Based on statistics of FRNSW response time from the 2018/2019 annual report [14], the average time for the fire brigade to respond to an emergency call (including call processing, turnout time and travel time) is less than 8 minutes. Further, the 90th percentile is less than 12 minutes. This is highlighted in Figure D-2. As the site is within the FRNSW jurisdictional turnout area, a time of 12 minutes can be conservatively assumed to represent the travel time required in this instance.

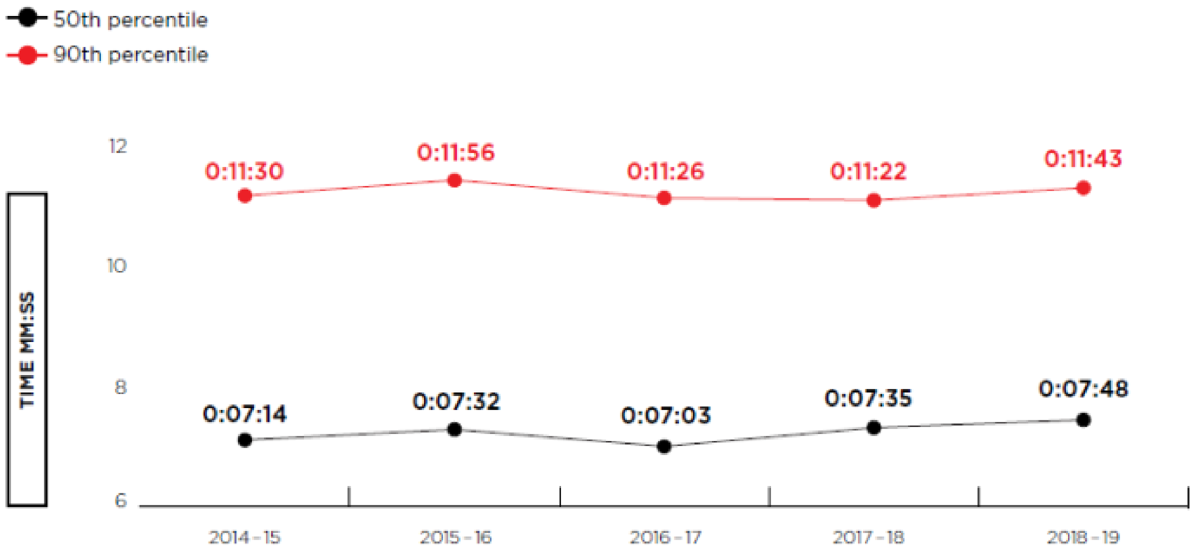


Figure D-2: FRNSW Response Time from 2018/2019 Annual Report

Time for Initial Determination of Fire Location

- On arrival, the brigade shall turn up at the Gatehouse, review the information provided at the Sub-Fire Indicator Panel (Sub-FIP) and discuss with the automation facility manager.
- Fire brigade personnel assemble at the Main FIP in the Main Office.
- Fire brigade tactical fire plans will be provided.
- It is assumed that a fire would occur during operational hours and that staff are present on site providing assistance to fire brigade personnel in relation to identifying the fire location and entry into the building. In the event that the facility is in shutdown or in a maintenance period, the fire alarm shall trigger a call-out of the relevant personnel. As such, forced entry into the building is not expected to be required.

Time to Assess the Fire

- Horizontal egress speeds have been based on fire brigade personnel dressed in turnout uniform in BA. An average travel speed of 1.4 m/s with a standard deviation of 0.6 m/s are utilised. As such, for the purposes of the calculations, a horizontal travel speed of 1.40 - (1.28 x 0.6) = 0.63 m/s is utilised.

Table D-1: FBIM Data for Horizontal Travel Speeds

GRAPH	TRAVEL CONDITIONS	SPEED (m/s)	
		MEAN (μ)	STANDARD DEVIATION (σ)
Q1	Dressed in turnout uniform	2.3	1.4
Q2	Dressed in turnout uniform with equipment	1.9	1.3
Q3	**Dressed in turnout uniform in BA with or without equipment**	**1.4**	**0.6**
Q4	Dressed in full hazardous incident suit in BA	0.8	0.5

- Horizontal travel distances (not including travel via lifts or stairs) will include the following:
  - Travel from the Gatehouse to the Main-Fire Indicator Panel is anticipated to be via utilising the brigade appliance, likely to be undertaken in less than 90 seconds.
  - Travel from the Fire Indicator Panel to the farthest point of the hardstand is anticipated to be via utilising the brigade appliance, likely to be less than 90 seconds.
  - Travel from a hardstand area to the farthest point of warehouse mezzanine platform is up to 200 m, for which 30 m of this travel would be vertical.
  - Based on the above, the total horizontal travel distance of 170 m coupled with an egress speed of 0.63 m/s results in a horizontal travel time of up to 270 seconds. Including the vertical travel time to utilise mezzanine platform stairs, this provides a total time of 475 s.
- Stair egress speeds have been based on fire brigade personnel dressed in turnout uniform is 0.9 steps/s with a standard deviation of 0.4 steps/s. Using a 90th percentile approach as documented in the FBIM V2.2 [13], the standard deviation is multiplied by a constant *k*, in this case being equal to 1.28. As such, for the purposes of the calculations to be undertaken, a stair travel speed of 0.9 - (1.28 x 0.4) = 0.39 steps/s is utilised.
  - Based on approximately 80 steps (based on the drawings provided), a stair travel time of 205 seconds may be expected.

Table D-2: FBIM Data for Travel Speed in Stairs

GRAPH	TRAVEL CONDITIONS	SPEED (STEPS/S)	
		MEAN (μ)	STANDARD DEVIATION (σ)
T1	**Ascend stairs in BA with equipment**	**0.9**	**0.4**
T2	Ascend stairs with high pressure hose	0.5	0.3
T3	Ascend stairs with 65mm diameter hose	0.7	0.3
T4	Ascend stairs with 38mm diameter hose	0.8	0.3
T5	Descend stairs in BA	1.0	0.5
T6	Rest breaks (valid after 6 stair flights)	1.9	0.8

- The total vertical travel time of 205 s to utilise mezzanine platform stairs is added to the horizontal travel time of 270 s. By then incorporating the time taken in the appliance (180 seconds), this provides a total time of 655 s to reach the fire base.

<u>Time for Water Setup</u>

- The first appliance would be expected to commence the initial attack on the fire.
- Time taken to connect and charge hoses from on-site hydrants to the fire area is based on V3 Table V of the Fire Brigade Intervention Model Guidelines, which indicates an average time of 45.3 seconds, and a standard deviation of 17.1 seconds. Using a 90th percentile approach as documented in the FBIM [13], the standard deviation is multiplied by a constant *k*, in this case being equal to 1.28. Therefore, the time utilised in this FBIM is 45.3 + (1.28 x 17.1) = 68 seconds.

<u>Search and Rescue</u>

- Search and Rescue within the warehouse facility will consist of a perimeter search of large areas and potentially an investigation upon mezzanine platforms under direction by the automation facility manager. This may require firefighting personnel to travel an additional 500 m. At a speed of 0.63 m/s, this will take firefighting personnel approximately 800 seconds.

Table D-3: Summary of the Fire Brigade Intervention Model (FBIM)

ACTION	TIME TAKEN FOR ACTION	CUMULATIVE TIME FROM IGNITION
Fire Ignition	-	0 s
Detector activation	60 s	60 s
Verification of alarm	20 s	80 s

ACTION	TIME TAKEN FOR ACTION	CUMULATIVE TIME FROM IGNITION
Dispatch resources	-	-
Travel to scene	720 s	800 s
Arrive at Scene	**-**	***13.3 minutes***
Assess and access fire	655 s	1,455 s
Water set-up	68 s	1,523 s
Attack Fire	**-**	***25.4 minutes***
Search and rescue	800 s	-

As summarised in Table D-3, the FBIM indicates that the arrival times of the brigade from the nearest fire station is after approximately 13.3 minutes respectively after fire ignition, and it is estimated that it takes another 12 minutes for the fire brigade to carry out activities including the determination of fire location and preparation of firefighting equipment. As such, the initial attack on the fire is expected to commence approximately 25.4 minutes after fire ignition.

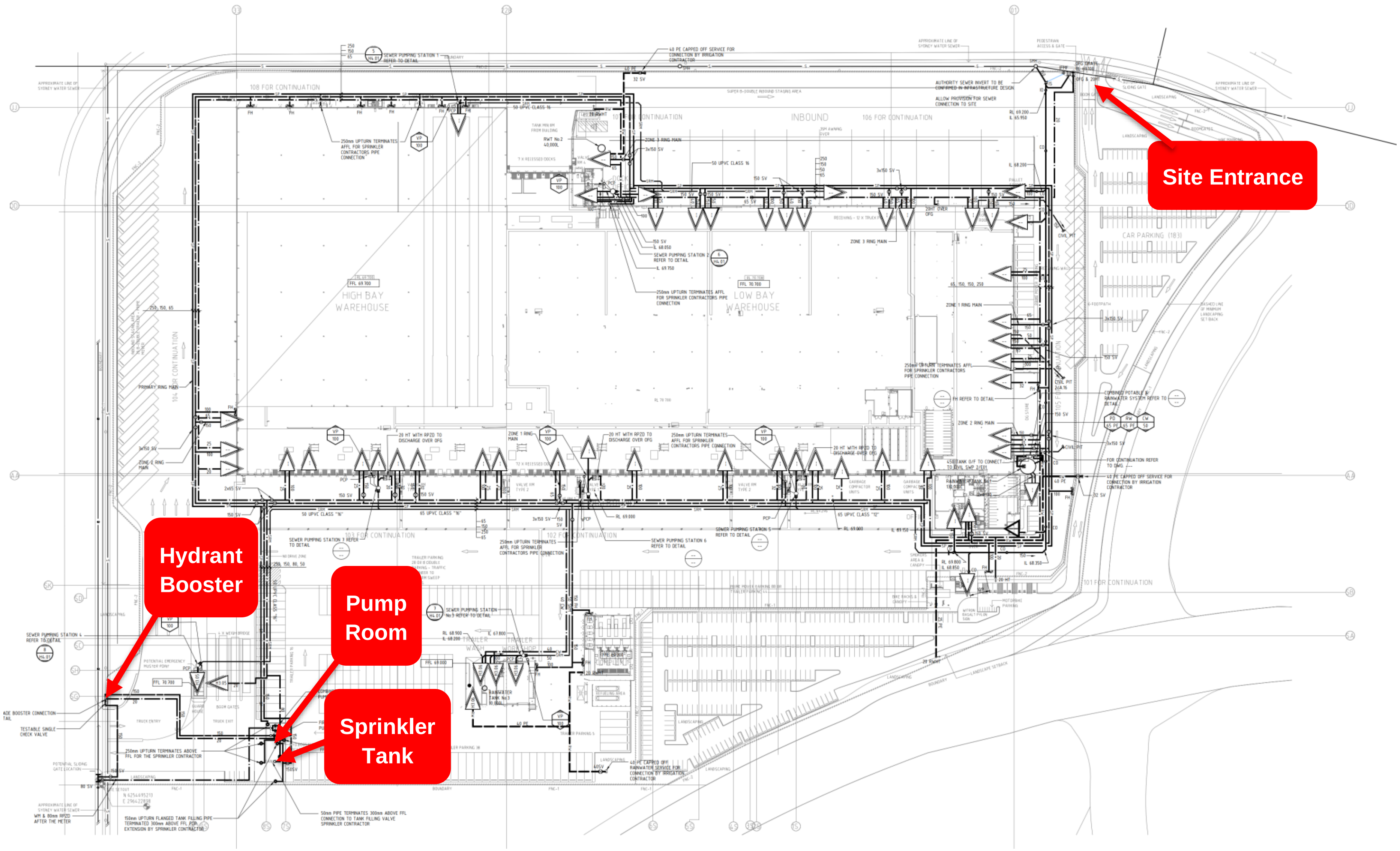


Figure 7-1: Fire Services Infrastructure

8.0 Fire Water Supply & Contaminated Fire Water Retention

8.1 Detailed Fire Water System Assessment

A hydrant system has been designed for the facility to comply with the BCA and also in consultation with FRNSW to ensure all credible scenarios can be combatted in the event of a fire. A detailed pressure loss analysis has been performed in **Appendix C** to ensure the pressure at the most hydraulically disadvantaged hydrant is above the minimum requirements of the BCA and AS 2419.5-2005 (Ref. [23]).

The results of the analysis showed the pressure loss through the pipework, valves and connections at 30 L/s is 147 kPa which is less than the maximum upper limit of 150 kPa.

The minimum pressure required per the AS 2419-2005 (Ref. [23]) for the installation is 250 kPa at the most disadvantaged hydrant. The analysis showed that the minimum pressure of 250 kPa would be achieved. Furthermore, an analysis was conducted where the system was boosted to demonstrate the minimum pressure at the most disadvantaged hydrant would exceed 700 kPa.

Therefore, it is considered the hydrant system is compliant with AS 2419-2005 (Ref. [23]) as required based upon the modelling conducted in **Appendix C**.

8.2 Contaminated Water/Fire Water Retention

Where materials are combusted in a fire, they may become toxic (i.e. formation of volatile organic compounds and aromatic hydrocarbons). Hence, when fire water is applied the materials may mix with the water resulting in a contaminated run off. To ensure environmental damage does not occur the facility is designed to contain a volume of liquid discharged from the site.

In a DG fire scenario, the following protection systems are likely to be discharging:

- SMSS at 12 heads at 0.455 m^3/min resulting in 5.46 m^3/min for 90 minutes
- 3 hydrant hoses each at 1.8 m^3/min for 90 minutes.

Therefore, the total discharge for all systems is 7.26 m^3/min x 90 = 653.4 m^3. The required water containment will be provided in a combination of recess dock storage, drainage systems and the retaining wall structure drainage.

9.0 Conclusion and Recommendations

9.1 Conclusions

A Fire Safety Study per the HIPAP No. 2 guidelines was prepared for the CA site as required by Condition 3.1.2 of the Conditions of Consent. In addition, the FSS assessed all incidents that could occur at the site and the recommendations made in the PHA were reviewed as required by Condition 3.1.2

The analysis performed in the FSS was based on the credible fire scenarios to assess whether the protection measures at the site were adequate to combat the hazards associated with the quantities and types of commodities being stored. Based on the assessment, it was concluded that the designs and existing fire protection adequately managed the risks.

9.2 Recommendations

Based on the analysis, the following recommendations have been made:

- All site personnel are to be trained in specific site procedures, emergency and first aid procedures and the use of fire extinguishers and hose reels.
- A storm water isolation point (i.e. penstock isolation valve) shall be incorporated into the design. The penstock shall automatically isolate the storm water system upon detection of a fire (smoke or sprinkler activation) to prevent potentially contaminated liquids from entering the water course.
- 9 kg dry powder fire extinguishers shall be located no closer than 2 m and no further than 10 m from manual DG storage locations.
- A spill kit suitable for the commodities being stored shall be provided for the DG store and a separate spill kit provided for the forklift transport areas.
- The warehouse and/or site boundaries shall be capable of containing 653.4 m^3 which may be contained within the warehouse footprint, site stormwater pipework and any recessed docks or other containment areas that may be present as part of the site design.
- Site management to prepare and maintain operational procedures to minimise the number of hazardous incidents and accidents on site and to mitigate the consequences of incidents regarding the handling of dangerous goods and chemicals.
- A site Emergency Response Plan per the requirements of HIPAP No. 1 shall be prepared and shall include measures to advise neighbouring premises in the event of an emergency with potential offsite impacts.
- Emergency response procedures shall be developed in conjunction with CA and the automation supplier (Witron) to ensure that all areas within the system can be accessed to facilitate FRNSW intervention as required.
- A person knowledgeable in the emergency response shall be on shift at all times such that FRNSW may be guided through the system to undertake intervention activities when required.
- CA shall engage with local FRNSW stations to undertake training and familiarisation of the automated system at a minimum of once (1) per year.

- A hazardous area classification in accordance with AS/NZS 60079.10.1:2009 shall be prepared to identify where hazardous areas may exist.
- Where electrical equipment is installed within a hazardous area, the equipment shall comply with AS/NZS 60079.14:2017.
- DG documentation shall be prepared as required by the Work Health and Safety Regulation 2017 to demonstrate the risks associated with the storage and handling of DGs has been assessed and minimised.
- The DG storages shall be appropriately placarded per the requirements of the Work Health and Safety Regulation 2017.

10.0 References

[1] NSW Department of Planning and Environment, “Applying SEPP33 – Hazardous and Offensive Developments,” NSW Department of Planning and Environment, Sydney, 2011.

[2] Department of Planning, “Hazardous Industry Planning Advisory Paper No. 2 - Fire Safety Study Guidelines,” Department of Planning, Sydney, 2011.

[3] Department of Planning, “Hazardous Industry Planning Advisory Paper No. 4 - Risk Criteria for Land Use Safety Planning,” Department of Planning, Sydney, 2011.

[4] Standards Australia, “AS/NZS 3833:2007 - Storage and Handling of Mixed Classes of Dangerous Goods, in Packages and Intermediate Bulk Containers,” Standards Australia, Sydney, 2007.

[5] FM Global, “FM Global Data Sheet 7-31: Storage of Aerosol Products,” 2016.

[6] NSW Department of Planning, “Best Practice Guidelines for Contaminated Water Retention and Treatment Systems,” NSW Department of Planning, Sydney, 1994.

[7] Standards Australia, AS/NZS 60079.10.1:2009 - Explosive Atmospheres Part 10.1: Classification of Areas, Explosive Gas Atmospheres, Sydney: Standards Association of Australia, 2009.

[8] Standards Australia, AS/NZS 60079.14:2017 - Explosive Atmospheres Part 14: Electrical Installations, Design, Selection and Erection, Sydney: Standards Australia, 2017.

[9] SafeWork NSW, “Work Health and Safety Regulation,” SafeWork NSW, Lisarow, 2017.

[10] National Transport Commission (NTC), “Australian Code for the Transport of Dangerous Goods by Road & Rail, 7th Edition,” 2011.

[11] Road Safety Council, The Australian Code for the Transport of Dangerous Goods by Road and Rail Edition 7.4, Canberra: Road Safety Council, 2016.

[12] Standards Australia, AS/NZS 1596:2014 - The Storage and Handling of LP Gas, Sydney: Standards Australia, 2014.

[13] Standards Australia, “AS 1210:2010 - Pressure Vessels,” Standards Australia, Sydney, 2010.

[14] Standards Australia, AS 1940-2017 - Storage and Handling of Flammable and Combustible Liquids, Sydney: Standards Australia, 2017.

[15] Standards Australia, “AS 4332-2004 - Storage and Handling of Gases in Cylinders,” Standards Australia, Sydney, 2004.

[16] F. P. Lees, Loss Prevention in the Process Industries, London: Butterworth-Heinemann, 2005.

[17] I. Cameron and R. Raman, Process Systems Risk Management, San Diego: Elsevier, 2005.

[18] Standards Australia, AS/NZS 60079.14:2017 - Explosive Atmospheres Part 14: Electrical Installations, Design, Selection and Erection, Sydney: Standards Australia, 2017.

[19] Standards Australia, "AS/NZS 3000:2007 - Wiring Rules," Standards Australia, Sydney, 2007.

[20] Department of Planning, "Hazardous Industry Planning Advisory Paper No. 1 - Industry Emergency Planning," Department of Planning, Sydney, 2011.

[21] New South Wales Government, "Environmental Planning and Assessment Regulation 2000," New South Wales Government, Sydney, 2000.

[22] Australasian Fire Authorities Council, "Fire Brigade Intervention Model V2.2," Australasian Fire Authorities Council, 2004.

[23] Standards Australia, "AS 2419.1-2005 - Fire Hydrant Installations - System Design, Installation and Commissioning," Standards Australia, Sydney, 2005.

[24] Standards Australia, "AS 1692-2006 - Steel tanks for flammable and combustible liquids," Standards Australia, Sydney, 2006.

[25] Brisbane City Council, "SC6.28 Storage and dispensing of petroleum products planning scheme policy," Brisbane City Council, Brisbane, 2014.

[26] I. R. R. Cameron, Process Systems Risk Management, Sydney: Elsevier Academic Press, 2005.

[27] Thermal-Fluids Central, "Heat of Combustion," Global Digital Central, 8 July 2011. [Online]. Available: https://www.thermalfluidscentral.org/encyclopedia/index.php/Heat_of_Combustion. [Accessed 4 July 2017].

Appendix A

Hazard Identification Table

A1. Hazard Identification Table

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
1	Warehouse	• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging	• Release of Class 2.1, 3, 4.1, 5.1, 6.1, 8s, 9s and other products to the environment	• Small retail sized packages (< 20 L) • Inspection of packages upon delivery to the site. • Trained forklift operators (including spill response training). • Storage of DGs within AS/NZS 3833:2007 compliant store (Ref. [4])
2		• Dropped pallet • Damaged packaging (receipt or during storage) • Deterioration of packaging	• Spill of flammable liquids, evolution of flammable vapour cloud ignition and vapour cloud explosion/flash fire • Spill of flammable liquids, ignition and pool fire/racking fire • Ignition of Class 1.4s materials	• Small retail sized packages (< 20 L) • Inspection of packages upon delivery to the site • Control of ignition sources according to AS/NZS 60079.14:2017 (Ref. [8]) • Automatic fire protection system (in-rack and SMSS) • First attack fire-fighting equipment (e.g. hose reels & extinguishers) • Fire detection systems • Storage of DGs within AS/NZS 3833:2007 compliant store (Ref. [4])
3		• Heating of Class 2.1 from a general warehouse fire	• Rupture, ignition and explosion/rocketing of cylinder within warehouse spreading fire	• Aerosols stored in 240/240/240 FRL bunker • In-rack sprinklers according to FM Global Data Sheet 7-31 (Ref. [5]) • Automatic fire protection system
4	Sprinkler activation	• Fire activates SMSS resulting in fire water release and potential contaminated fire water offsite	• Environmental impact to surrounding areas (e.g. stormwater drainage)	• Dangerous Goods Stores are bunded to contain in excess of the maximum required fire water, per AS/NZS 3833:2007 (Ref. [4])

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
				• Site drainage to comply with the Best Practice Guide for Potentially Contaminated Water Retention and Treatment Systems (Ref. [6])
5	Pallet Loading/Unloading	• Dropped containers from the pallet • Impact damage to containers on the pallet (collision with racks or other forklifts)	• Spill of flammable liquids, evolution of flammable vapour cloud ignition pool, fire under the pallet • Full pallet fire as a result of fire growth	• Trained & licensed forklift drivers • First attack fire-fighting equipment (hose reels & extinguishers) • SMSS if incident occurs internally • No potential for fire growth beyond the single pallet (limited stock externally)
6	Diesel tank refuelling tank	• Loss of containment of diesel fuel during fuel transfers • Loss of hose connection during fuel transfers • Loss of containment of diesel storage tank • Loss of containment of tanker vehicle • Overfilling of tank • Vehicle collision resulting in damage	• Release of diesel to the environment	• Storage area to comply with AS 1940-2017 (Ref. [14]) • Storage tank to comply with AS 1692-2006 (Ref. [24]) • Spill containment for delivery vehicles • Self-bunded tank • Vehicle impact protection • Delivery area to comply with SC6.28 (Ref. [25]) • Overfill protection
7			• Release of diesel, ignition and fire	• Storage area to comply with AS 1940-2017 (Ref. [14]) • Storage tank to comply with AS 1692-2006 (Ref. [24]) • Spill containment for delivery vehicles • Self-bunded tank • Vehicle impact protection • Overfill protection

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
				• Low ignition probability due to high flash point of diesel (i.e. flash point above ambient conditions)
8	LPG Tank	• Releases from pipework due to corrosion, flange leaks, hose/pump leaks, weld failure, operator error, maintenance error, mechanical damage (e.g. tanker impact on fill point) etc. • Overfilling of tank due to operator error (incorrect tank reading) • Overfilling of tanker due to equipment fault or procedures not followed (e.g. leaving operation unattended). • Hose failure or coupling failure or coupling not properly engaged during transfers due to mechanical damage or undetected wear and tear or operator error. • Drive away with hoses attached.	• Minor leak (5 mm hole) • Major leak (50 mm hole) • If ignition then: ○ Flash fire, jet fire, pool fire, VCE or BLEVE (tanker), possible explosion if enters drains, and potentially hazardous heat radiation, direct fire involvement, and/or overpressure/ projectiles. • Potential fire propagation to adjacent sites.	• LPG facilities to be designed to comply with AS/NZS 1596:2014 (Ref. [12]) and will be installed by an experienced LPG facility supply company. • Tank and associated pipework/fitting will be pressure tested in accordance with the requirements of the pressure vessels code • Ignition source control including earthing to prevent static sparks. • Hoses tested annually as per AS/NZS 1596:2014 and the ADG (Ref. [11]) • Excess flow valves installed in pipework. • Valves to fill point closed until air connected to truck. • Valves shut on breaking of air connection to truck. • All staff including contract drivers will be trained in the specific transfer operations at the site. • Tanker fitted with Emergency Shut Down • Excess flow valve on tanker • Manual shutdown valve • Non-return valve on delivery line • Emergency Shutdown on delivery line • Manual valve on delivery line • Overfill protection device • Fusible link on tanker and vessel

ID	Area/Operation	Hazard Cause	Hazard Consequence	Safeguards
9	LPG Cylinders	• Damage to cylinders, valves, pipework, etc	• Minor leaks which may result in gas accumulation, ignition, and flash fire or explosions	• Minor storage under AS 4332-2004 (Ref. [15]) • Relatively low volume of gas prevents accumulation to levels which may have offsite impacts • Adequately ventilated • Hazardous area classification per AS/NZS 60079.10.1:2009 (Ref. [7]) • Electrical equipment controlled per AS/NZS 60079.14:2017 (Ref. [8])

Appendix B

Consequence Analysis

B1. Incidents Assessed in Detailed Consequence Analysis

The following incidents are assessed for consequence impacts.

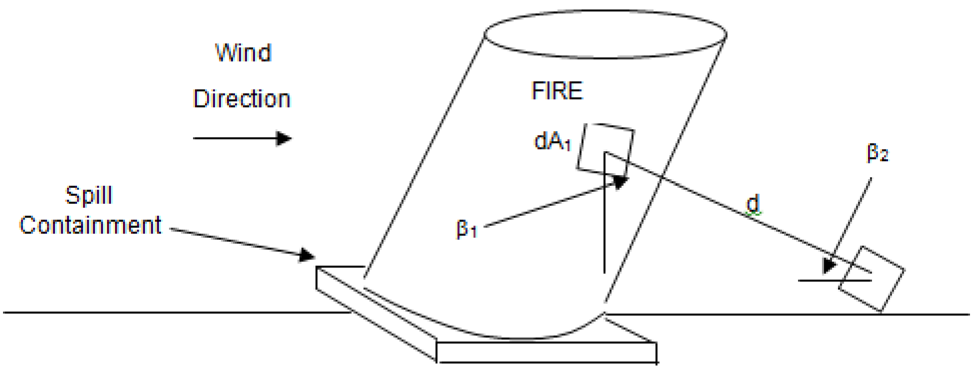
- Flammable material spill, ignition and racking fire.
- LPG release (from aerosol), ignition and racking fire.
- Full warehouse fire and radiant heat.
- Full warehouse fire and toxic smoke emission.
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire.
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire and impact on LPG delivery tanker and Boiling Liquid Expanding Vapour Explosion (BLEVE).
- LPG unloading incident, hose rupture, LPG release, ignition and jet fire and impact on LPG tank and BLEVE.

Each incident has been assessed in the sections below.

B2. Spreadsheet Calculator (SSC)

The SSC is designed on the basis of finite elements. The liquid flame area is calculated as if it is a circle to find the radius for input into the SSC model.

The SSC is designed on the basis of finite elements. The liquid flame area is calculated as if it is a circle to find the radius for input into the SSC model. **Appendix Figure B-1** shows a typical pool fire, indicating the target and fire impact details.



Appendix Figure B-1: Heat Radiation on a Target from a Cylindrical Flame

A fire in a bund or at a tank roof will act as a cylinder with the heat from the cylindrical flame radiating to the surrounding area. A number of mathematical models may be used for estimating the heat radiation impacts at various distances from the fire. The point source method is adequate for assessing impacts in the far field; however, a more effective approach is the view factor method, which uses the flame shape to determine the fraction of heat radiated from the flame to a target. The radiated heat is also reduced by the presence of water vapour and the amount of carbon dioxide in air. The formula for estimating the heat radiation impact at a set distance is shown in **Equation B-1** (Ref. [17]).

$$Q = EF\tau$$ **Equation B-1**

Where:

- Q = incident heat flux at the receiver (kW/m^2)
- E = surface emissive power of the flame (kW/m^2)
- F = view factor between the flame and the receiver
- τ = atmospheric transmissivity

The calculation of the view factor (F) in **Equation B-1** depends upon the shape of the flame and the location of the flame to the receiver. F is calculated using an integral over the surface of the flame, S (Ref. [17]). The formula can be shown as:

$$F = \int\int_S \frac{\cos\beta_1 \cos\beta_2}{\pi d^2}$$ **Equation B-2**

Equation B-2 may be solved using the double integral **or** using a numerical integration method in spread sheet form. This is explained below.

For the assessment of pool fires, a Spread Sheet Calculator (SCC) has been developed, which is designed on the basis of finite elements. The liquid flame area is calculated as if the fire is a vertical cylinder, for which the flame diameter is estimated based on the fire characteristics (e.g. contained within a bund). Once the flame cylindrical diameter is estimated, it is input into the SSC model. The model then estimates the flame height, based on diameter, and develops a flame geometric shape (cylinder) on which is performed the finite element analysis to estimate the view factor of the flame. **Appendix Figure B-1** shows a typical pool fire, indicating the target and fire impact details.

The SSC integrates the element dA_1 by varying the angle theta θ (the angle from the centre of the circle to the element) from zero to 90^o in intervals of 2.5 degrees. Zero degrees represents the straight line joining the centre of the cylinder to the target (x0, x1, x2) while 90^o is the point at the extreme left hand side of the fire base. In this way the fire surface is divided up into elements of the same angular displacement. Note the tangent to the circle in plan. This tangent lies at an angle, gamma, with the line joining the target to where the tangent touches the circle (x4). This angle varies from 90^o at the closest distance between the liquid flame (circle) and the target (x0) and gets progressively smaller as θ increases. As θ increases, the line x4 subtends an angle phi Φ with x0. By similar triangles we see that the angle gamma γ is equal to 90- θ - Φ . This angle is important because the sine of the angle give us the proportion of the projected area of the plane. When γ is 90^o, sin(γ) is 1.0, meaning that the projected area is 100% of the actual area.

Before the value of θ reaches 90^o the line x4 becomes tangential to the circle. The fire cannot be seen from the rear and negative values appear in the view factors to reflect this. The SSC filters out all negative contributions.

For the simple case, where the fire is of unit height, the view factor of an element is simply given by the expression in **Equation B-3** (Derived from **Equation B-2**):

$$VF = \Delta A \frac{\sin\gamma}{\pi \times X4 \times X4}$$ **Equation B-3**

Where ΔA is the area of an individual element at ground level.

Note: the denominator (π. x4. x4) is a term that describes the inverse square law for radiation assumed to be distributed evenly over the surface of a sphere.

Applying the above approach, we see the value of x4 increase as θ increase, and the value of sin(γ) decreases as θ increase. This means that the contribution of the radiation from the edge of the circular fire drops off quite suddenly compared to a view normal to the fire. Note that the SSC adds up the separate contributions of **Equation B-3** for values of θ between zero until x4 makes a tangent to the circle.

It is now necessary to do two things: (i) to regard the actual fire as occurring on top of a fire wall (store) and (ii) to calculate and sum all of the view factors over the surface of the fire from its base to its top. The overall height of the flame is divided into 10 equal segments. The same geometric technique is used. The value of x4 is used as the base of the triangle and the height of the flame, as the height. The hypotenuse is the distance from target to the face of the flame (called X4'). The angle of elevation to the element of the fire (alpha α) is the arctangent of the height over the ground distance. From the cos(α) we get the projected area for radiation. Thus there is a new combined distance and an overall equation becomes in **Equation B-4 ((**Derived from **Equation B-3**):

$$VF = \Delta A \frac{\sin\gamma \times \cos\alpha}{\pi \times X4 \times X4}$$ **Equation B-4**

The SCC now turns three dimensional. The vertical axis represents the variation in θ from 0 to 90º representing half a projected circle. The horizontal axis represents increasing values of flame height in increments of 10%. The average of the extremes is used (e.g. if the fire were 10 m high then the first point would be the average of 0 and 1 i.e. 0.5 m), the next point would be 1.5 m and so on).

Thus the surface of the flame is divided into 360 equal area increments per half cylinder making 720 increments for the whole cylinder. Some of these go negative as described above and are not counted because they are not visible. Negative values are removed automatically.

The sum is taken of the View Factors in **Equation B-3**. Actually the sum is taken without the ΔA term. This sum is then multiplied by ΔA which is constant. The value is then multiplied by 2 to give both sides of the cylinder. This is now the integral of the incremental view factors. It is dimensionless so when we multiply by the emissivity at the "face" of the flame (or surface emissive power, SEP), which occurs at the same diameter as the fire base (pool), we get the radiation flux at the target.

The SEP is calculated using the work by Mudan & Croche (Ref. [16] & Ref. [17]) which uses a weighted value based on the luminous and non-luminous parts of the flame. The weighting is based on the diameter and uses the flame optical thickness ratio where the flame has a propensity to extinguish the radiation within the flame itself. The formula is shown in **Equation B-5**.

$$SEP = E_{max}e^{-sD} + E_s(1 - e^{-sD})$$ **Equation B-5**

Where;

E_{max} = 140

S = 0.12

E_s = 20

D = pool diameter

The only input that is required is the diameter of the pool fire and then estimation for the SEP is produced for input into the SSC.

The flame height is estimated using the Thomas Correlation (Ref. [17]) which is shown in **Equation B-6**.

$$H = 42d_p\left[\frac{\dot{m}}{\rho_a\sqrt{gd_p}}\right]^{0.61}$$ **Equation B-6**

Where;

d_p = pool diameter (m)

ρ_a = density of air (1.2 kg/m^3 at 20^{o}C)

$\dot{m}$ = burning rate (kg/m^2.s)

g = 9.81 m/s^2

The transmissivity is estimated using **Equation B-7** (Ref. [17]).

$$\tau = 1.006 - 0.01171(\log_{10} X(H_2O) - 0.02368(\log_{10}X(H_2O))^2 - 0.03188(\log_{10} X(CO_2) + 0.001164(\log_{10}X(CO_2))^2$$ **Equation B-7**

Where:

- τ = Transmissivity (%)
- X(H_2O) = $\frac{R_H \times L \times S_{mm} \times 2.88651 \times 10^2}{T}$
- X(CO_2) = $\frac{L \times 273}{T}$

and

- R_H = Relative humidity (% expressed as a decimal)
- L = Distance to target (m)
- S_{mm} = saturated water vapour pressure in mm of mercury at temperature (at 25^{o}C S_{mm} = 23.756)
- T = Atmospheric temperature (K)

B3. Jet Fire Modelling

The flow rate of a liquid from a hole may be calculated from **Equation B-8** (Ref. [26]).

$$m = C_d A(2\rho\Delta P)^{0.5}$$ **Equation B-8**

Where:

- m = Mass flow rate (kg/s)
- C_d = Discharge coefficient (0.6 for irregular holes)
- A = area of the orifice (m^2)
- ρ = Density of the material (kg/m^3)
- ΔP = Pressure difference across the orifice (Pa).

The flame length and width, as a result of a release, can be estimated from the empirical formula published by Lees (Ref. [16]). The equations for the length and width are shown in **Equation B-9** and **Equation B-10**.

$$L = 9.1{G_L}^{0.5}$$ **Equation B-9**

Where:

- L = Length (m)
- G_L = Mass flow rate (kg/s)

$$W = 0.25L$$ **Equation B-10**

Where:

- W = Width (m)
- L = Length (m)

B4. BLEVE Modelling

The diameter of the fireball and the duration of the BLEVE may be estimated using the following formulae (Ref. [26]):

$$D = 6.48m^{0.325}$$ **Equation B-11**

$$t = 0.852m^{0.25}$$ **Equation B-12**

Where:

- D = diameter of the fire ball (m)
- m = mass of LPG in the tank (kg)
- t = duration of the BLEVE (seconds)

B5. Radiant Heat Physical Impacts

Appendix Table B-1 provides noteworthy heat radiation values and the corresponding physical effects of an observer exposed to these values (Ref. [3]).

Appendix Table B-1: Heat Radiation and Associated Physical Impacts

Heat Radiation (kW/m^2)	Impact
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of a fatality for people exposed instantaneously
23	• Likely fatality for extended exposure and chance of a fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
12.6	• Significant chance of a fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
4.7	• Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second degree burns will occur)

Heat Radiation (kW/m²)	Impact
2.1	• Minimum to cause pain after 1 minute

B6. Flammable Material Spill, Ignition and Racking Fire

In the event that a flammable liquid package is damaged and flammable liquid is released the volatile component will vaporise which may contact an ignition source resulting in a pool fire. As the fire grows it may accelerate the deterioration of other packages resulting in failure and release of additional flammable material and combustion of packaging.

As heat and smoke is generated from the fire, the in-rack sprinklers and the SMSS will activate. Two sprinkler activation scenarios have been assessed:

- A worst credible (WC) scenario whereby the first row of the SMSS activates and controls the spread of a fire.
- A sensitivity scenario whereby the first row of sprinklers fails to activate and the fire is instead controlled by the second row of the SMSS.

The first row of sprinklers has an approximate diameter of 3 m with the second row having an approximate diameter of 9 m. These diameters are used to estimate the flame height and SEP for the fire scenarios. To estimate the flame height and SEP the following information was substituted into the models:

- Equivalent fire diameter: WC – 3 m, Sensitivity - 9 m
- Burning rate – 0.0667 kg/m^2.s (this value encompasses a large range of flammable liquid burning rates and is considered conservative due to the nature of the flammable liquids stored, Ref. [16])

The selection of a flammable liquid burning rate is considered appropriate and conservative as a the fire will be composed of burning flammable liquids and packaging. The packaging is a solid material that will yield a lower burning rate than selected as it requires an additional phase change prior to combustion reducing the rate at which the product burns.

Furthermore, the analysis is considered incredibly conservative as it assumes a 100% burning area; however, as the subject areas will encompass aisle spaces, which will have no combustible material stored these locations. Therefore, it is considered the results generated from this analysis would substantially overestimate the radiant heat impacts from the identified scenarios.

The results for flame height and SEP for each scenario are summarised in **Appendix Table B-2**.

Appendix Table B-2: Flame Height and SEP for a Flammable Material Sprinkler Controlled Fire

Output	Base Case	Sensitivity
Flame Height (m)	7.7	16.5
SEP (kW/m^2)	103.7	60.8

The inputs summarised in **Appendix Table B-2** were input in to the SSC with the results for each scenario shown in **Appendix Table B-3**.

Appendix Table B-3: Heat Radiation from a Flammable Material Sprinkler Controlled Fire

Heat Radiation (kW/m^2)	Distance (m)	
	Base Case	Sensitivity
35	4.6	8.5
23	5.6	10.3
12.6	7.5	13.7
4.7	12.0	22.2
3.0	14.9	27.5

B7. LPG Release (From Aerosol), Ignition and Racking Fire

The release of LPG from a damaged package could result in a fire if the release ignited. The fire would begin to grow expanding LPG within other aerosols which may rupture, ignite and rocket around the aerosol store. The store is fitted with SMSS and in-rack sprinklers to suppress the fire and cool adjacent packages to minimise the potential for rocketing.

As heat and smoke is generated from the fire, the in-rack sprinklers and the SMSS will activate. Two sprinkler activation scenarios have been assessed:

- A worst credible (WC) scenario whereby the first row of the SMSS activates and controls the spread of a fire.
- A sensitivity scenario whereby the first row of sprinklers fails to activate and the fire is instead controlled by the second row of the SMSS.

The first row of sprinkler has an approximate diameter of 3 m with the second row having an approximate diameter of 9 m. These diameters are used to estimate the flame height and SEP for the fire scenarios. To estimate the flame height and SEP the following information was substituted into the models:

- Equivalent fire diameter: WC – 3 m, Sensitivity - 9 m
- Burning rate – 0.099 $kg/m^2.s$ (the burning rate for LPG, Ref. [16]).

The selection of a LPG burning rate is considered appropriate and conservative as a fire involving aerosols will be composed predominantly of packaging (i.e. plastic wrapping and cardboard) which will be punctuated by rupturing of cans and combustion of the released LPG. The packaging is a solid material that will yield a lower burning rate than selected as it requires an additional phase change prior to combustion reducing the rate at which the product burns.

Furthermore, the analysis is considered incredibly conservative as it assumes a 100% burning area; however, as the subject areas will encompass aisle spaces, there will be no combustible material stored in these locations. Therefore, it is considered the results generated from this analysis would substantially overestimate the radiant heat impacts from the identified scenarios.

The results for flame height and SEP for each scenario are summarised in **Appendix Table B-4**.

Appendix Table B-4: Flame Height and SEP for Class 2.1 Sprinkler Controlled Scenarios

Output	Base Case	Sensitivity
Flame Height (m)	7.7	21.0

Output	Base Case	Sensitivity
SEP (kW/m²)	103.7	60.8

The inputs summarised in **Appendix Table B-4** were input in to the SSC with the results for each scenario shown in **Appendix Table B-5**.

Appendix Table B-5: Heat Radiation from Class 2.1 Sprinkler Controlled Scenarios

Heat Radiation (kW/m²)	Distance (m)	
	Base Case	Sensitivity
35	5.4	10.1
23	6.5	12.1
12.6	8.6	15.9
4.7	13.7	25.5
3.0	16.9	31.5

B8. Full Warehouse Fire

The main warehouse has a floor area of 61,754 m² which is the area that is assumed to participate in the fire. The equivalent diameter for the fire can be calculated by:

$$D = \sqrt{\frac{4 \times 61754}{\pi}} = 289.3\ m$$

Provided in **Appendix Table B-6** is a summary of the classes of materials stored within the facility, the applicable burning rates based on commodities stored and the contribution of each product to the total burning rate

Appendix Table B-6: Estimation of Average Burning Rate

Class	Quantity (L)*	% of Total Quantity	Burning Rate (kg/m².s)	Burning Rate Based on %
1.4s	20,000	1%	0.099	0.0011
2.1	70,000	4%	0.099	0.0039
2.2	25,000	1%	0.099	0.0014
3	300,000	17%	0.022	0.0037
4.1	15,000	1%	0.0667	0.0006
5.1	25,000	1%	0.0667	0.0009
6.1	45,000	3%	0.022	0.0006
8	60,000	3%	0.022	0.0007
9	105,000	6%	0.022	0.0013
C1/C2	1,100,000	62%	0.022	0.0137
Total	**1,765,000**	**100**	**-**	**0.0280**

*Assumed density of 1,000 kg/m³

The following information was input into the models;

- Equivalent fire diameter – 289.3 m
- Burning rate – 0.0280 kg/m^2.s
- Fire wall height: no fire wall

The models provided the following information for the warehouse fire;

- SEP – 20 kW/m^2
- Flame Height – 108.6 m (from model without roof restriction)

Provided in **Appendix Table B-7** are the results generated by the SSC.

Appendix Table B-7: Heat Radiation Impacts from a Full Warehouse Fire

Heat Radiation (kW/m^2)	Distance (m)
35	Maximum heat flux is 20*
23	Maximum heat flux is 20*
12.6	46.0
4.7	104.0
3.0	142.0

* Research conducted in relation to large fires (Ref. [17]) indicates that where a large fire occurs, it is difficult for complete combustion to occur towards the centre of the fire due to the lack of air being unable to reach the centre of the flames. Hence, combustion tends to occur effectively at the fire surface, but poorly towards the centre of the fire. This generates large quantities of black smoke, which shields the flame surface as the smoke from the centre of the fire escapes towards the outer fire surface. The research presented in Lees (Ref. [16]) indicates that fires will generate a SEP within a range of between 20 kW/m^2 for larger fires and 130 kW/m^2 for smaller fires. Hence, a full warehouse fire would be of significant dimensions, generating large quantities of black smoke, shielding the flames at the fire surface. Hence, for the analysis of a full warehouse fire in this study, an SEP value of 20 kW/m^2 has been used.

B9. Full Warehouse Fire and Smoke Emission

During the fire, uncombusted toxic products may be present in the smoke plume or toxic bi-products may be generated which will be dispersed in the smoke plume. It is necessary to assess the associated impacts of the smoke plume downwind of the facility as it may have far reaching impacts on the wider community. When assessing the downwind impacts of the fire plume, the main contributors to the dispersion are:

- The fire size (diameter) and energy released as convective heat
- The atmospheric conditions such as wind speed, relative humidity, atmospheric stability and ambient temperature.

These parameters interact to determine the buoyancy of the smoke plume (vertical rise) which is controlled by the convective energy within the smoke plume in addition to the atmospheric conditions. The atmospheric conditions will vary from stable conditions (generally night time) to unstable conditions (high insolation from solar radiation) which results in substantial vertical mixing which aids in the dispersion. Contributing to this is the impact of wind speed which will limit the vertical rise of a plume but may exacerbate the downwind impact distance.

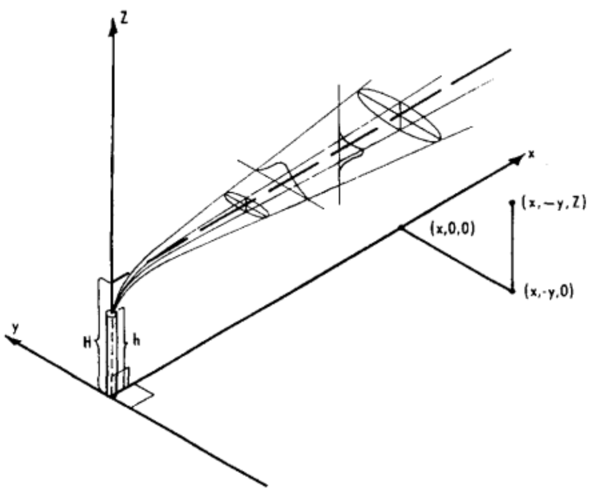
The atmospheric conditions are classified as Pasquill Guifford's Stability categories which are summarised in **Appendix Table B-8** (Ref. [17]).

Appendix Table B-8: Pasquill's Stability Categories

Surface wind speed at 10 m height (m/s)	Insolation			Night	
	Strong	Moderate	Slight	Thinly overcast or ≥50% cloud	<50% cloud.
<2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

Generally, the most onerous conditions are F conditions which result in stable air masses and typically have inversion characteristics. Inversion characteristics occur when a warm air mass sits above a cold air mass. Typically, hot air will rise due to lower density than the bulk air; however, in an inversion, a warm air mass sits above the cooler denser air; hence, as the warm air rises through the cold mass it hits a 'wall' of warmer air preventing vertical mixing above this point. In a fire scenario, the hot smoke plume will cool as it rises; however, if it encounters an inversion, it will begin to run along this boundary layer preventing vertical mixing and allowing the smoke plume to spread laterally for substantial distances.

A smoke plume is buoyant, and will disperse laterally and vertically as it rises essentially following a Gaussian dispersion as shown in **Appendix Figure B-2** (Ref. [17]).



Appendix Figure B-2: Co-ordinate System for Gas Dispersion

Ian Cameron, professor of Risk Engineering at the University of Queensland, has developed a risk assessment tool known as Risk Assessor produced by DAESIM Technologies. The tool has numerous risk engineering applications; however, the component of interest for this assessment is the smoke plume modelling from fire scenarios. The model has been developed based on a Gaussian dispersion model accounting for modifications to the plume drag coefficients required to model a plume dispersion from a warehouse fire (Ref. [17]).

The model requires several inputs which have been summarised in **Appendix Table B-9** with the associated value input as part of this modelling exercise. As noted, the more onerous conditions occur during stable air conditions which allow far reaching effects with reduced dispersion due to low air velocities and vertical mixing. The industry standard for modelling this scenario is selection of F1.5 (F stability at 1.5 m/s wind velocity) which has been adopted for this assessment.

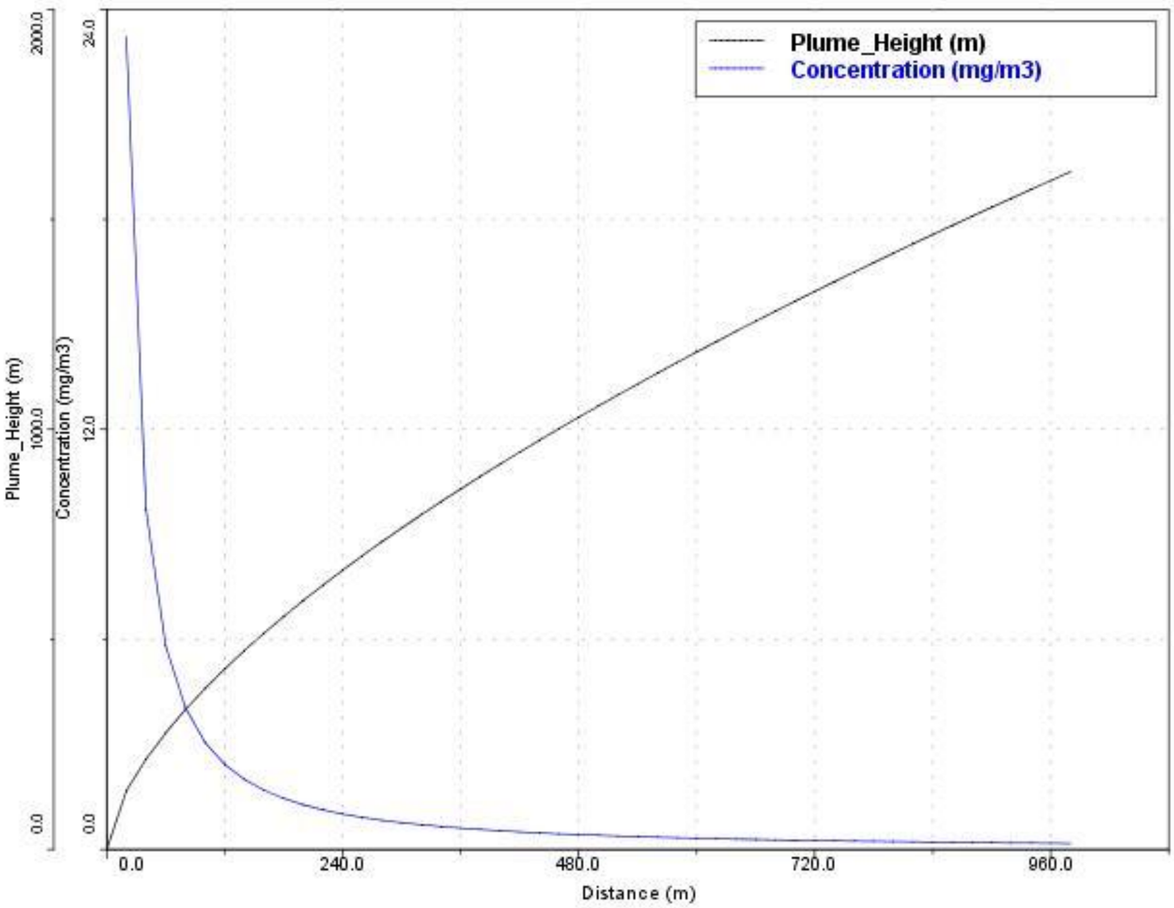
Appendix Table B-9: Input Data for Plume Gaussian Dispersion

Input	Selected Values	Justification
Max burning rate (kg/m^2.s)	0.0453	Taken from full warehouse fire above
Warehouse Area	61,754	Warehouse Area
Heat of combustion (kJ/kg)	45,000	Heat of combustion for combustible liquid (diesel) Ref. [27]
Fraction energy radiated	0.5	Conservative assumption based on high radiant heat blocking which occurs from dense smoke
Pollutant Rate (kg/s)	78,328	Burning rate multiplied by area multiplied 2/3 (amount of space allocated for racking) by 7 (number of racks) multiplied by 6 (number of surfaces on a pallet that can burn)
Wind speed (m/s)	1.5	Industry standard
Stability	F	Industry standard

Provided in **Appendix Figure B-3** is an overlayed plot of plume smoke concentrations and plume height with distance. The analysis is based on the F stability; however, the Gaussian dispersion is unable to model temperature inversions. The response of the smoke plume to an inversion will depend on the height that the plume interacts with the inversion. At low altitudes, the smoke plume will have substantial heat and will 'punch through' the inversion and continue a Gaussian dispersion as expected. However, with increasing height, the plume will cool which may equalise at a temperature less than the inverted air mass. Subsequently, the plume will level out at the point of the inversion.

The worst-case concentration occurs in the initial phases of the fire and rapidly decrease with distance from the fire. It has been assumed that an inversion occurs at low level and the plume has insufficient heat to 'punch through' the inversion and remains trapped relatively close to the ground. A maximum value of 15 mg/m^3 has been selected per **Appendix Figure B-3** that may impact the surrounding area with regards to potential toxic bi-products of combustion.

Toxic products are a minor quantity of materials stored within the warehouse. Therefore, the mass of other products burning generating toxic bi-products of combustion far exceeds the quantity of toxic products that could be release in the smoke plume considering the majority of the toxic products will be combusted. Therefore, it is considered conservative to apply the toxic bi-products of combustion concentration to any toxic products stored in the warehouse.



Appendix Figure B-3: Plume Concentration and Plume Height vs Distance

Provided in **Appendix Table B-10** is a summary of several toxic products of combustion which may be present in the smoke plume and their acceptable concentration of exposure for the Acute Exposure Guideline Levels (AEGL). These levels provide guidance on exposure concentrations for general populations, including susceptible populations over a range of exposure times to assist in the assessment of releases which may result in a toxic exposure.

Provide below is a summary of the AEGL tiers of exposure:

- **AEGL-3** is the airborne concentration, expressed as parts per million (ppm) or milligrams per cubic meter (mg/m^3), of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.
- **AEGL-2** is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- **AEGL-1** is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

Selection for fatality or serious injury is based on an AEGL-3 values with injury values selected as those based on AEGL-2. It is noted the report AEGL values are based on 30-minute exposure.

Appendix Table B-10: Concentration of Toxic Products of Combustion in Smoke Plume

Pollutant	Fatality or Serious Injury (ppm)	Injury (ppm)	Concentration (ppm)
Carbon monoxide	600	150	20.9
Nitric Dioxide	25	15	19.6
Hydrogen cyanide	21	10	21.7
Hydrogen chloride	210	43	16.1
Sulphur dioxide	30	0.75	9.2

B10. LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire

A hose rupture could occur and ignite which would result in a jet fire. To estimate the dimensions of a jet fire, the flow rate of the liquid from the hose must be estimated. The following data was input into **Equation B-8** to estimate the flow rate through the ruptured hose:

- C_d = Discharge coefficient (0.6 for irregular holes)
- A = 50 mm hose = $\frac{\pi D^2}{4} = \frac{\pi \times 0.050^2}{4} = 0.002\, m^2$
- ρ = 508 kg/m^3
- ΔP = 8.6 bar = 860000 Pa

Substituting the information into **Equation B-8** gives a flow rate of 34.8 kg/s.

$$m = 0.6 \times 0.004 \times (2 \times 508 \times 860000)^{0.5} = 34.8\ \frac{kg}{s}$$

Now, a liquid LPG release would be too fuel dense to ignite as it would be above the LEL so the only portion that could ignite would be the liquid that vapourises upon release. Assuming a flash fraction of 50%, the vapour flow rate from the release would be 0.5 x 34.8 = 17.4 kg/s.

Substituting the mass flow rate of vapour into **Equation B-9** gives a jet fire length of 38 m.

$$L = 9.1 \times 17.4^{0.5} = 38\, m$$

B11. LPG Unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire and Impact on LPG Delivery Tanker and BLEVE

In the event of a jet fire and impingement on the delivery tanker there is potential for the LPG in the tanker to boil escalating to a BLEVE if intervention measures fail. It is assumed that impingement will occur at the 30% fill level of the tanker and that the tanker holds a maximum 7,500 L. A BLEVE will only occur once the liquid level falls below the impingement level; hence, the maximum volume of LPG that could be involved in the BLEVE is 2,250 L. As noted, the density of LPG is 508 kg/m3; therefore, the mass of LPG involved in the BLEVE is 1,143 kg.

Inputting the mass into **Equation B-11** and **Equation B-12** yields an impact diameter of 63.9 m and a resonance time of 5 seconds.

$$D = 6.48 \times 1{,}143^{0.325} = 63.9\, m$$

$$t = 0.852 \times 1{,}143^{0.25} = 5\, s$$

B12. LPG unloading Incident, Hose Rupture, LPG Release, Ignition and Jet Fire and Impact on LPG Tank and BLEVE

In the event of a jet fire and impingement on the above ground tank there is potential for the LPG in the tanker to boil escalating to a BLEVE if intervention measures fail. It is assumed that impingement will occur at the 30% fill level of the tank. The tank holds 7,500 L; hence, at the 30% fill level 2,250 L of LPG is involved in the BLEVE. As noted, the density of LPG is 508 kg/m3; therefore, the mass of LPG involved in the BLEVE is 1,143 kg.

Inputting the mass into **Equation B-11** and **Equation B-12** yields an impact diameter of 63.9 m and a resonance time of 5 seconds.

$D = 6.48 \times 1{,}143^{0.325} = 63.9\ m$

$$t = 0.852 \times 1{,}143^{0.25} = 5\ s$$

Appendix C

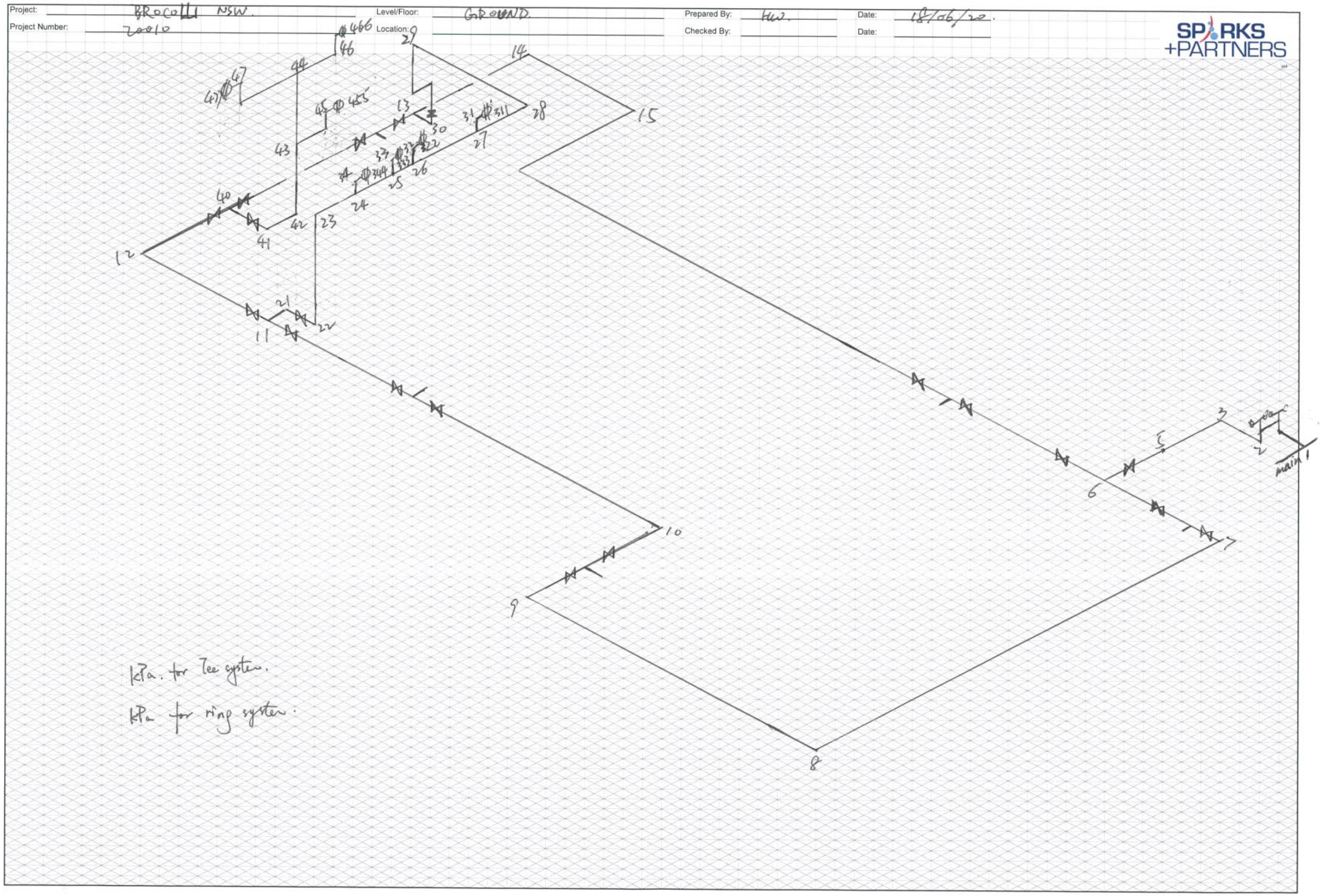
Hydraulic Analysis

C1. Hydraulic Analysis of Most Hydraulically Disadvantaged Hydrant

A review of the Worst Credible Case Fire Scenario (WCCFS) determined that the most demanding fire water scenario for the hydrant system would be a warehouse fire requiring application from three (3) hydrant hoses. Based on the WCCFS scenario the highest fire water demand would be where the three hydrant hoses are operating discharging 0.6 m^3/min each totalling 1.8 m^3/min.

A hydraulic analysis of the most disadvantaged hydrants has been performed by Sparkes and Partners Consulting Engineers. The results have been presented in the following analysis sheets which demonstrates that the most disadvantaged hydrants will operate at a minimum pressure of 250 kPa under normal operating conditions and will operate at a minimum of 700 kPa when boosted.

C2. Hydrant Drawing Showing Hydrants



C3. Normal Operation with Three Hydrant Hoses in Operation

```
Sparks and Partners Consulting Engineers                                DATE 23 JUN 2020
L1, 91 George St PARRAMATTA NSW 2150                                    TIME       16:06
```

THE ACADS-BSG PROGRAM

HYENA

VERSION 6.11.1

ACADS BSG advises that the program HYENA is intended to be used only by persons who are proficient in its use and application and that these results should be verified independently. The results must not be used without acceptance of the ACADS-BSG's License Agreement for this program.

DESIGN PROGRAM FOR SPRINKLER, HOSE REEL AND HYDRANT SYSTEMS
Copyright (C) 2000 ACADS-BSG Pty Ltd
Calculation build number 6.11.1A

DESIGN DATA AND SUMMARY RESULTS
Page 1 of 1 - Job No. 20010

```
------------------------------------------------------------------------------------------------
 Designer :  HW                                                          DATE :23 JUN 2020
 Client   :                                                              TIME :      16:06
 Project  :  BROCCOLI NSW
------------------------------------------------------------------------------------------------

 Maximum unbalanced head loss is  =  0.00000 kPa
 Maximum node unbalanced flow is  =  0.00012 l/m and occurs at node 11
 Maximum loop unbalanced flow is  =  0.00158 l/m and occurs in Pipe Loop 1

 Fittings Specified as NFPA
 Calculate Input Flow and Pressure to achieve Minimum Discharge Flows

 Hazen-Williams formula used

 Number of Hydrants Operating    :   3
 Total water flow for Hydrants   :  1800 l/m

 Required Flow & Pressure,            Input Node 1    : 1800 l/m at 531 kPa

     Specified available pressure at input node  1    : 0.100 kPa
     Available pressure minus required pressure is    : -530 kPa

 Pressure at zero flow 160.15 kPa - Smallest elevation difference between discharges and input points

 Calculated Total Pipe Volume is : 37293 Litres

 Authourising Company            :
 Certification Number            :

 Input data file name : W:/2 - PROJECTS/2020/20010 - BROCCOLI NSW/4-CALCULATION
 .. S\C-FIRE\HYDRANT-ZONE3-TREE.DAT
 Results file name    : W:/2 - PROJECTS/2020/20010 - BROCCOLI NSW/4-CALCULATION
 .. S\C-FIRE\HYDRANT-ZONE3-TREE.OUT
```

PIPE CHARACTERISTICS

Page 1 of 2 - Job No. 20010

Designer : HW
Client :
Project : BROCCOLI NSW

DATE :23 JUN 2020
TIME : 16:06

Pipe No.	Pipe node Numbers		Flow (l/m)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
2	1	2	1800.4	150	155.09	ASAM	20.000	63.891	0.196	12.53	0.00	12.53	120	1.59	1.26
						3SE	12.802								
						2GV	1.829								
						3CV	29.261								
4	2	3	1800.4	150	155.09	ASAM	105.00	117.80	0.196	23.11	0.00	23.11	120	1.59	1.26
						3SE	12.802								
6	3	5	1800.4	150	155.09	ASAM	20.000	29.449	0.196	5.78	0.00	5.78	120	1.59	1.26
						2SE	8.534								
						1GV	0.914								
8	5	6	1800.4	150	155.09	ASAM	105.00	114.14	0.196	22.39	0.00	22.39	120	1.59	1.26
						1TT	9.144								
10	6	7	818.2	150	155.09	ASAM	35.000	41.096	0.046	1.87	0.00	1.87	120	0.72	0.26
						1SE	4.267								
						2GV	1.829								
12	7	8	818.2	150	155.09	ASAM	200.00	204.27	0.046	9.30	0.00	9.30	120	0.72	0.26
						1SE	4.267								
14	8	9	818.2	150	155.09	ASAM	160.00	164.27	0.046	7.48	0.00	7.48	120	0.72	0.26
						1SE	4.267								
16	9	10	818.2	150	155.09	ASAM	16.000	22.096	0.046	1.01	0.00	1.01	120	0.72	0.26
						1SE	4.267								
						2GV	1.829								
18	10	11	818.2	150	155.09	ASAM	244.00	255.89	0.046	11.65	0.00	11.65	120	0.72	0.26
						1TT	9.144								
						3GV	2.743								
20	11	12	29.9	150	155.09	ASAM	26.000	31.182	0.00010	0.00	0.00	0.00	120	0.03	0.00
						1SE	4.267								
						1GV	0.914								
21	12	40	29.9	150	155.09	ASAM	65.000	74.144	0.00010	0.01	0.00	0.01	120	0.03	0.00
						1TT	9.144								
22	40	13	29.9	150	155.09	ASAM	100.00	112.80	0.00010	0.01	0.00	0.01	120	0.03	0.00
						1TT	9.144								
						4GV	3.658								
24	14	13	982.2	150	155.09	ASAM	44.000	49.182	0.064	3.14	0.00	3.14	120	0.87	0.37
						1SE	4.267								
						1GV	0.914								
26	15	14	982.2	150	155.09	ASAM	55.000	59.267	0.064	3.78	0.00	3.78	120	0.87	0.37
						1SE	4.267								
28	6	15	982.2	150	155.09	ASAM	366.00	382.15	0.064	24.40	0.00	24.40	120	0.87	0.37
						1SE	4.267								
						1TT	9.144								
						3GV	2.743								
30	11	21	788.3	150	155.09	ASAM	65.000	69.267	0.042	2.94	0.00	2.94	120	0.70	0.24
						1SE	4.267								
32	21	22	788.3	150	155.09	ASAM	27.000	32.182	0.042	1.37	0.00	1.37	120	0.70	0.24
						1SE	4.267								

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:06

						1GV	0.914								
34	22	23	788.3	150	155.09	ASAM	15.200	21.296	0.042	0.91	145.95	146.86	120	0.70	0.24
						1SE	4.267								
						2GV	1.829								
36	23	24	788.3	150	155.09	ASAM	9.000	18.144	0.042	0.77	0.00	0.77	120	0.70	0.24
						1TT	9.144								
38	24	25	788.3	150	155.09	ASAM	40.000	49.144	0.042	2.09	0.00	2.09	120	0.70	0.24
						1TT	9.144								
40	25	26	188.3	150	155.09	ASAM	10.000	20.058	0.0030	0.06	0.00	0.06	120	0.17	0.01
						1TT	9.144								
						1GV	0.914								
42	27	26	412.1	150	155.09	ASAM	40.000	49.144	0.013	0.63	0.00	0.63	120	0.36	0.07
						1TT	9.144								
44	28	27	1012.1	150	155.09	ASAM	10.000	14.267	0.068	0.96	0.00	0.96	120	0.89	0.40
						1SE	4.267								
46	29	28	1012.1	150	155.09	ASAM	15.200	21.296	0.068	1.44	145.95	147.39	120	0.89	0.40
						1SE	4.267								

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:06

PIPE CHARACTERISTICS

Page 2 of 2 - Job No. 20010

Pipe No.	Pipe node Numbers		Flow (l/m)	Pipe diam. Nom (mm)	Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
						2GV	1.829								
48	30	29	1012.1	150	155.09	ASAM	10.000	15.182	0.068	1.02	0.00	1.02	120	0.89	0.40
						1SE	4.267								
						1GV	0.914								
50	13	30	1012.1	150	155.09	ASAM	51.000	60.144	0.068	4.06	0.00	4.06	120	0.89	0.40
						1TT	9.144								
52	24	34	0.0	100	105.11	ASAM	1.400	21.212	0.00000	0.00	-145.95	-145.95	120	0.00	0.00
						1SE	3.048								
						1NV	16.764								
56	26	32	600.4	100	105.11	ASAM	1.400	21.212	0.171	3.62	-145.95	-142.33	120	1.15	0.66
						1SE	3.048								
						1NV	16.764								
58	27	31	600.0	100	105.11	ASAM	1.400	21.212	0.171	3.62	-145.95	-142.33	120	1.15	0.66
						1SE	3.048								
						1NV	16.764								
60	25	33	600.0	100	105.11	ASAM	1.400	21.212	0.171	3.62	-145.95	-142.33	120	1.15	0.66
						1SE	3.048								
						1NV	16.764								
62	40	41	0.0	150	155.09	ASAM	10.000	15.182	0.00000	0.00	0.00	0.00	120	0.00	0.00
						1SE	4.267								
						1GV	0.914								
64	41	42	0.0	150	155.09	ASAM	50.000	54.267	0.00000	0.00	0.00	0.00	120	0.00	0.00
						1SE	4.267								
66	42	43	0.0	150	155.09	ASAM	7.000	16.144	0.00000	0.00	63.18	63.18	120	0.00	0.00
						1TT	9.144								
68	43	44	0.0	150	155.09	ASAM	5.000	15.058	0.00000	0.00	47.12	47.12	120	0.00	0.00
						1TT	9.144								
						1GV	0.914								
70	43	45	0.0	100	105.11	ASAM	50.000	56.096	0.00000	0.00	13.71	13.71	120	0.00	0.00
						2SE	6.096								
72	44	46	0.0	100	105.11	ASAM	30.000	36.096	0.00000	0.00	13.71	13.71	120	0.00	0.00
						2SE	6.096								
74	44	47	0.0	100	105.11	ASAM	20.000	26.096	0.00000	0.00	13.71	13.71	120	0.00	0.00
						2SE	6.096								
76	45	455	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00	120	0.00	0.00
						1NV	9.754								
78	46	466	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00	120	0.00	0.00
						1NV	9.754								
80	47	477	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00	120	0.00	0.00
						1NV	9.754								
82	34	344	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	160.15	160.15	120	0.00	0.00
						1NV	9.754								
84	33	333	600.0	65	68.81	ASAM	0.100	9.854	1.342	13.22	160.15	173.38	120	2.69	3.61
						1NV	9.754								
86	32	322	600.4	65	68.81	ASAM	0.100	9.854	1.344	13.24	160.15	173.39	120	2.69	3.62
						1NV	9.754								
88	31	311	600.0	65	68.81	ASAM	0.100	9.854	1.342	13.22	160.15	173.38	120	2.69	3.61
						1NV	9.754								

```
Sparks and Partners Consulting Engineers                                    DATE 23 JUN 2020
L1, 91 George St PARRAMATTA NSW 2150                                        TIME       16:06
```

```
LEGEND - Fittings and Pipe Materials used in this run

Standard Fittings
SE      = 90 Degree Elbow              TT      = Tee Branch                    GV      = Gate Valve
CV      = Check Valve                  NV      = Angle Valve

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 -1989 & BS 1387
-----------------------------------------------------------------------------------------------------------------------
*** WARNING : THE FOLLOWING PIPES (EXCLUDING SPRINKLER RISERS/DROPPERS) HAVE FLOWS SMALLER THAN 0.1 l/m
               52     62     64     66     68     70     72     74     76     78     80     82
```

Maximum unbalanced head loss is = 0.00000 kPa

```
 Maximum loop unbalanced flow is  =  0.00158 l/m and occurs in Pipe Loop 1
 Maximum node unbalanced flow is  =  0.00012 l/m
```

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:06

NODE CHARACTERISTICS

Page 1 of 1 - Job No. 20010

Designer : HW
Client :
Project : BROCCOLI NSW

DATE :23 JUN 2020
TIME : 16:06

Input Node 1 : 1800.4 l/m 530.60 kPa -1.000 m elevation

Node No	Node Type		Flow l/m calc'ed	Flow l/m min	Pressure kPa total	Pressure kPa min	Pressure kPa max	Elev. m	K-Factor l/m kPa	K-Factor Exp
2					518.07			-1.000		
3					494.96			-1.000		
5					489.19			-1.000		
6					466.80			-1.000		
7					464.93			-1.000		
8					455.63			-1.000		
9					448.15			-1.000		
10					447.14			-1.000		
11					435.49			-1.000		
12					435.49			-1.000		
13					435.47			-1.000		
14					438.61			-1.000		
15					442.39			-1.000		
21					432.55			-1.000		
22					431.18			-1.000		
23					284.32			13.900		
24					283.55			13.900		
25					281.46			13.900		
26					281.40			13.900		
27					282.03			13.900		
28					283.00			13.900		
29					430.38			-1.000		
30					431.41			-1.000		
31					424.37			-1.000		
32					423.73			-1.000		
33					423.80			-1.000		
34					429.50			-1.000		
40					435.48			-1.000		
41					435.48			-1.000		
42					435.48			-1.000		
43					372.30			5.450		
44					325.18			10.260		
45					358.59			6.850		
46					311.47			11.660		
47					311.47			11.660		
311	Hydrant		600.0	600.00	250.99	250.00	1200.00	15.350		
322	**Hydrant**		**600.4**	**600.00**	**250.34**	**250.00**	**1200.00**	**15.350**		
333	Hydrant		600.0	600.00	250.42	250.00	1200.00	15.350		
344	Hydrant	Nop			269.35			15.350		
455	Hydrant	Nop			358.59			6.850		
466	Hydrant	Nop			311.47			11.660		
477	Hydrant	Nop			311.47			11.660		

Sparks and Partners Consulting Engineers DATE 23 JUN 2020
L1, 91 George St PARRAMATTA NSW 2150 TIME 16:06

ADDITIONAL PRESSURE INFORMATION

Page 1 of 2 - Job No. 20010

Designer : HW **DATE :23 JUN 2020**
Client : **TIME : 16:06**
Project : BROCCOLI NSW

Pipe No.	Pipe node Numbers		Flow (l/m)	Pipe diam. Nom (mm)	Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	Node Pressure First (KPa)	Second (KPa)
2	1	2	1800.4	150	155.09	ASAM	20.000	63.891	0.196	12.53	0.00	12.53	530.60	518.07
						3SE	12.802							
						2GV	1.829							
						3CV	29.261							
4	2	3	1800.4	150	155.09	ASAM	105.00	117.80	0.196	23.11	0.00	23.11	518.07	494.96
						3SE	12.802							
6	3	5	1800.4	150	155.09	ASAM	20.000	29.449	0.196	5.78	0.00	5.78	494.96	489.19
						2SE	8.534							
						1GV	0.914							
8	5	6	1800.4	150	155.09	ASAM	105.00	114.14	0.196	22.39	0.00	22.39	489.19	466.80
						1TT	9.144							
10	6	7	818.2	150	155.09	ASAM	35.000	41.096	0.046	1.87	0.00	1.87	466.80	464.93
						1SE	4.267							
						2GV	1.829							
12	7	8	818.2	150	155.09	ASAM	200.00	204.27	0.046	9.30	0.00	9.30	464.93	455.63
						1SE	4.267							
14	8	9	818.2	150	155.09	ASAM	160.00	164.27	0.046	7.48	0.00	7.48	455.63	448.15
						1SE	4.267							
16	9	10	818.2	150	155.09	ASAM	16.000	22.096	0.046	1.01	0.00	1.01	448.15	447.14
						1SE	4.267							
						2GV	1.829							
18	10	11	818.2	150	155.09	ASAM	244.00	255.89	0.046	11.65	0.00	11.65	447.14	435.49
						1TT	9.144							
						3GV	2.743							
20	11	12	29.9	150	155.09	ASAM	26.000	31.182	0.00010	0.00	0.00	0.00	435.49	435.49
						1SE	4.267							
						1GV	0.914							
21	12	40	29.9	150	155.09	ASAM	65.000	74.144	0.00010	0.01	0.00	0.01	435.49	435.48
						1TT	9.144							
22	40	13	29.9	150	155.09	ASAM	100.00	112.80	0.00010	0.01	0.00	0.01	435.48	435.47
						1TT	9.144							
						4GV	3.658							
24	14	13	982.2	150	155.09	ASAM	44.000	49.182	0.064	3.14	0.00	3.14	435.47	438.61
						1SE	4.267							
						1GV	0.914							
26	15	14	982.2	150	155.09	ASAM	55.000	59.267	0.064	3.78	0.00	3.78	438.61	442.39
						1SE	4.267							
28	6	15	982.2	150	155.09	ASAM	366.00	382.15	0.064	24.40	0.00	24.40	442.39	466.80
						1SE	4.267							
						1TT	9.144							
						3GV	2.743							
30	11	21	788.3	150	155.09	ASAM	65.000	69.267	0.042	2.94	0.00	2.94	435.49	432.55
						1SE	4.267							
32	21	22	788.3	150	155.09	ASAM	27.000	32.182	0.042	1.37	0.00	1.37	432.55	431.18
						1SE	4.267							

						1GV	0.914							
34	22	23	788.3	150	155.09	ASAM	15.200	21.296	0.042	0.91	145.95	146.86	431.18	284.32
						1SE	4.267							
						2GV	1.829							
36	23	24	788.3	150	155.09	ASAM	9.000	18.144	0.042	0.77	0.00	0.77	284.32	283.55
						1TT	9.144							
38	24	25	788.3	150	155.09	ASAM	40.000	49.144	0.042	2.09	0.00	2.09	283.55	281.46
						1TT	9.144							
40	25	26	188.3	150	155.09	ASAM	10.000	20.058	0.0030	0.06	0.00	0.06	281.46	281.40
						1TT	9.144							
						1GV	0.914							
42	27	26	412.1	150	155.09	ASAM	40.000	49.144	0.013	0.63	0.00	0.63	281.40	282.03
						1TT	9.144							
44	28	27	1012.1	150	155.09	ASAM	10.000	14.267	0.068	0.96	0.00	0.96	282.03	283.00
						1SE	4.267							
46	29	28	1012.1	150	155.09	ASAM	15.200	21.296	0.068	1.44	145.95	147.39	283.00	430.38
						1SE	4.267							

ADDITIONAL PRESSURE INFORMATION

Page 2 of 2 - Job No. 20010

Pipe No.	Pipe node Numbers		Flow (l/m)	Pipe diam. Nom (mm)	Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	Node Pressure First (KPa)	Second (KPa)
						2GV	1.829							
48	30	29	1012.1	150	155.09	ASAM	10.000	15.182	0.068	1.02	0.00	1.02	430.38	431.41
						1SE	4.267							
						1GV	0.914							
50	13	30	1012.1	150	155.09	ASAM	51.000	60.144	0.068	4.06	0.00	4.06	431.41	435.47
						1TT	9.144							
52	24	34	0.0	100	105.11	ASAM	1.400	21.212	0.00000	0.00	-145.95	-145.95	283.55	429.50
						1SE	3.048							
						1NV	16.764							
56	26	32	600.4	100	105.11	ASAM	1.400	21.212	0.171	3.62	-145.95	-142.33	281.40	423.73
						1SE	3.048							
						1NV	16.764							
58	27	31	600.0	100	105.11	ASAM	1.400	21.212	0.171	3.62	-145.95	-142.33	282.03	424.37
						1SE	3.048							
						1NV	16.764							
60	25	33	600.0	100	105.11	ASAM	1.400	21.212	0.171	3.62	-145.95	-142.33	281.46	423.80
						1SE	3.048							
						1NV	16.764							
62	40	41	0.0	150	155.09	ASAM	10.000	15.182	0.00000	0.00	0.00	0.00	435.48	435.48
						1SE	4.267							
						1GV	0.914							
64	41	42	0.0	150	155.09	ASAM	50.000	54.267	0.00000	0.00	0.00	0.00	435.48	435.48
						1SE	4.267							
66	42	43	0.0	150	155.09	ASAM	7.000	16.144	0.00000	0.00	63.18	63.18	435.48	372.30
						1TT	9.144							
68	43	44	0.0	150	155.09	ASAM	5.000	15.058	0.00000	0.00	47.12	47.12	372.30	325.18
						1TT	9.144							
						1GV	0.914							
70	43	45	0.0	100	105.11	ASAM	50.000	56.096	0.00000	0.00	13.71	13.71	372.30	358.59
						2SE	6.096							
72	44	46	0.0	100	105.11	ASAM	30.000	36.096	0.00000	0.00	13.71	13.71	325.18	311.47
						2SE	6.096							
74	44	47	0.0	100	105.11	ASAM	20.000	26.096	0.00000	0.00	13.71	13.71	325.18	311.47
						2SE	6.096							
76	45	455	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00	358.59	358.59
						1NV	9.754							
78	46	466	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00	311.47	311.47
						1NV	9.754							
80	47	477	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00	311.47	311.47
						1NV	9.754							
82	34	344	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	160.15	160.15	429.50	269.35
						1NV	9.754							
84	33	333	600.0	65	68.81	ASAM	0.100	9.854	1.342	13.22	160.15	173.38	423.80	250.42
						1NV	9.754							
86	32	322	600.4	65	68.81	ASAM	0.100	9.854	1.344	13.24	160.15	173.39	423.73	250.34
						1NV	9.754							
88	31	311	600.0	65	68.81	ASAM	0.100	9.854	1.342	13.22	160.15	173.38	424.37	250.99
						1NV	9.754							

Sparks and Partners Consulting Engineers DATE 23 JUN 2020
L1, 91 George St PARRAMATTA NSW 2150 TIME 16:06

LEGEND - Fittings and Pipe Materials used in this run

Standard Fittings

SE	= 90 Degree Elbow	TT	= Tee Branch	GV	= Gate Valve
CV	= Check Valve	NV	= Angle Valve		

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 -1989 & BS 1387

Input Data

```
LABL1=Authourising Company
TEXT1=
LABL2=Certification Number
TEXT2=
OCC=Hydrant
DENS=
AREA=
ORIF=
COVER=
NOPLOT
PLEN=M
PDIAM=MM
PRESSURE=KPA
FLOW=L/MIN
ELEV=MM
FITTING=NFPA
REPORT
EQ
FDESPT
MAXV=15
\ Fitting Type =Comm
\
\ Pipes
\ Pipes Mtr and Coef: Defaults= MCASAM HW120
P  2 1 2 20 150      ASAM120 3SE  2GV 3CV
P  4 2 3 105 150      ASAM120 3SE
P  6 3 5 20 150      ASAM120 2SE  GV
P  8 5 6 105 150      ASAM120  1TT
P  10 6 7 35 150      ASAM120 1SE  2GV
P  12 7 8 200 150      ASAM120 1SE
P  14 8 9 160 150      ASAM120 1SE
P  16 9 10 16 150      ASAM120 1SE  2GV
P  18 10 11 244 150      ASAM120  1TT 3GV
P  20 11 12 26 150      ASAM120  SE GV
P  21 12 40 65 150      ASAM120  TT
P  22 40 13 100 150      ASAM120  1TT 4GV
P  24 13 14 44 150      ASAM120 1SE  GV
P  26 14 15 55 150      ASAM120 1SE
P  28 15 6 366 150      ASAM120 1SE 1TT 3GV
P  30 11 21 65 150      ASAM120 1SE
P  32 21 22 27 150      ASAM120 1SE  GV
P  34 22 23 15.2 150      ASAM120 1SE  2GV
P  36 23 24 9 150      ASAM120  1TT
P  38 24 25 40 150      ASAM120  1TT
P  40 25 26 10 150      ASAM120  1TT GV
P  42 26 27 40 150      ASAM120  1TT
P  44 27 28 10 150      ASAM120 1SE
P  46 28 29 15.2 150      ASAM120 1SE  2GV
P  48 29 30 10 150      ASAM120 1SE  GV
P  50 30 13 51 150      ASAM120  1TT
P  52 24 34 1.4 100      ASAM120 1SE  NV
P  56 26 32 1.4 100      ASAM120 1SE  NV
P  58 27 31 1.4 100      ASAM120 1SE  NV
P  60 25 33 1.4 100      ASAM120 1SE  NV
```

```
P  62 40 41 10 150      ASAM120 1SE  GV
P  64 41 42 50 150      ASAM120 1SE
P  66 42 43 7 150      ASAM120  1TT
P  68 43 44 5 150      ASAM120  1TT GV
P  70 43 45 50 100      ASAM120 2SE
P  72 44 46 30 100      ASAM120 2SE
P  74 44 47 20 100      ASAM120 2SE
P  76 45 455 .1 65      ASAM120  NV
P  78 46 466 .1 65      ASAM120  NV
P  80 47 477 .1 65      ASAM120  NV
P  82 34 344 .1 65      ASAM120  NV
P  84 33 333 .1 65      ASAM120  NV
P  86 32 322 .1 65      ASAM120  NV
P  88 31 311 .1 65      ASAM120  NV
\Discharges Default=  PE0.5
\Hydrants Default=  HE15350 HD600 HI250 HA1200
\
\ Hydrants
H  455       6850    600    250    1200 NOP
H  466      11660    600    250    1200 NOP
H  477      11660    600    250    1200 NOP
H  344      15350    600    250    1200 NOP
H  333      15350    600    250    1200
H  322      15350    600    250    1200
H  311      15350    600    250    1200
\
\ Reference Points
\Reference Point Default= ED-1000
R    2      -1000
R    3      -1000
R    5      -1000
R    6      -1000
R    7      -1000
R    8      -1000
R    9      -1000
R   10      -1000
R   11      -1000
R   12      -1000
R   13      -1000
R   14      -1000
R   15      -1000
R   21      -1000
R   22      -1000
R   23      13900
R   24      13900
R   25      13900
R   26      13900
R   27      13900
R   28      13900
R   29      -1000
R   30      -1000
R   31      -1000
R   32      -1000
R   33      -1000
R   34      -1000
R   40      -1000
R   41      -1000
```

```
R   42      -1000
R   43       5450
R   44      10260
R   45       6850
R   46      11660
R   47      11660
\
\ InputPoints
IF 1 -1000 0.1
```

LOOP INFORMATION

LOOP	PIPES													
1	86	56	42	44	46	48	50	24	26	28	8	6	4	2
2	42	44	46	48	50	22	21	20	30	32	34	36	38	40
3	22	24	26	28	10	12	14	16	18	20	21			

BANDWIDTH = 3

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:06

FITTING EQUIVALENT PIPE LENGTHS IN METERS   Diameter in mm

NFPA Steel Fittings in Schedule 40 to ASTM A-153, A-795 pipe with C=120

	15	20	25	32	40	50	65	80	90	100	125	150	200	225	250	300	350	375
SE	.30	.61	.61	.91	1.22	1.52	1.83	2.13	2.44	3.05	3.66	4.27	5.49	6.10	6.71	8.23	9.14	9.45
HE	.30	.30	.30	.30	.61	.61	.91	.91	.91	1.22	1.52	2.13	2.74	3.05	3.35	3.96	4.57	4.88
LE	.15	.30	.61	.61	.61	.91	1.22	1.52	1.52	1.83	2.44	2.74	3.96	4.42	4.88	5.49		
TT	.91	1.22	1.52	1.83	2.44	3.05	3.66	4.57	5.18	6.10	7.62	9.14	10.7	13.0	15.2	18.3	19.8	20.6
TN	(NO LOSS)																	
TR	(NO LOSS)																	

NFPA Steel Valves etc. in Schedule 40 to ASTM A-153, A-795 pipe with C=120

	15	20	25	32	40	50	65	80	90	100	125	150	200	225	250	300	350	375
GV	.30	.30	.30	.30	.30	.30	.30	.30	.30	.61	.61	.91	1.22	1.37	1.52	1.83	1.83	1.98
CV			1.52	2.13	2.74	3.35	4.27	4.88	5.79	6.71	8.23	9.75	13.7	15.2	16.8	19.8	21.3	22.1
LV	4.88	6.10	7.62	10.4	12.5	16.2	18.6	24.4	27.4	30.8	36.6	48.8	64.0	76.2	88.4	104		
NV	2.44	3.35	3.96	5.49	6.40	8.23	9.75	12.2	14.3	16.8	18.3	25.0	32.0	38.1	44.2	51.8		
BV						1.83	2.13	3.05	3.35	3.66	2.74	3.05	3.66	4.72	5.79	6.40		
AV			.02	.06	.12	.37	.91	2.44	3.05	3.66	4.57	6.10	9.75					
MV										12.8		21.4	32.0		42.7			
DV			.03	.06	.15	.46	1.07	3.05	3.66	5.49	6.10	9.14						
SR			.03	.12	.23	.76	1.83	5.18	6.10	9.14	10.7	12.2	21.3					

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:06

QUANTITIES FOR COSTING

PIPES and FITTINGS

Material	Diameter (mm)	Ftgs	Length No.off	Units	Rate	Totals
ASAM						
	65		0.7	m		
		NV	7	off		
	100		105.6	m		
		SE	10	off		
		NV	4	off		
	150		1925.4	m		
		SE	24	off		
		TT	12	off		
		GV	28	off		
		CV	3	off		

HYDRANTS

Flow Rate	No.Off	Rate	Totals
600.00	3		

Note 4: Fittings have not been included at the sprinkler connection points
unless extra fittings have been added to the Ranges and Trees.

C4. Boosted Hydrant Scenario

```
Sparks and Partners Consulting Engineers                              DATE 23 JUN 2020
L1, 91 George St PARRAMATTA NSW 2150                                  TIME       16:05
```

THE ACADS-BSG PROGRAM

HYENA

VERSION 6.11.1

ACADS BSG advises that the program HYENA is intended to be used only by persons who are proficient in its use and application and that these results should be verified independently. The results must not be used without acceptance of the ACADS-BSG's License Agreement for this program.

DESIGN PROGRAM FOR SPRINKLER, HOSE REEL AND HYDRANT SYSTEMS
Copyright (C) 2000 ACADS-BSG Pty Ltd
Calculation build number 6.11.1A

DESIGN DATA AND SUMMARY RESULTS
Page 1 of 1 - Job No. 20010

```
------------------------------------------------------------------------------------------
-----------
  Designer :  HW                                                                      DATE
:23 JUN 2020
  Client   :                                                                          TIME
:      16:05
  Project  :  BROCCOLI NSW
------------------------------------------------------------------------------------------
-----------

 Maximum unbalanced head loss is  =  0.00000 kPa
 Maximum node unbalanced flow is  =  0.00003 l/m and occurs at node 6
 Maximum loop unbalanced flow is  =  0.00031 l/m and occurs in Pipe Loop 1

 Fittings Specified as NFPA
 Calculate Input Flow and Pressure to achieve Minimum Discharge Flows

 Hazen-Williams formula used

 Number of Hydrants Operating    :   3
 Total water flow for Hydrants   :  900 l/m

 Required Flow & Pressure,             Input Node 1    : 900 l/m at 894 kPa

     Specified available pressure at input node  1    : 0.100 kPa
     Available pressure minus required pressure is    : -894 kPa

 Pressure at zero flow 160.15 kPa - Smallest elevation difference between discharges and input points

 Calculated Total Pipe Volume is : 37293 Litres

 Authourising Company            :
 Certification Number            :

 Input data file name : W:/2 - PROJECTS/2020/20010 - BROCCOLI NSW/4-CALCULATION
 .. S\C-FIRE\HYDRANT-ZONE3-TREE.DAT
 Results file name    : W:/2 - PROJECTS/2020/20010 - BROCCOLI NSW/4-CALCULATION
 .. S\C-FIRE\HYDRANT-ZONE3-TREE.OUT
```

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:05

PIPE CHARACTERISTICS

Page 1 of 2 - Job No. 20010

Designer : HW **DATE :23 JUN 2020**
Client : **TIME : 16:05**
Project : BROCCOLI NSW

Pipe No.	Pipe node Numbers		Flow (l/m)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	H&W Co-eff	Water Vel. (m/s)	Vel. Press (KPa)
2	1	2	900.2	150	155.09	ASAM	20.000	63.891	0.054	3.47	0.00	3.47	120	0.79	0.31
						3SE	12.802								
						2GV	1.829								
						3CV	29.261								
4	2	3	900.2	150	155.09	ASAM	105.00	117.80	0.054	6.40	0.00	6.40	120	0.79	0.31
						3SE	12.802								
6	3	5	900.2	150	155.09	ASAM	20.000	29.449	0.054	1.60	0.00	1.60	120	0.79	0.31
						2SE	8.534								
						1GV	0.914								
8	5	6	900.2	150	155.09	ASAM	105.00	114.14	0.054	6.20	0.00	6.20	120	0.79	0.31
						1TT	9.144								
10	6	7	409.1	150	155.09	ASAM	35.000	41.096	0.013	0.52	0.00	0.52	120	0.36	0.07
						1SE	4.267								
						2GV	1.829								
12	7	8	409.1	150	155.09	ASAM	200.00	204.27	0.013	2.58	0.00	2.58	120	0.36	0.07
						1SE	4.267								
14	8	9	409.1	150	155.09	ASAM	160.00	164.27	0.013	2.07	0.00	2.07	120	0.36	0.07
						1SE	4.267								
16	9	10	409.1	150	155.09	ASAM	16.000	22.096	0.013	0.28	0.00	0.28	120	0.36	0.07
						1SE	4.267								
						2GV	1.829								
18	10	11	409.1	150	155.09	ASAM	244.00	255.89	0.013	3.23	0.00	3.23	120	0.36	0.07
						1TT	9.144								
						3GV	2.743								
20	11	12	15.0	150	155.09	ASAM	26.000	31.182	0.00003	0.00	0.00	0.00	120	0.01	0.00
						1SE	4.267								
						1GV	0.914								
21	12	40	15.0	150	155.09	ASAM	65.000	74.144	0.00003	0.00	0.00	0.00	120	0.01	0.00
						1TT	9.144								
22	40	13	15.0	150	155.09	ASAM	100.00	112.80	0.00003	0.00	0.00	0.00	120	0.01	0.00
						1TT	9.144								
						4GV	3.658								
24	14	13	491.1	150	155.09	ASAM	44.000	49.182	0.018	0.87	0.00	0.87	120	0.43	0.09
						1SE	4.267								
						1GV	0.914								
26	15	14	491.1	150	155.09	ASAM	55.000	59.267	0.018	1.05	0.00	1.05	120	0.43	0.09
						1SE	4.267								
28	6	15	491.1	150	155.09	ASAM	366.00	382.15	0.018	6.76	0.00	6.76	120	0.43	0.09
						1SE	4.267								
						1TT	9.144								
						3GV	2.743								
30	11	21	394.1	150	155.09	ASAM	65.000	69.267	0.012	0.82	0.00	0.82	120	0.35	0.06
						1SE	4.267								
32	21	22	394.1	150	155.09	ASAM	27.000	32.182	0.012	0.38	0.00	0.38	120	0.35	0.06
						1SE	4.267								
						1GV	0.914								
34	22	23	394.1	150	155.09	ASAM	15.200	21.296	0.012	0.25	145.95	146.20	120	0.35	0.06

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:05

						1SE	4.267					
						2GV	1.829					
36	23	24	394.1	150	155.09	ASAM	9.000	18.144	0.012	0.21	0.00	0.21
120	0.35	0.06										
						1TT	9.144					
38	24	25	394.1	150	155.09	ASAM	40.000	49.144	0.012	0.58	0.00	0.58
120	0.35	0.06										
						1TT	9.144					
40	25	26	94.1	150	155.09	ASAM	10.000	20.058	0.00083	0.02	0.00	0.02
120	0.08	0.00										
						1TT	9.144					
						1GV	0.914					
42	27	26	205.9	150	155.09	ASAM	40.000	49.144	0.0035	0.17	0.00	0.17
120	0.18	0.02										
						1TT	9.144					
44	28	27	506.0	150	155.09	ASAM	10.000	14.267	0.019	0.27	0.00	0.27
120	0.45	0.10										
						1SE	4.267					
46	29	28	506.0	150	155.09	ASAM	15.200	21.296	0.019	0.40	145.95	146.35
120	0.45	0.10										
						1SE	4.267					

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:05

PIPE CHARACTERISTICS

Page 2 of 2 - Job No. 20010

H&W Pipe No. / Co-eff	Water Pipe Numbers / Vel. (m/s)	Vel. node / Press (KPa)	Flow (l/m)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)
						2GV	1.829					
48	30	29	506.0	150	155.09	ASAM	10.000	15.182	0.019	0.28	0.00	0.28
120	0.45	0.10										
						1SE	4.267					
						1GV	0.914					
50	13	30	506.0	150	155.09	ASAM	51.000	60.144	0.019	1.12	0.00	1.12
120	0.45	0.10										
						1TT	9.144					
52	24	34	0.0	100	105.11	ASAM	1.400	21.212	0.00000	0.00	-145.95	-145.95
120	0.00	0.00										
						1SE	3.048					
						1NV	16.764					
56	26	32	300.0	100	105.11	ASAM	1.400	21.212	0.047	1.00	-145.95	-144.95
120	0.58	0.17										
						1SE	3.048					
						1NV	16.764					
58	27	31	300.2	100	105.11	ASAM	1.400	21.212	0.047	1.00	-145.95	-144.95
120	0.58	0.17										
						1SE	3.048					
						1NV	16.764					
60	25	33	300.0	100	105.11	ASAM	1.400	21.212	0.047	1.00	-145.95	-144.95
120	0.58	0.17										
						1SE	3.048					
						1NV	16.764					
62	40	41	0.0	150	155.09	ASAM	10.000	15.182	0.00000	0.00	0.00	0.00
120	0.00	0.00										
						1SE	4.267					
						1GV	0.914					
64	41	42	0.0	150	155.09	ASAM	50.000	54.267	0.00000	0.00	0.00	0.00
120	0.00	0.00										
						1SE	4.267					
66	42	43	0.0	150	155.09	ASAM	7.000	16.144	0.00000	0.00	63.18	63.18
120	0.00	0.00										
						1TT	9.144					
68	43	44	0.0	150	155.09	ASAM	5.000	15.058	0.00000	0.00	47.12	47.12
120	0.00	0.00										
						1TT	9.144					
						1GV	0.914					
70	43	45	0.0	100	105.11	ASAM	50.000	56.096	0.00000	0.00	13.71	13.71
120	0.00	0.00										
						2SE	6.096					
72	44	46	0.0	100	105.11	ASAM	30.000	36.096	0.00000	0.00	13.71	13.71
120	0.00	0.00										
						2SE	6.096					
74	44	47	0.0	100	105.11	ASAM	20.000	26.096	0.00000	0.00	13.71	13.71
120	0.00	0.00										
						2SE	6.096					
76	45	455	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00
120	0.00	0.00										
						1NV	9.754					
78	46	466	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00
120	0.00	0.00										
						1NV	9.754					
80	47	477	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00
120	0.00	0.00										
						1NV	9.754					
82	34	344	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	160.15	160.15
120	0.00	0.00										
						1NV	9.754					
84	33	333	300.0	65	68.81	ASAM	0.100	9.854	0.372	3.66	160.15	163.82
120	1.34	0.90										
						1NV	9.754					
86	32	322	300.0	65	68.81	ASAM	0.100	9.854	0.372	3.66	160.15	163.82
120	1.34	0.90										
						1NV	9.754					
88	31	311	300.2	65	68.81	ASAM	0.100	9.854	0.372	3.67	160.15	163.82
120	1.35	0.90										
						1NV	9.754					

LEGEND - Fittings and Pipe Materials used in this run

```
Sparks and Partners Consulting Engineers                                                    DATE 23 JUN 2020
L1, 91 George St PARRAMATTA NSW 2150                                                        TIME       16:05
________________________________________________________________________________________________________

Standard Fittings
SE      = 90 Degree Elbow              TT      = Tee Branch                    GV      = Gate Valve
CV      = Check Valve                  NV      = Angle Valve

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 -1989 & BS 1387
----------------------------------------------------------------------------------------------------------
----------------
*** WARNING : THE FOLLOWING PIPES (EXCLUDING SPRINKLER RISERS/DROPPERS) HAVE FLOWS SMALLER THAN 0.1 l/m
               52    62    64    66    68    70    72    74    76    78    80    82
```

Maximum unbalanced head loss is = 0.00000 kPa

```
Maximum loop unbalanced flow is  =  0.00031 l/m and occurs in Pipe Loop 1
Maximum node unbalanced flow is  =  0.00003 l/m
```

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:05

NODE CHARACTERISTICS

Page 1 of 1 - Job No. 20010

Designer : HW **DATE :23 JUN 2020**
Client : **TIME : 16:05**
Project : BROCCOLI NSW

Input Node 1 : 900.2 l/m 893.99 kPa -1.000 m elevation

Node No	Node Type		--- Flow l/m ---- calc'ed	min	------ Pressure kPa ---- total	min	max	Elev. m	K-Factor l/m kPa	Exp
2					890.52			-1.000		
3					884.12			-1.000		
5					882.52			-1.000		
6					876.32			-1.000		
7					875.80			-1.000		
8					873.22			-1.000		
9					871.15			-1.000		
10					870.87			-1.000		
11					867.64			-1.000		
12					867.64			-1.000		
13					867.64			-1.000		
14					868.51			-1.000		
15					869.56			-1.000		
21					866.83			-1.000		
22					866.45			-1.000		
23					720.25			13.900		
24					720.04			13.900		
25					719.46			13.900		
26					719.44			13.900		
27					719.61			13.900		
28					719.88			13.900		
29					866.23			-1.000		
30					866.51			-1.000		
31					864.56			-1.000		
32					864.39			-1.000		
33					864.41			-1.000		
34					865.99			-1.000		
40					867.64			-1.000		
41					867.64			-1.000		
42					867.64			-1.000		
43					804.46			5.450		
44					757.35			10.260		
45					790.75			6.850		
46					743.63			11.660		
47					743.63			11.660		
311	**Hydrant**		**300.2**	**300.00**	**700.74**	**700.00**	**1200.00**	**15.350**		
322	Hydrant		300.0	300.00	700.57	700.00	1200.00	15.350		
333	Hydrant		300.0	300.00	700.59	700.00	1200.00	15.350		
344	Hydrant	Nop			705.83			15.350		
455	Hydrant	Nop			790.75			6.850		
466	Hydrant	Nop			743.63			11.660		
477	Hydrant	Nop			743.63			11.660		

ADDITIONAL PRESSURE INFORMATION

Page 1 of 2 - Job No. 20010

Designer : HW **DATE :23 JUN 2020**
Client : **TIME : 16:05**
Project : BROCCOLI NSW

Pipe No.	Pipe node Numbers (First)	Pipe node Numbers (Second)	Flow (l/m)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Pipe & Fitting Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)	Node Pressure First (KPa)	Node Pressure Second (KPa)
2	1	2	900.2	150	155.09	ASAM	20.000	63.891	0.054	3.47	0.00	3.47	893.99	890.52
						3SE	12.802							
						2GV	1.829							
						3CV	29.261							
4	2	3	900.2	150	155.09	ASAM	105.00	117.80	0.054	6.40	0.00	6.40	890.52	884.12
						3SE	12.802							
6	3	5	900.2	150	155.09	ASAM	20.000	29.449	0.054	1.60	0.00	1.60	884.12	882.52
						2SE	8.534							
						1GV	0.914							
8	5	6	900.2	150	155.09	ASAM	105.00	114.14	0.054	6.20	0.00	6.20	882.52	876.32
						1TT	9.144							
10	6	7	409.1	150	155.09	ASAM	35.000	41.096	0.013	0.52	0.00	0.52	876.32	875.80
						1SE	4.267							
						2GV	1.829							
12	7	8	409.1	150	155.09	ASAM	200.00	204.27	0.013	2.58	0.00	2.58	875.80	873.22
						1SE	4.267							
14	8	9	409.1	150	155.09	ASAM	160.00	164.27	0.013	2.07	0.00	2.07	873.22	871.15
						1SE	4.267							
16	9	10	409.1	150	155.09	ASAM	16.000	22.096	0.013	0.28	0.00	0.28	871.15	870.87
						1SE	4.267							
						2GV	1.829							
18	10	11	409.1	150	155.09	ASAM	244.00	255.89	0.013	3.23	0.00	3.23	870.87	867.64
						1TT	9.144							
						3GV	2.743							
20	11	12	15.0	150	155.09	ASAM	26.000	31.182	0.00003	0.00	0.00	0.00	867.64	867.64
						1SE	4.267							
						1GV	0.914							
21	12	40	15.0	150	155.09	ASAM	65.000	74.144	0.00003	0.00	0.00	0.00	867.64	867.64
						1TT	9.144							
22	40	13	15.0	150	155.09	ASAM	100.00	112.80	0.00003	0.00	0.00	0.00	867.64	867.64
						1TT	9.144							
						4GV	3.658							
24	14	13	491.1	150	155.09	ASAM	44.000	49.182	0.018	0.87	0.00	0.87	867.64	868.51
						1SE	4.267							
						1GV	0.914							
26	15	14	491.1	150	155.09	ASAM	55.000	59.267	0.018	1.05	0.00	1.05	868.51	869.56
						1SE	4.267							
28	6	15	491.1	150	155.09	ASAM	366.00	382.15	0.018	6.76	0.00	6.76	869.56	876.32
						1SE	4.267							
						1TT	9.144							
						3GV	2.743							
30	11	21	394.1	150	155.09	ASAM	65.000	69.267	0.012	0.82	0.00	0.82	867.64	866.83
						1SE	4.267							
32	21	22	394.1	150	155.09	ASAM	27.000	32.182	0.012	0.38	0.00	0.38	866.83	866.45
						1SE	4.267							
						1GV	0.914							
34	22	23	394.1	150	155.09	ASAM	15.200	21.296	0.012	0.25	145.95	146.20	866.45	720.25

						1SE	4.267					
						2GV	1.829					
36	23	24	394.1	150	155.09	ASAM	9.000	18.144	0.012	0.21	0.00	0.21
720.25	720.04											
						1TT	9.144					
38	24	25	394.1	150	155.09	ASAM	40.000	49.144	0.012	0.58	0.00	0.58
720.04	719.46											
						1TT	9.144					
40	25	26	94.1	150	155.09	ASAM	10.000	20.058	0.00083	0.02	0.00	0.02
719.46	719.44											
						1TT	9.144					
						1GV	0.914					
42	27	26	205.9	150	155.09	ASAM	40.000	49.144	0.0035	0.17	0.00	0.17
719.44	719.61											
						1TT	9.144					
44	28	27	506.0	150	155.09	ASAM	10.000	14.267	0.019	0.27	0.00	0.27
719.61	719.88											
						1SE	4.267					
46	29	28	506.0	150	155.09	ASAM	15.200	21.296	0.019	0.40	145.95	146.35
719.88	866.23											
						1SE	4.267					

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:05

ADDITIONAL PRESSURE INFORMATION

Page 2 of 2 - Job No. 20010

Pipe No. / Node Pressure First (KPa)	Pipe node First / Node Pressure Second (KPa)	Pipe node Second	Flow (l/m)	Pipe diam. Nom (mm)	Pipe diam. Actual (mm)	Pipe & Fitting CODE #	Pipe & Fitting Length (m)	TOTAL Length (m)	Loss per m (KPa)	Pipe Loss (KPa)	Static Loss (KPa)	TOTAL Loss (KPa)
						2GV	1.829					
48	30	29	506.0	150	155.09	ASAM	10.000	15.182	0.019	0.28	0.00	0.28
866.23	866.51											
						1SE	4.267					
						1GV	0.914					
50	13	30	506.0	150	155.09	ASAM	51.000	60.144	0.019	1.12	0.00	1.12
866.51	867.64											
						1TT	9.144					
52	24	34	0.0	100	105.11	ASAM	1.400	21.212	0.00000	0.00	-145.95	-145.95
720.04	865.99											
						1SE	3.048					
						1NV	16.764					
56	26	32	300.0	100	105.11	ASAM	1.400	21.212	0.047	1.00	-145.95	-144.95
719.44	864.39											
						1SE	3.048					
						1NV	16.764					
58	27	31	300.2	100	105.11	ASAM	1.400	21.212	0.047	1.00	-145.95	-144.95
719.61	864.56											
						1SE	3.048					
						1NV	16.764					
60	25	33	300.0	100	105.11	ASAM	1.400	21.212	0.047	1.00	-145.95	-144.95
719.46	864.41											
						1SE	3.048					
						1NV	16.764					
62	40	41	0.0	150	155.09	ASAM	10.000	15.182	0.00000	0.00	0.00	0.00
867.64	867.64											
						1SE	4.267					
						1GV	0.914					
64	41	42	0.0	150	155.09	ASAM	50.000	54.267	0.00000	0.00	0.00	0.00
867.64	867.64											
						1SE	4.267					
66	42	43	0.0	150	155.09	ASAM	7.000	16.144	0.00000	0.00	63.18	63.18
867.64	804.46											
						1TT	9.144					
68	43	44	0.0	150	155.09	ASAM	5.000	15.058	0.00000	0.00	47.12	47.12
804.46	757.35											
						1TT	9.144					
						1GV	0.914					
70	43	45	0.0	100	105.11	ASAM	50.000	56.096	0.00000	0.00	13.71	13.71
804.46	790.75											
						2SE	6.096					
72	44	46	0.0	100	105.11	ASAM	30.000	36.096	0.00000	0.00	13.71	13.71
757.35	743.63											
						2SE	6.096					
74	44	47	0.0	100	105.11	ASAM	20.000	26.096	0.00000	0.00	13.71	13.71
757.35	743.63											
						2SE	6.096					
76	45	455	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00
790.75	790.75											
						1NV	9.754					
78	46	466	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00
743.63	743.63											
						1NV	9.754					
80	47	477	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	0.00	0.00
743.63	743.63											
						1NV	9.754					
82	34	344	0.0	65	68.81	ASAM	0.100	9.854	0.00000	0.00	160.15	160.15
865.99	705.83											
						1NV	9.754					
84	33	333	300.0	65	68.81	ASAM	0.100	9.854	0.372	3.66	160.15	163.82
864.41	700.59											
						1NV	9.754					
86	32	322	300.0	65	68.81	ASAM	0.100	9.854	0.372	3.66	160.15	163.82
864.39	700.57											
						1NV	9.754					
88	31	311	300.2	65	68.81	ASAM	0.100	9.854	0.372	3.67	160.15	163.82
864.56	700.74											
						1NV	9.754					

LEGEND - Fittings and Pipe Materials used in this run

```
Sparks and Partners Consulting Engineers                                    DATE 23 JUN 2020
L1, 91 George St PARRAMATTA NSW 2150                                        TIME       16:05
____________________________________________________________________________________________

Standard Fittings
SE      = 90 Degree Elbow          TT      = Tee Branch              GV      = Gate Valve
CV      = Check Valve              NV      = Angle Valve

Standard Pipe Materials
ASAM = Medium Steel Tube to AS1074 -1989 & BS 1387
--------------------------------------------------------------------------------------------------------
----------------
```

Input Data

```
LABL1=Authourising Company
TEXT1=
LABL2=Certification Number
TEXT2=
OCC=Hydrant
DENS=
AREA=
ORIF=
COVER=
NOPLOT
PLEN=M
PDIAM=MM
PRESSURE=KPA
FLOW=L/MIN
ELEV=MM
FITTING=NFPA
REPORT
EQ
FDESPT
MAXV=15
\ Fitting Type =Comm
\
\ Pipes
\ Pipes Mtr and Coef: Defaults= MCASAM HW120
P  2 1 2 20 150      ASAM120 3SE  2GV 3CV
P  4 2 3 105 150      ASAM120 3SE
P  6 3 5 20 150      ASAM120 2SE  GV
P  8 5 6 105 150      ASAM120  1TT
P  10 6 7 35 150      ASAM120 1SE  2GV
P  12 7 8 200 150      ASAM120 1SE
P  14 8 9 160 150      ASAM120 1SE
P  16 9 10 16 150      ASAM120 1SE  2GV
P  18 10 11 244 150      ASAM120  1TT 3GV
P  20 11 12 26 150      ASAM120  SE GV
P  21 12 40 65 150      ASAM120  TT
P  22 40 13 100 150      ASAM120  1TT 4GV
P  24 13 14 44 150      ASAM120 1SE  GV
P  26 14 15 55 150      ASAM120 1SE
P  28 15 6 366 150      ASAM120 1SE 1TT 3GV
P  30 11 21 65 150      ASAM120 1SE
P  32 21 22 27 150      ASAM120 1SE  GV
P  34 22 23 15.2 150      ASAM120 1SE  2GV
P  36 23 24 9 150      ASAM120  1TT
P  38 24 25 40 150      ASAM120  1TT
P  40 25 26 10 150      ASAM120  1TT GV
P  42 26 27 40 150      ASAM120  1TT
P  44 27 28 10 150      ASAM120 1SE
P  46 28 29 15.2 150      ASAM120 1SE  2GV
P  48 29 30 10 150      ASAM120 1SE  GV
P  50 30 13 51 150      ASAM120  1TT
P  52 24 34 1.4 100      ASAM120 1SE  NV
P  56 26 32 1.4 100      ASAM120 1SE  NV
P  58 27 31 1.4 100      ASAM120 1SE  NV
P  60 25 33 1.4 100      ASAM120 1SE  NV
P  62 40 41 10 150      ASAM120 1SE  GV
P  64 41 42 50 150      ASAM120 1SE
P  66 42 43 7 150      ASAM120  1TT
P  68 43 44 5 150      ASAM120  1TT GV
P  70 43 45 50 100      ASAM120 2SE
P  72 44 46 30 100      ASAM120 2SE
P  74 44 47 20 100      ASAM120 2SE
P  76 45 455 .1 65      ASAM120  NV
P  78 46 466 .1 65      ASAM120  NV
P  80 47 477 .1 65      ASAM120  NV
P  82 34 344 .1 65      ASAM120  NV
P  84 33 333 .1 65      ASAM120  NV
P  86 32 322 .1 65      ASAM120  NV
P  88 31 311 .1 65      ASAM120  NV
\Discharges Default=  PE0.5
\Hydrants Default=  HE15350 HD300 HI700 HA1200
\
\ Hydrants
H  455       6850     300     700    1200 NOP
H  466      11660     300     700    1200 NOP
H  477      11660     300     700    1200 NOP
H  344      15350     300     700    1200 NOP
H  333      15350     300     700    1200
H  322      15350     300     700    1200
H  311      15350     300     700    1200
\
\ Reference Points
\Reference Point Default= ED-1000
```

```
R    2     -1000
R    3     -1000
R    5     -1000
R    6     -1000
R    7     -1000
R    8     -1000
R    9     -1000
R   10     -1000
R   11     -1000
R   12     -1000
R   13     -1000
R   14     -1000
R   15     -1000
R   21     -1000
R   22     -1000
R   23     13900
R   24     13900
R   25     13900
R   26     13900
R   27     13900
R   28     13900
R   29     -1000
R   30     -1000
R   31     -1000
R   32     -1000
R   33     -1000
R   34     -1000
R   40     -1000
R   41     -1000
R   42     -1000
R   43      5450
R   44     10260
R   45      6850
R   46     11660
R   47     11660
\
\ InputPoints
IF 1 -1000 0.1
```

LOOP INFORMATION

LOOP	PIPES													
1	88	58	44	46	48	50	24	26	28	8	6	4	2	
2	42	44	46	48	50	22	21	20	30	32	34	36	38	40
3	22	24	26	28	10	12	14	16	18	20	21			

BANDWIDTH = 3

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:05

FITTING EQUIVALENT PIPE LENGTHS IN METERS   Diameter in mm

	15	20	25	32	40	50	65	80	90	100	125	150	200	225	250	300	350	375
NFPA Steel Fittings in Schedule 40 to ASTM A-153, A-795 pipe with C=120																		
SE	.30	.61	.61	.91	1.22	1.52	1.83	2.13	2.44	3.05	3.66	4.27	5.49	6.10	6.71	8.23	9.14	9.45
HE	.30	.30	.30	.30	.61	.61	.91	.91	.91	1.22	1.52	2.13	2.74	3.05	3.35	3.96	4.57	4.88
LE	.15	.30	.61	.61	.61	.91	1.22	1.52	1.52	1.83	2.44	2.74	3.96	4.42	4.88	5.49		
TT	.91	1.22	1.52	1.83	2.44	3.05	3.66	4.57	5.18	6.10	7.62	9.14	10.7	13.0	15.2	18.3	19.8	20.6
TN	(NO LOSS)																	
TR	(NO LOSS)																	
NFPA Steel Valves etc. in Schedule 40 to ASTM A-153, A-795 pipe with C=120																		
GV	.30	.30	.30	.30	.30	.30	.30	.30	.30	.61	.61	.91	1.22	1.37	1.52	1.83	1.83	1.98
CV			1.52	2.13	2.74	3.35	4.27	4.88	5.79	6.71	8.23	9.75	13.7	15.2	16.8	19.8	21.3	22.1
LV	4.88	6.10	7.62	10.4	12.5	16.2	18.6	24.4	27.4	30.8	36.6	48.8	64.0	76.2	88.4	104		
NV	2.44	3.35	3.96	5.49	6.40	8.23	9.75	12.2	14.3	16.8	18.3	25.0	32.0	38.1	44.2	51.8		
BV						1.83	2.13	3.05	3.35	3.66	2.74	3.05	3.66	4.72	5.79	6.40		
AV			.02	.06	.12	.37	.91	2.44	3.05	3.66	4.57	6.10	9.75					
MV										12.8		21.4	32.0		42.7			
DV			.03	.06	.15	.46	1.07	3.05	3.66	5.49	6.10	9.14						
SR			.03	.12	.23	.76	1.83	5.18	6.10	9.14	10.7	12.2	21.3					

Sparks and Partners Consulting Engineers
L1, 91 George St PARRAMATTA NSW 2150

DATE 23 JUN 2020
TIME 16:05

QUANTITIES FOR COSTING

PIPES and FITTINGS

Material	Diameter (mm)	Ftgs	Length No.off	Units	Rate	Totals
ASAM						
	65		0.7	m		
		NV	7	off		
	100		105.6	m		
		SE	10	off		
		NV	4	off		
	150		1925.4	m		
		SE	24	off		
		TT	12	off		
		GV	28	off		
		CV	3	off		

HYDRANTS

Flow Rate	No.Off	Rate	Totals
300.00	3		

Note 4: Fittings have not been included at the sprinkler connection points unless extra fittings have been added to the Ranges and Trees.

C5. Sydney Water Pressure Inquiry

Statement of Available Pressure and Flow

Sydney WATER

Justin Hill
153 Walker Street
North Sydney, 2060

Attention: Justin Hill Date: 22/07/2020

Pressure & Flow Application Number: 865367
Your Pressure Inquiry Dated: 2020-05-06
Property Address: 2-18 Aldington Road Kemps Creek NSW 2178

The expected maximum and minimum pressures available in the water main given below relate to modelled existing demand conditions, either with or without extra flows for emergency fire fighting, and are not to be construed as availability for normal domestic supply for any proposed development.

Please Note :- **The results below are based on a future state model with network assets not yet in the ground and assumptions made regarding future infrastructure etc, therefore results are only indicative.**

ASSUMED CONNECTION DETAILS

Street Name: Proposed Road No. 1	Side of Street: East
Distance & Direction from Nearest Cross Street	380 metres South from Proposed Road No. 3
Approximate Ground Level (AHD):	71 metres
Nominal Size of Water Main (DN):	**PROPOSED 300mm**

EXPECTED WATER MAIN PRESSURES AT CONNECTION POINT

Normal Supply Conditions	
Maximum Pressure	87 metre head
Minimum Pressure	46 metre head

WITH PROPERTY FIRE PREVENTION SYSTEM DEMANDS	Flow l/s	Pressure head m
Fire Hose Reel Installations (Two hose reels simultaneously)	0.66	46
Fire Hydrant / Sprinkler Installations (Pressure expected to be maintained for 95% of the time)	5	46
	10	46
	15	45
	20	44
	26	43
	30	42
	40	40
Fire Installations based on peak demand (Pressure expected to be maintained with flows combined with peak demand in the water main)	5	46
	10	46
	15	45
	20	44
	26	43
	30	42
	40	40
Maximum Permissible Flow	50	37

(Please refer to reverse side for Notes)

For any further inquiries regarding this application please email :

swtapin@sydneywater.com.au

Sydney Water Corporation ABN 49 776 225 038
1 Smith St Parramatta 2150 | PO Box 399 Parramatta 2124 | DX 14 Sydney | T 13 20 92 | www.sydneywater.com.au
Delivering essential and sustainable water services for the benefit of the community

Appendix Figure C-1: Pressure Flow Inquiry

Appendix D

Fire System Drawings

Due to the complexity of the number and complexity of the drawings, these have not been included within the report. Please refer to the compressed folder attached with the FSS submission for fire system drawings.

Appendix E

Implementation Commitment

E1. Implementation Commitment – Goodman

28th July 2020

Renton Parker
Director
Riskcon Engineering Pty Ltd
19 / 5 Pyrmont Bridge Road
Camperdown NSW 2050

<u>RE: Oakdale West Industrial Estate - Warehouse 1A Fire Safety Study</u>

Goodman Property Services (Aust) Pty Limited acknowledges receipt of the Fire Safety Study for Warehouse 1A located within the Oakdale West Industrial Estate, Kemps Creek, NSW.

We feel comfortable with the recommendations made and the business intention is to ensure the Customer implements the recommendations as outlined in the study. In addition, we commit to comply with the Prevention, Detection, Protection and Mitigation measures as detailed throughout the Fire Safety Study; specifically, the ongoing commitment to the findings and recommendations of the Fire Safety Study

Yours faithfully

Rob Moody
Senior Project Manager
Goodman Property Services (Aust) Pty Limited

Level 17, 60 Castlereagh Street, Sydney NSW 2000 | GPO Box 4703, Sydney NSW 2001 Australia
Tel +61 2 9230 7400 | Fax +61 2 9230 7444 | info-sydney@goodman.com | www.goodman.com
GTA Industrial Custodian Pty Ltd ACN 081 823 743

E2. Implementation Commitment – CA

27th of July, 2020

Renton Parker
Director
Riskcon Engineering Pty Ltd
19 / 5 Pyrmont Bridge Road
Camperdown NSW 2050

RE: Oakdale West Industrial Estate - Warehouse 1A Fire Safety Study

Coles Group Limited acknowledges receipt of the Fire Safety Study for Warehouse 1A located within the Oakdale West Industrial Estate, Kemps Creek, NSW.

We feel comfortable with the recommendations made and the business intention is to ensure the implementation of the recommendations as outlined in the study. In addition, we commit to comply with the Prevention, Detection, Protection and Mitigation measures as detailed throughout the Fire Safety Study; specifically, the ongoing commitment to the findings and recommendations of the Fire Safety Study.

Yours Sincerely,

Wayne Crabbe
National Development Manager - Property

Coles Supermarkets Australia Pty Ltd ABN 45 004 189 708
800 Toorak Road Hawthorn East Victoria 3123 Australia
PO Box 2000 Glen Iris Victoria 3146 Australia +61 3 9829 5111 coles.com.au