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Fire Safety Strategy

Lot 1A, 1B, 1C and 1D

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Report Details

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|-----|-------------|---|--|---|-------------|
| 01 | 02/09/15 | Draft Issue for comment | Jun Liu <i>PhDEng (Chemical Engineering)</i> | Graham Morris <i>MEng (Structural and Fire Safety Engineering)</i> | |
| 02 | 31/05/16 | Updated Draft | Dean Watt <i>BEng (Chemical Engineering)</i> | Colin Thomson <i>BEng (Chemical Engineering)</i> | |
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| 04 | 25/07/16 | Updated Master Plan | | | |
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| 06 | 21/09/16 | Final Issue with Updated Master Plan | | | |
| 07 | 04/05/17 | Final Issue <i>Update to include revised Precinct 1 Masterplan & BCA Non-Compliances</i> | | Sandro Razzi <i>BE (Building) Grad Dip (Performance Based Building & Fire Codes) Accredited Fire Engineer BPB 0501 FIEAust CPEng 2180287</i>  | |
| 08 | 02/05/19 | Final Issue <i>Update to consider Dangerous Goods storage within Warehouse 1D</i> | Dean Watt <i>BEng (Chemical Engineering)</i> | Graham Morris <i>MEng (Structural and Fire Safety Engineering) MIEAust, CPEng, NER (Fire Safety)</i> | |

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1 INTRODUCTION

1.1 OVERVIEW

This Fire Engineering Report has been undertaken to nominate proposed Alternative Solutions for assessing compliance with the nominated Performance Requirements of the Building Code of Australia 2015 (BCA) [1] in accordance with the methodologies defined in the International Fire Engineering Guideline IFEG [3].

In order to develop and assess the nominated non-compliances the following flowchart process is to be adopted.

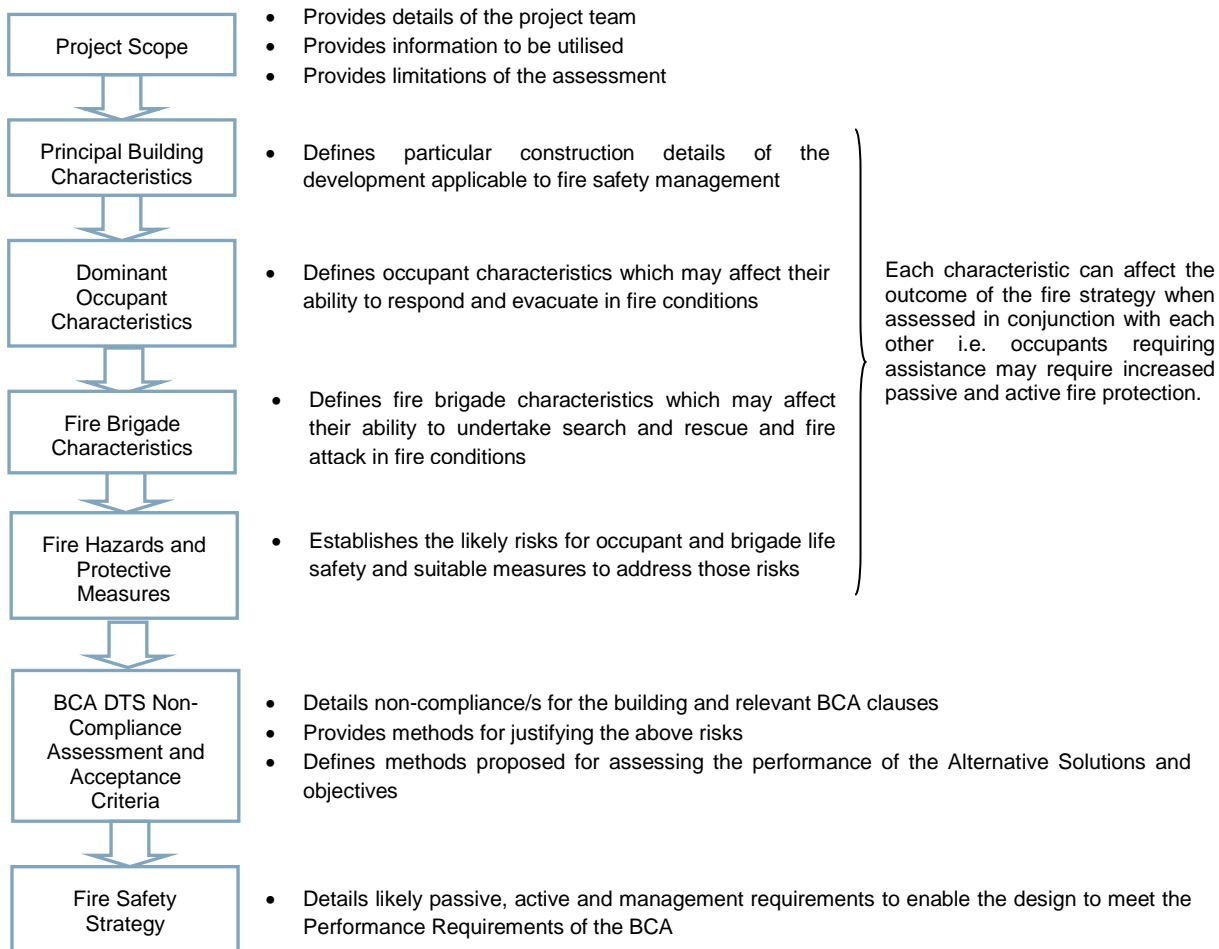


Figure 1-1: Fire Safety Strategy Process

The scope of the Fire Safety Strategy is to detail the nominated non-complying BCA Deemed-to-Satisfy (DTS) provisions with the performance requirements of the BCA and provide methodologies for establishing a workable and safe Fire Safety Strategy through a trial design.

1.2 FIRE SAFETY OBJECTIVES

The objective of this Fire Engineering Assessment is to develop a Fire Safety System, which satisfies the performance requirements of the BCA whilst maintaining an acceptable level of life safety, protection of adjacent property and adequate provisions for Fire Brigade intervention. At a community level, fire safety objectives are met if the relevant legislation and regulations are complied with. As stated in the BCA, “A Building Solution will comply with the BCA if it satisfies the Performance Requirements”. In addition to this, certain non-regulatory objectives exist as detailed below.

1.2.1 Building regulatory objectives

The following items are a summary of the fire and life safety objectives of the BCA:

- **Life safety of occupants** - the occupants must be able to leave the building (or remain in a safe refuge) without being subject to hazardous or untenable conditions. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of exposing building occupants to hazardous or untenable conditions in an event of a fire.
- **Life safety of fire fighters** - fire fighters must be given a reasonable time to rescue any remaining occupants before hazardous conditions or building collapse occurs. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would facilitate fire brigade intervention and minimise the risk of exposing fire fighters to hazardous or untenable conditions in an event of a fire.
- **Protection of adjoining buildings** - structures must not collapse onto adjacent property and fire spread by radiation should not occur. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of fire spreading from one building to another.

1.2.2 Fire Brigade objectives

The overall philosophical Fire Brigade objectives throughout Australia are to protect life, property and the environment from fire according to the Fire Brigade Intervention Model (FBIM) [11] as per the Fire Services State and Territory Acts and Regulations.

Over and above the requirements of the BCA, the Fire Brigade has functions with regard to property and environmental protection and considerations regarding occupational health and safety for its employees.

1.2.3 Non-prescribed objectives

Fire Engineering has an overarching benefit to many facets of the built environment where non-prescribed objectives can have an influence on the Fire Safety Strategy adopted. Although not assessed within, the following can be considered if requested.

- **Business continuity** - will the loss of a particular facility due to fire / smoke damage result in excessive financial impact on the client? For example, is the facility critical to business continuity?
- **Public perception** - should a fire occur within the facility is there likely to be questionable public perception about the safety and operation of the facility?
- **Environmental protection** - fires of excessive sizes can have significant effects on the environment which may require a detailed risk assessment to minimise such outcomes.
- **Heritage salvation** - buildings can have a heritage value for both cultural and educational purposes which can be destroyed by insufficient fire protection.
- **Risk mitigation / insurance limitations** - are there specific limitations on insurance with respect to risk mitigation and fire safety design? i.e. Does the relevant insurer have concerns with respect to open voids through the building?
- **Future proofing (isolation of systems)** - what flexibility is required in the overall design to allow for future development or changes in building layout?
- **Occupational Health and Safety (OHS) requirements** - buildings may have specific fire safety requirements pertaining to OHS requirements.

1.3 REGULATORY FRAMEWORK OF THE FIRE ENGINEERING ASSESSMENT

1.3.1 Building Code of Australia

One of the goals of the BCA is the achievement and maintenance of acceptable standards of safety from fire for the benefit of the community. This goal extends no further than is necessary in the public interest and is considered to be cost effective and not needlessly onerous in its application.

Section A0.5 of the BCA [1] outlines how compliance with the Performance Requirements can be achieved. These are as follows:

- (a) complying with the Deemed-to-Satisfy Provisions; or
- (b) formulating an Alternative Solution which –
 - (i) complies with the Performance Requirements; or

- (ii) is shown to be at least equivalent to the Deemed-to-Satisfy Provisions or
- (c) a combination of (a) and (b).

Section A0.9 of the BCA provides several different methods for assessing that an Alternate Solution complies with the Performance Requirements. These methods are summarised as follows:

- (a) Evidence to support that the use of a material, form of construction or design meets a Performance Requirement or a Deemed-to-Satisfy Provision.
- (b) Verification Methods such as:
 - (i) the Verifications Methods in the BCA; or
 - (ii) such other Verification Methods as the appropriate authority accepts for determining compliance with the Performance Requirements.
- (c) Comparison with the Deemed-to-Satisfy Provisions.
- (d) Expert Judgment.

Section A0.10 of the BCA provides methods for complying with provisions A1.5 (to comply with Sections A to J of the BCA inclusive). The following method must be used to determine the Performance Requirements relevant to the Alternative Solution: These methods are summarised as follows:

- (a) Identify the relevant Deemed-to-Satisfy Provision of each Section or Part that is to be the subject of the Alternative Solution.
- (b) Identify the Performance Requirements from the same Section or Part that are relevant to the identified Deemed-to-Satisfy Provisions.
- (c) Identify Performance Requirements from the other Sections and Parts that are relevant to any aspects of the Alternative Solution proposed or that are affected by the application of the Deemed-to-Satisfy Provisions that are the subject of the Alternative Solution.

1.3.2 International Fire Engineering Guidelines

The IFEG [3] document has been developed for use in fire safety design and assessment of buildings and reflects world's best practice. The document is intended to provide guidance for fire engineers as they work to develop and assess strategies that provide acceptable levels of safety.

The document is particularly useful in providing guidance in the design and assessment of Alternative Solutions against the Performance Requirements of the BCA. The prescribed methodology set out in the IFEG has been generally adopted in the Fire Engineering Report.

2 PROJECT SCOPE

2.1 OVERVIEW



Core Engineering has been engaged to develop a Fire Safety Strategy for the construction of Lot 1A, 1B, 1C and 1D at Oakdale South Industrial Estate, Horsley Park NSW. The purpose of this fire safety strategy is to outline the fire engineering principles that will be utilised in ensuring that the prescriptive Deemed-to-Satisfy (DTS) non-compliances noted in the Building Code of Australia (BCA) report are resolved in order to conform to the building regulations and permit development approval.

The complete fire engineered analysis will be included within the Fire Engineering Report, and as such is not documented herein. This document does however outline the construction and management requirements considered necessary to achieve an acceptable level of life safety within the building as a result of the Alternative Solution and to satisfy the Performance Requirements of the BCA.

2.2 RELEVANT STAKEHOLDERS

This Alternative Solution has been developed collaboratively with the relevant stakeholders as identified below:

Table 2-1: Relevant Stakeholders

| ROLE | NAME | ORGANISATION |
|---|--------------------------------|------------------------------|
| Planning Manager | Guy Smith | Goodman |
| Principal Certifying Authority/BCA Consultant | Dean Goldsmith Tony Heaslip | Blackett Maguire + Goldsmith |
| Architect | Greg Baird Michael Harris | SBA Architects |
| Fire Engineer | Dean Watt Graham Morris | Core Engineering |
| C10 Accredited Fire Engineer | Sandro Razzi | |

It should be noted that at times some parties may have a vested interest in the outcome of the Fire Engineering assessment. Such parties can include local fire brigades, insurers, Environmental Protection Authority (EPA), project control groups, end users and community representatives. Although not always a legislative requirement, the design team should give due consideration to their inclusion in the Fire Engineering process. Where not required by legislation it is the client's decision to involve such parties, especially local fire brigade, to ensure a transparent and adequate fire safety solution for all. Where we are not notified of the inclusion of such parties it is assumed the client / representative has given due consideration to the above.

2.3 SOURCES OF INFORMATION

The following sources of information have been provided by the design team:

- The BCA report provided by Blackett Maguire + Goldsmith, Revision 3 dated 03/05/2017.
- Architectural plans provided by SBA Architects, as indicated in Table 2-2.
- Preliminary Hazard Analysis provided by RiskCon Engineering, Revision 0, dated 23 April 2019.

Table 2-2: Drawings

| DRAWING NO. | DESCRIPTION | ISSUE | DATE |
|-----------------|--|-------|------------|
| OAK SOU MP02 | Precinct Master Plan | HH | 24/04/2017 |
| OAK SOU MP04 | Precinct 1 Plan | P | 21/04/2017 |
| OAK SOU 1B DA20 | Proposed Industrial Facility – Building 1B Site Plan | P | 21/04/2017 |

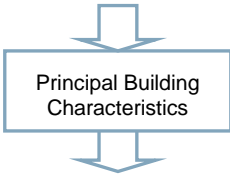
2.4 LIMITATIONS AND ASSUMPTIONS

In this instance the Fire Safety Strategy 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 3.
- The report is based on the information provided by the team as listed above in Section 2.3.
- Building and occupant characteristics are as per Section 3 and 4 respectively of this report. Variations to these assumptions may affect the Fire Engineering Strategy and therefore they should be reviewed by a suitably qualified Fire Engineer should they differ.
- As per any building design, DTS or otherwise, the report is limited to the fire hazards and fuel loads as prescribed in Section 6.2 and 6.4 respectively. The report does not provide guidance in respect of areas, which are used for Dangerous Good storage, processing of flammable liquids, explosive materials, multiple fire ignitions or sabotage of fire safety systems.
- The development complies with the fire safety DTS provisions of the BCA [1] with all aspects for fire and life safety unless otherwise stated in this report. Where not specifically mentioned, the design is expected to meet the BCA DTS requirements of all relevant codes and legislation at the time of construction and / or at the time of issue of this report.
- The assessment is limited to the objectives of the BCA 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 objectives of the BCA. 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.
- The Fire Engineering Strategy is only applicable to the completed building. This report is not suitable, unless approved otherwise, to the building in a staged handover.
- Where parties nominated in Section 2.2 have not been consulted or legislatively are not required to be, this report does not take into account, nor warrant, that fire safety requirements specific to their needs have been complied with.

3 PRINCIPAL BUILDING CHARACTERISTICS

3.1 OVERVIEW



Building characteristics are assessed as part of the Fire Engineering Review due the following:

1. The location can affect the time for fire brigade intervention and potential external fire exposure issues.
2. The structure will impact on the ability to resist a developing fire and support condition to allow occupants to escape the building and the fire brigade to undertake firefighting to the degree necessary.
3. The floor area determines the potential fire size and area required to be evacuated in the event of a fire.
4. BCA details such as Type of Construction, Class and Height will dictate passive and active fire safety systems.

3.2 SITE LOCATION

The development site is located in Horsley Park, approximately 41km north-west of Sydney's central business district. The Oakdale South Industrial Estate consists of six precincts and is located on Estate Road connecting to Milner Avenue. This report is for Precinct 1 within the estate.

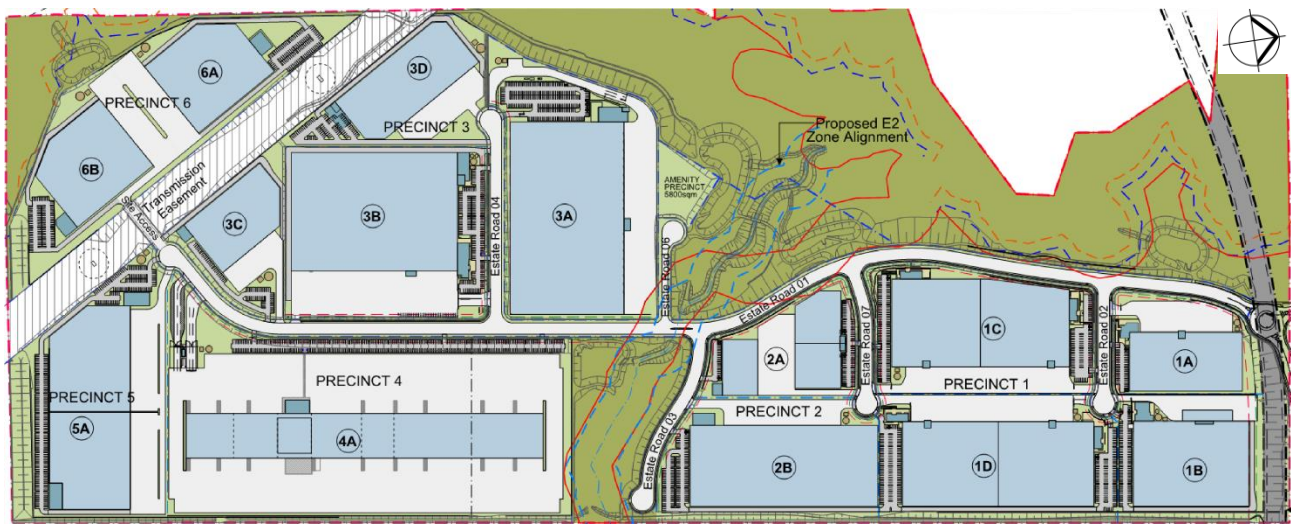


Figure 3-1: Estate Plan

Source: www.googlemaps.com.au

Precinct 1 consists of four buildings on four sites, i.e. Lot 1A to 1D. Lots 1C and 1D consist of two warehouses adjoining one another to constitute a single building (Figure 3-2).

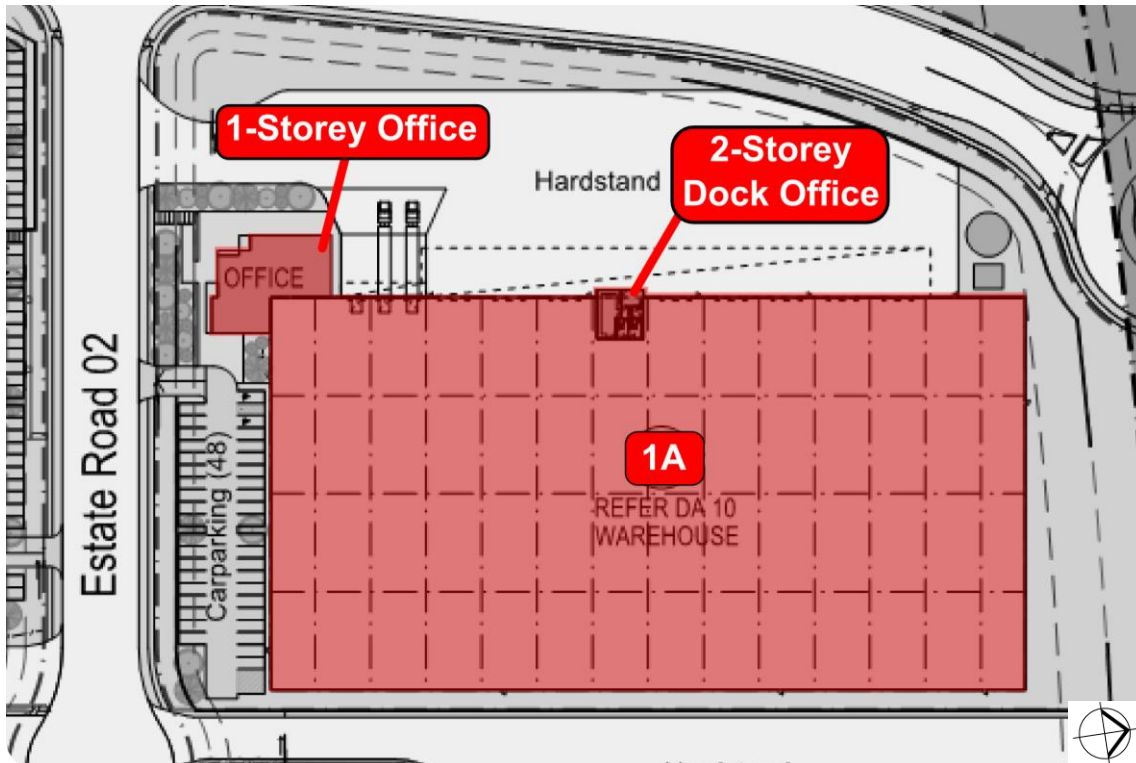


Figure 3-3: Site Plan of Lot 1A

The Lot 1B building has a total floor area of approximately 19,532m², consisting of a warehouse (17,900m²), single-storey office (532m²) and single-storey dock office (100m²). Onsite external carparking is available to the south of the site. Loading docks and associated hardstands for the warehouse are provided to the west. A drive-through area is also provided adjacent to the dock office on the hardstand (1,000m²).

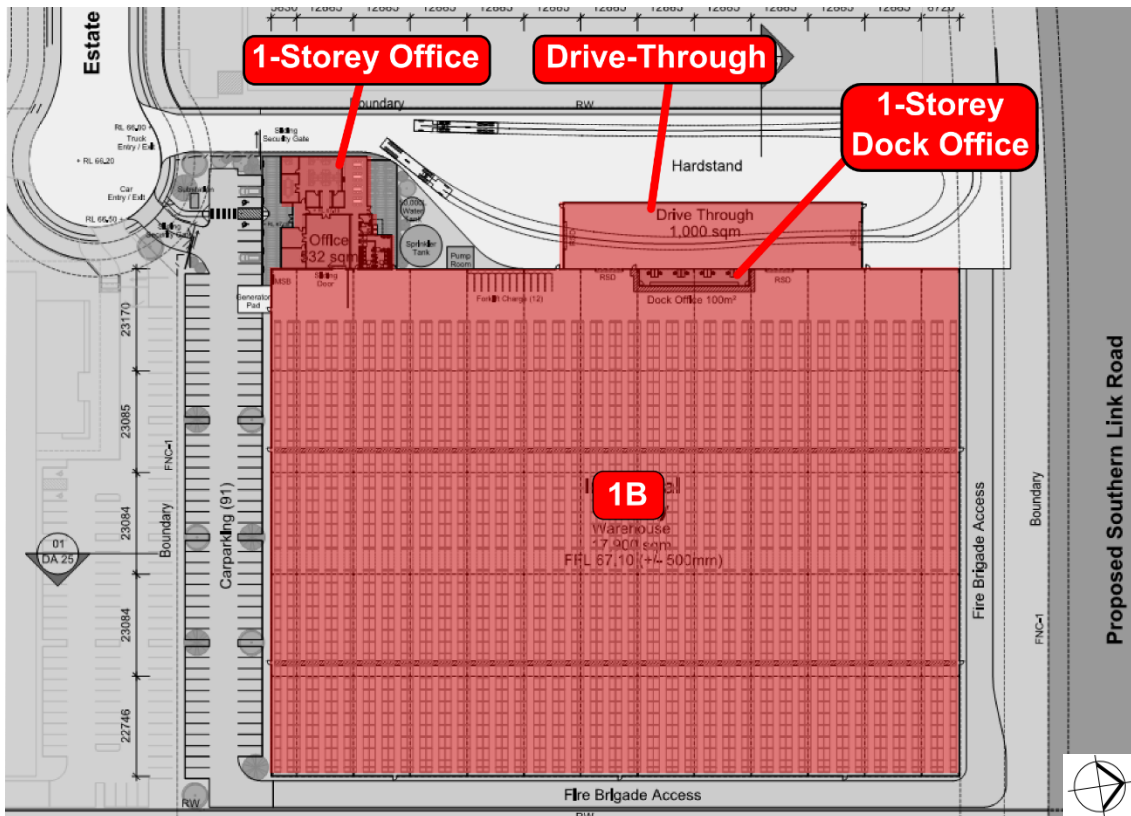


Figure 3-4: Site Plan of Lot 1B

The Lot 1C building consists of 2 adjoining warehouses with the total floor area of approximately 29,404m². Warehouse 1 and 2 have a floor area of 14,180m² and 13,460m² respectively. Each warehouse is provided with a 2-storey office (692m²) and a 2-storey dock office (190m²).

Onsite external carparking is available to the north and south of the site. Loading docks and associated hardstands for the warehouses are located in the east of the site.

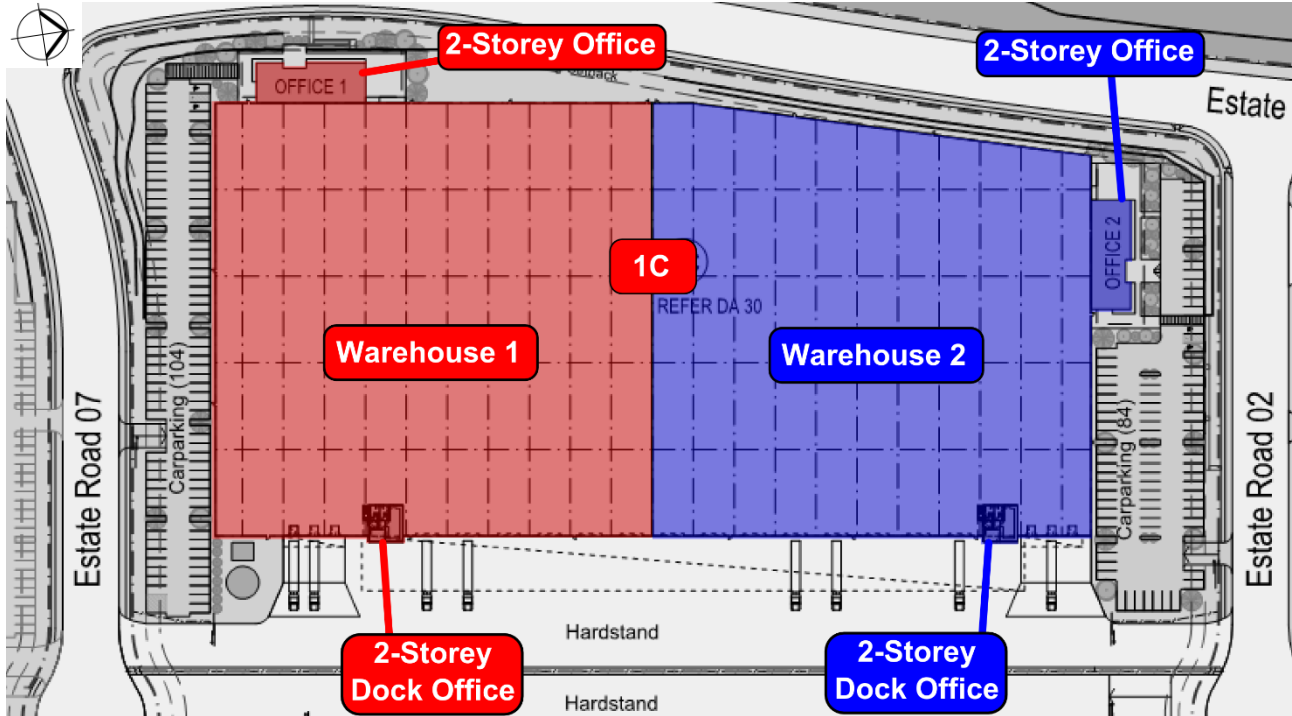


Figure 3-5: Site Plan of Lot 1C

The Lot 1D building has a total floor area of approximately 31,330m², consisting of two adjoining warehouses (14,750m² each), with each warehouse being provided with a 2-storey office (758m² and 692m²) and a 2-storey dock office (190m² each). It is proposed to incorporate Dangerous Goods storage within Tenancy 2 (see Section 6.7.5).

Onsite external carparking is available to the north and south of the site. Loading docks and associated hardstands for the warehouses are located on the west.

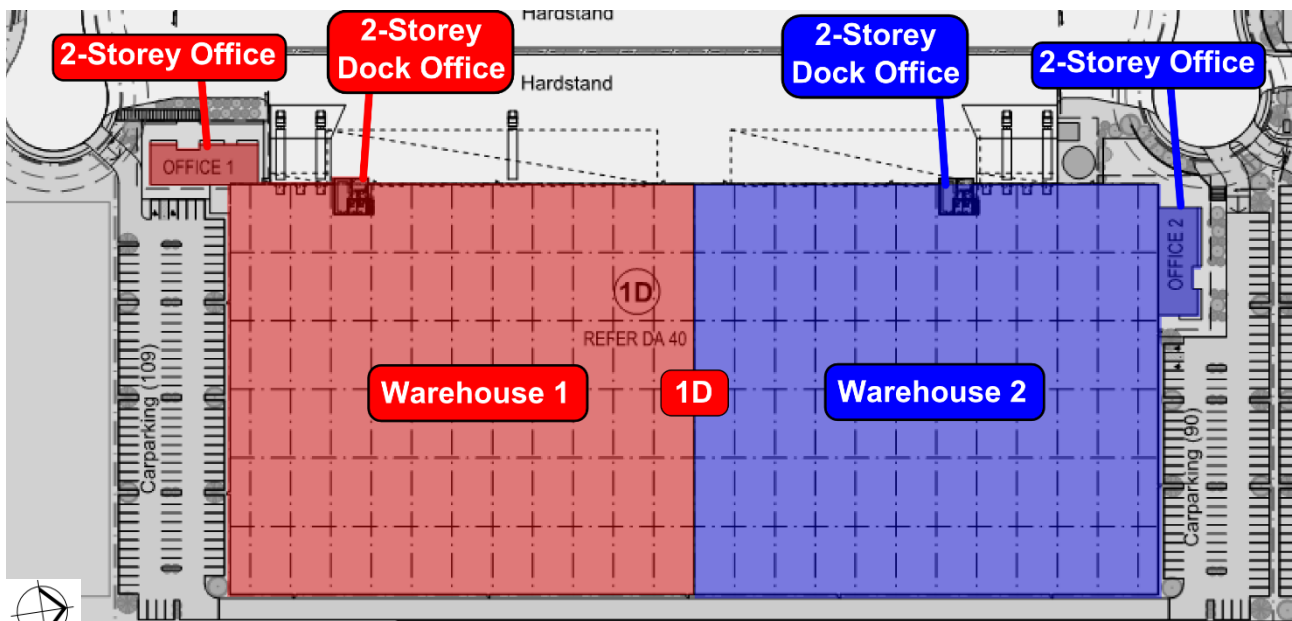


Figure 3-6: Site Plan of Lot 1D

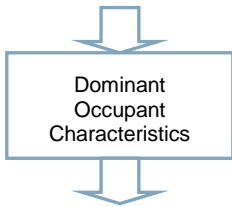
3.4 BCA ASSESSMENT SUMMARY

Table 3-1: BCA Building Characteristics

| CHARACTERISTIC | DESCRIPTION |
|--------------------------|--|
| Classification | Class 7b (Warehouse), Class 5 (Office) for each building |
| Construction Type | Type C Construction (<i>Large Isolated Building</i>) for each building |
| Rise in Storeys | Two (2) for each building |
| Effective Height | Less than 12m for each building |
| Floor Area | <p>The total floor area of the building is detailed below.</p> <p><u>Lot 1A</u></p> <ul style="list-style-type: none"> ● Warehouse: 12,130 m² ● Two-storey office: 739 m² ● One-storey dock office: 95 m² <p style="text-align: right;">TOTAL: 12,964 m²</p> <p><u>Lot 1B</u></p> <ul style="list-style-type: none"> ● Warehouse: 17,900 m² ● One-storey office: 532 m² ● One-storey dock office: 100 m² ● Drive through: 1000 m² <p style="text-align: right;">TOTAL: 19,532 m²</p> <p><u>Lot 1C</u></p> <ul style="list-style-type: none"> ● Warehouse 1: 14,180 m² ● Two-storey office 1: 692 m² ● Two-storey dock office 1: 190 m² ● Warehouse 2: 13,460 m² ● Two-storey office 2: 692 m² ● Two-storey dock office 2: 190 m² <p style="text-align: right;">TOTAL: 29,404 m²</p> <p><u>Lot 1D</u></p> <ul style="list-style-type: none"> ● Warehouse 1: 14,750 m² ● Two-storey office 1: 758 m² ● Two-storey dock office 1: 190 m² ● Warehouse 2: 14,750 m² ● Two-storey office 2: 692 m² ● Two-storey dock office 2: 190 m² <p style="text-align: right;">TOTAL: 31,330 m²</p> |

4 DOMINANT OCCUPANT CHARACTERISTICS

4.1 OVERVIEW



The occupant characteristics are assessed within the Fire Engineering Report due to the following:

1. Population numbers can dictate the time required to evacuate the building and the required life safety systems to be provided due to evacuation times.
2. Physical and mental attributes affect the occupants' capacity to respond to various fire cues and react accordingly.
3. Familiarity of occupants can affect the time taken to evacuate the building and subsequent active / passive requirements.

4.2 OCCUPANT NUMBERS AND DISTRIBUTION

The BCA assumes the following occupant densities per an area's function and use according to Table D1.13:

- Warehouse: 30m² per person
- Office: 10m² per person

These values result in the following estimated populations based on the floor areas provided in Section 3.4.

Table 4-1: Estimated Building Population (DTS Table D1.13)

| LOT NO | BUILDING PART | FLOOR AREA | OCCUPANT NUMBER |
|--------|-----------------|----------------------|-----------------|
| 1A | Warehouse | 12,130m ² | 404 |
| | Office | 739m ² | 73 |
| | Dock Office | 95m ² | 9 |
| 1B | Warehouse | 18,000m ² | 600 |
| | Office | 532m ² | 53 |
| | Dock Office | 100m ² | 10 |
| 1C | Warehouse 1 | 14,180m ² | 472 |
| | Warehouse 2 | 13,460m ² | 448 |
| | Office 1/2 | 692m ² | 69 |
| | Dock Office 1/2 | 190m ² | 19 |
| 1D | Warehouse 1/2 | 14,750m ² | 491 |
| | Office 1 | 758m ² | 75 |
| | Office 2 | 692m ² | 69 |
| | Dock Office 1/2 | 190m ² | 19 |

In the absence of specific occupant numbers provided by the tenant, the population estimated from Table D1.13 of the BCA DTS Provisions will be utilised in the analysis, therefore providing a conservative population in the warehouse parts.

4.3 OCCUPANT ATTRIBUTES

Occupants in the building may be of mixed age, although the elderly and children are generally not expected to be present. The population is therefore expected to be that of the general working public and be adults between the ages of 16 to 70. Due to the nature of the work conducted the majority of occupants are assumed to be able bodied people with a small number of less mobile occupants requiring assistance during an evacuation.

All occupants are expected to be awake and alert adults or in the direct company of an adult, capable of entering the leaving the building under their own volition. Occupants in all of these areas are not expected to

be adversely impaired by drugs, alcohol, fatigue or other adverse conditions to degrees greater than in other warehouse and office buildings.

- **Staff and Security** are expected to be mobile with normal hearing and visual abilities, and occupants in this group are considered to take and implement decisions independently, and require minimal assistance during evacuation in a fire emergency. This occupant group is expected to be awake and fully conscious at all times when inside the building; and
- **Clients / Visitors** are expected to be mobile with normal hearing and visual abilities, this occupant group are expected to be capable of making and implementing decisions independently however may require assistance in locating the nearest and safest egress path in an emergency; and
- **External Maintenance Contractors** are expected to be mobile with normal hearing and visual abilities and occupants in this group are considered to take and implement decisions independently and require minimal assistance during evacuation in a fire emergency. The contractors are expected to be awake and aware of their surroundings at all times when inside the building; and
- **FRNSW** are expected to be equipped with safety equipment and will be educated in firefighting activities and the dangers associated with fire incidents. This occupant group would be expected to be in a position to assist other occupants requiring assistance to evacuate. It is not expected that this occupant group would be present in the building at the time of fire ignition; however, they are expected to enter the building at a later stage to assist with the evacuation of occupants, if required, and to undertake fire suppression activities.

4.4 OCCUPANT FAMILIARITY

The majority of occupants within the building are expected to be staff and therefore the population in general are likely to react favourably in an emergency situation.

- **Staff, Maintenance and Security** can be expected to have a good familiarity with the building and the fire safety systems provided and may be trained in emergency procedures; and
- **Clients / Visitors** may or may not be familiar with the layout of the building and may require assistance in locating the exits; and
- **External Maintenance Contractors** this occupant group is expected to have a reasonable familiarity with the building as they would have to undergo site specific induction prior to commencement of work on site; and
- **FRNSW** are not expected to have any familiarity of the building layout, however are assumed to obtain the required information from the site block plans and tactical fire plans available prior to entering the building. Notwithstanding this they will be equipped with breathing apparatus and specialist equipment to prevent them from being adversely affected by fire hazards.

4.5 EMERGENCY TRAINING

Occupants should be familiar with escape procedures through fire drills and designated fire wardens being appointed to mitigate risks under Workplace Health and Safety legislation (AS 3745:2010). Clear escape routes should be maintained with doors unlocked, and no obstructions or rubbish to hinder evacuation.

Staff and visitors are not expected to have fire suppression training and such training is not relied upon for this building population; however, staff are expected to possibly attempt to extinguish a fire or limit fire spread by removing objects in the vicinity of the fire in order to defend their belongings.

5 FIRE BRIGADE CHARACTERISTICS

5.1 OVERVIEW



The fire brigade characteristics are assessed within the Fire Engineering Report due to the fact that Fire Brigade characteristics can dictate the time required for fire brigade intervention including search and rescue and fire attack.

5.2 FIRE BRIGADE ASSESSMENT

The following figures illustrate the site plan with fire services provided on the site. These include vehicular perimeter access, the Fire Control Centres (FCCs), main FIPs, Sub FIPs, sprinkler tanks and pump rooms.

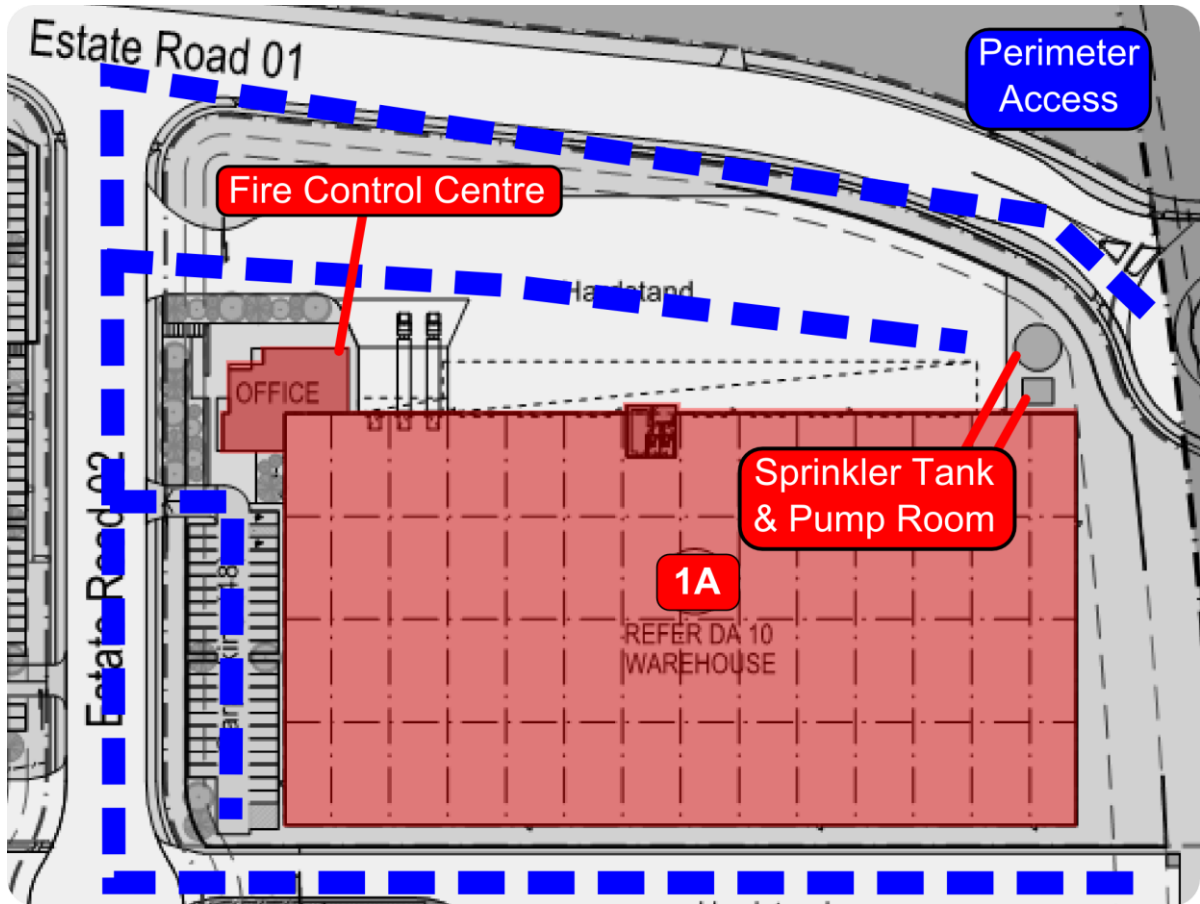


Figure 5-1: Fire Brigade Access and Site Facilities for Lot 1A

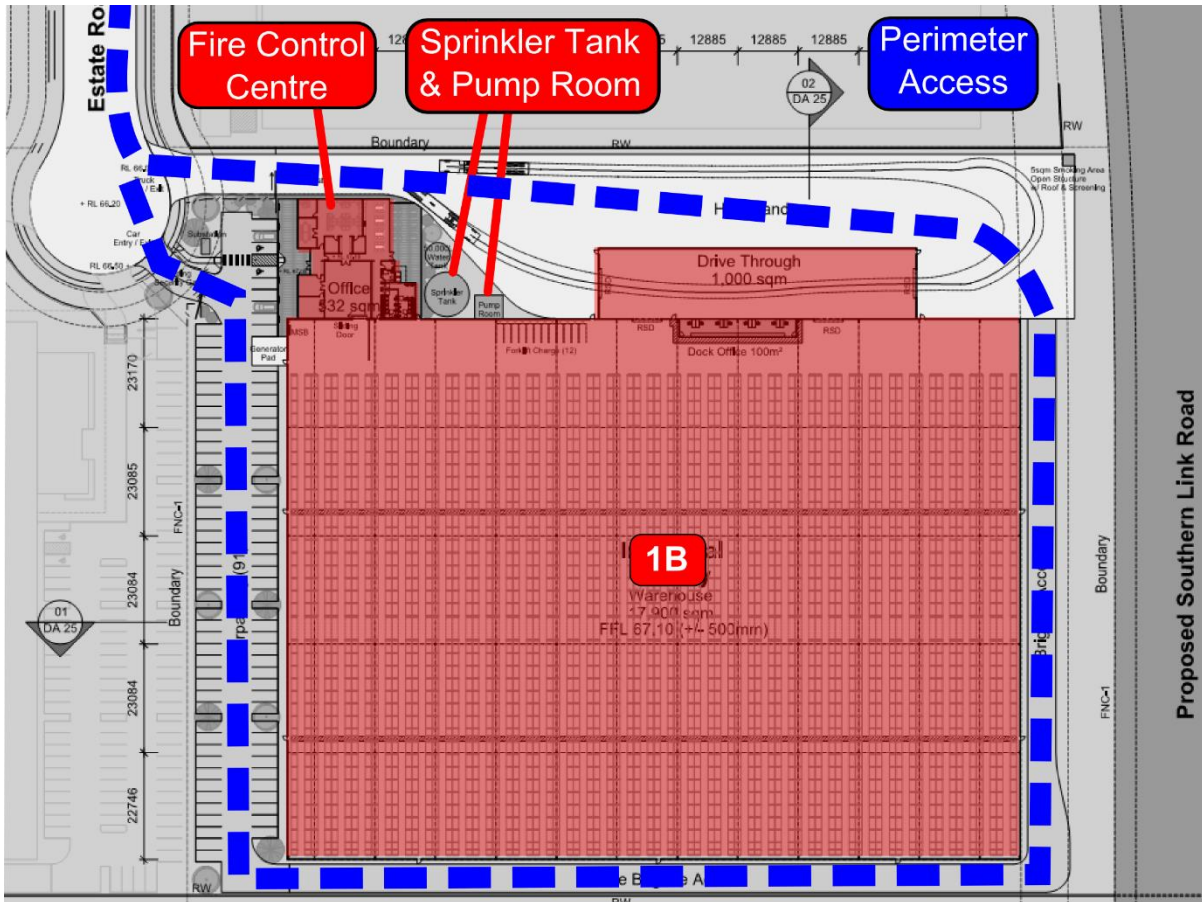


Figure 5-2: Fire Brigade Access and Site Facilities for Lot 1B

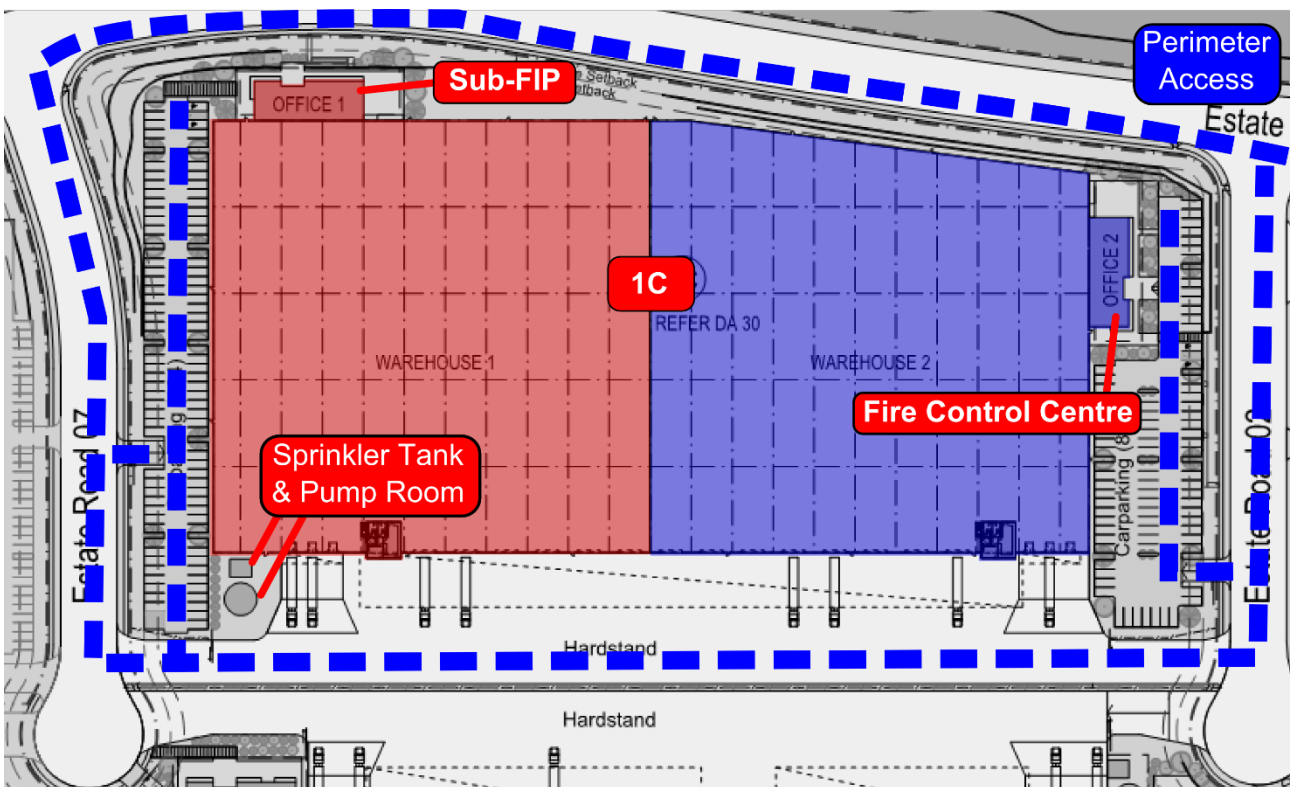


Figure 5-3: Fire Brigade Access and Site Facilities for Lot 1C

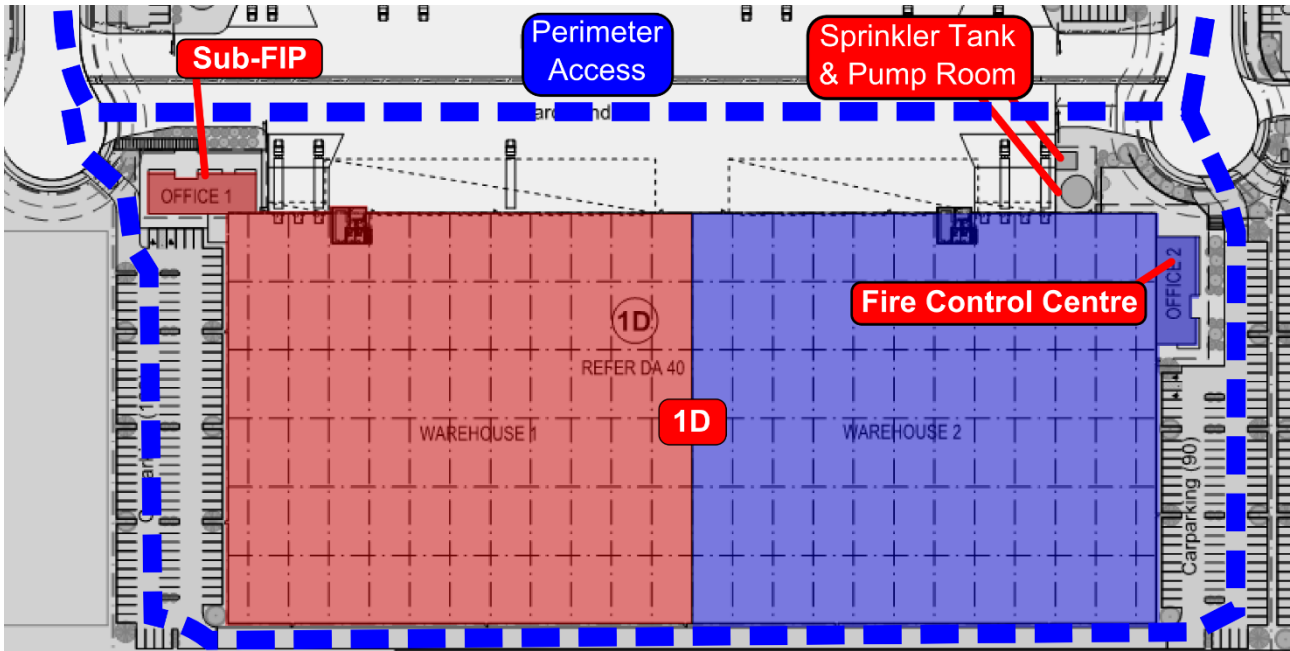


Figure 5-4: Fire Brigade Access and Site Facilities for Lot 1D

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 Mount Druitt approximately 10.7km and 10.9km.

6 FIRE HAZARDS AND PROTECTIVE MEASURES

6.1 OVERVIEW



The fire hazard analysis forms the basis for the review of non-compliances within the building. In assessing expected and statistically validated hazards, preventative and protective measures are developed commensurate with those expected risks. The following section reviews applicable hazards and recommends possible measures to address those risks. Furthermore, hazards identified can form a justified basis for selected scenarios.

6.2 FIRE STATISTICS

In order to assess the most likely fire hazards within the building, and subsequently the risk presented by these hazards it is necessary to develop an understanding of the factors that have an influence on the fire safety of building occupants. The best method in doing so is to review existing statistical data.

Existing data is an invaluable tool in providing an overview of the situations in which occupant deaths have, and are likely to occur, and factors that contribute to more severe fires. This aids in understanding, and helps evaluate the effectiveness of, and the need for various fire safety systems. Reference is made to the American database as it is significantly larger than Australian data sets, but is generally considered to be representative of the Australian situation.

Table 6-1: Fire Statistics in all Building Types [5]

| STRUCTURE USE | FIRES PER YEAR | CIVILIAN FATALITIES PER YEAR | CIVILIAN FATALITIES PER 1000 FIRES |
|-------------------------|----------------|------------------------------|------------------------------------|
| Hospitals | 1,288 | 0 | 0 |
| Schools | 4,060 | 0 | 0 |
| Public assembly | 14,650 | 5 | 0.34 |
| Retail/Department Store | 1,150 | 1 | 0.87 |
| Business offices | 2,890 | 3 | 1.04 |
| Manufacturing | 5,303 | 7 | 1.32 |
| Vehicle Storage/Garage | 6,200 | 10 | 1.61 |
| 24-hour nursing homes | 2,749 | 5 | 1.82 |
| Hotels or motels | 3,610 | 11 | 3.05 |
| Warehouse | 1,270 | 4 | 3.15 |
| Apartments | 106,380 | 410 | 3.85 |
| Homes | 260,180 | 2165 | 8.32 |

From the NFPA 'Structure Fires by Occupancy 2007-2011' Report [5], The civilian fatality rates from 2007 to 2011 highlighted in Table 6-1 show that storage warehouses have a medium risk to life compared to other property types with 3.15 civilian deaths per 1000 fires on average. This indicates a much greater risk per fire than other non-residential occupancies; however, this is balanced by the relatively low number of fires that occur.

6.2.1 Warehouse and Storage Facilities

From the National Fire Protection Association (NFPA) report on 'Structure Fires in U.S. Warehouses' [6] statistics specific to warehouses can be analysed.

A total of 1,270 structure fires were reported in warehouses between 2007 and 2011. The fires recorded resulted in 4 occupant fatalities, 23 occupant injuries and \$188 million in direct property damage per year. Overall, 19% of fires were intentionally set, however no civilian injuries were reported from these fires. Shop tools and industrial equipment caused 8% of fires; however, these fires resulted in 27% of the civilian injuries recorded annually. The leading area of fire origin in warehouses comes from unclassified storage areas, resulting in 13% of fires and 18% civilian injuries.

Figure 6-1 illustrates the leading cause of structure fires in warehouses, while Figure 6-2 indicates the leading areas of origin.

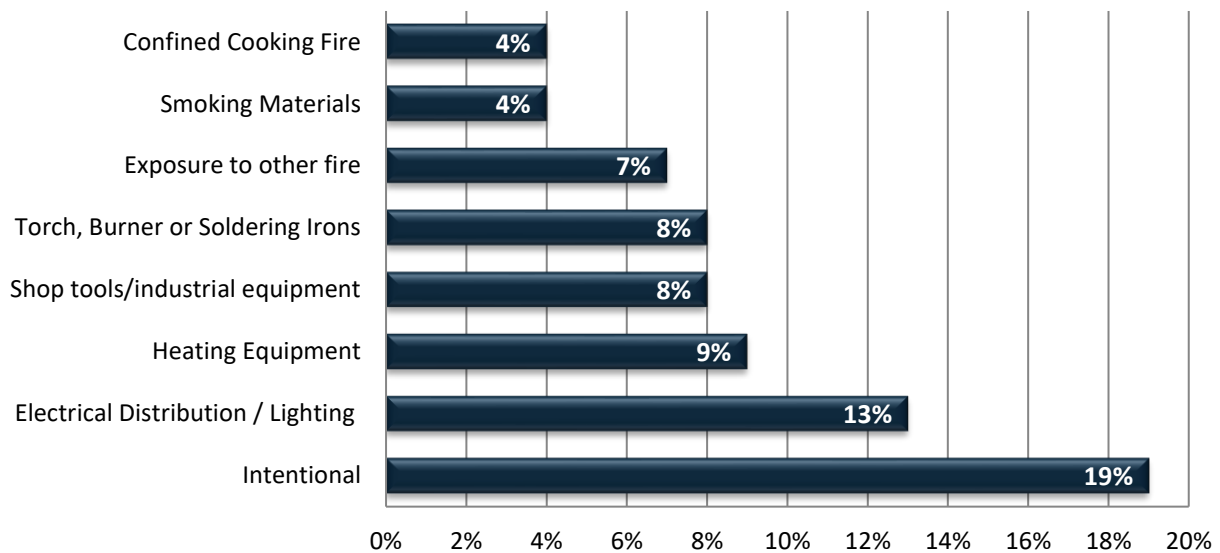


Figure 6-1: Leading Causes of Structure Fires in Warehouses

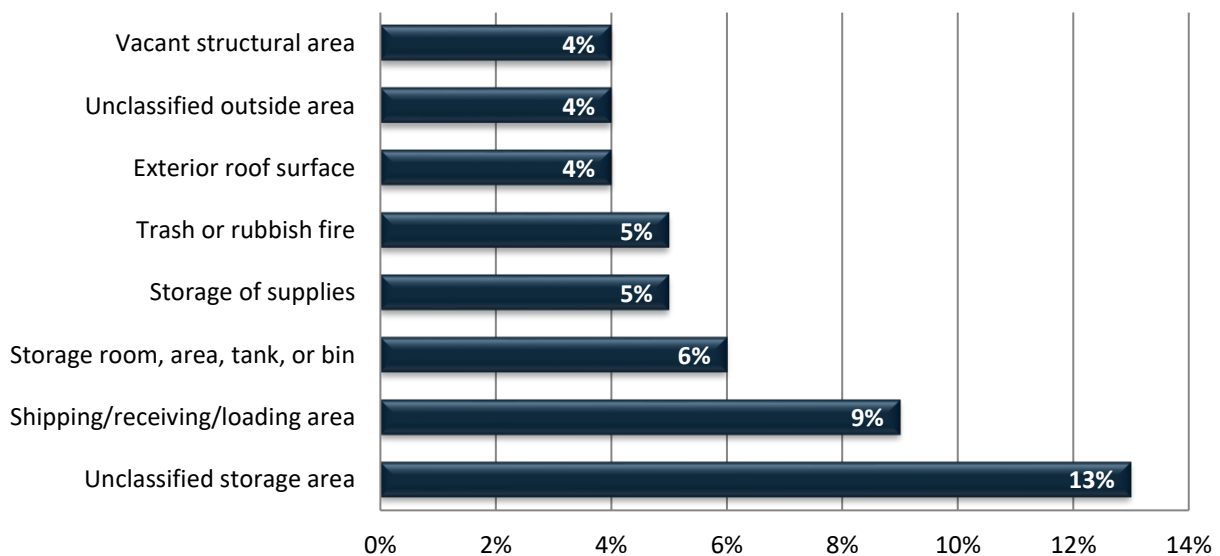


Figure 6-2: Structure Fires in Warehouse Structures by Area of Origin

6.2.2 Office Areas

From the National Fire Protection Association (NFPA) report on 'U.S Structure Fires in Office Properties' [7] statistics specific to building types relevant to this development can be analysed.

A total of 3,340 structure fires occurred in offices with 4 occupant fatalities, 44 occupant injuries and \$112 million in direct property damage per year from 2007-2011.

The potential fire hazards in terms of leading areas of origins of fires and most frequent causes of fires in the office area of this building are investigated by using statistics for similar buildings. Campbell [7] reports that the leading cause of office fires in the US between 2007 and 2011 was cooking equipment followed by electrical/lighting equipment, and heating equipment. This is highlighted in Figure 6-3 with the areas of origin illustrated in Figure 6-4 compounding this data with the most common area of fire origin being in a cooking space. With only 4 civilian fatalities per year in office buildings, fatality data is deemed not to accurately represent risk and so has been omitted from the graphs.

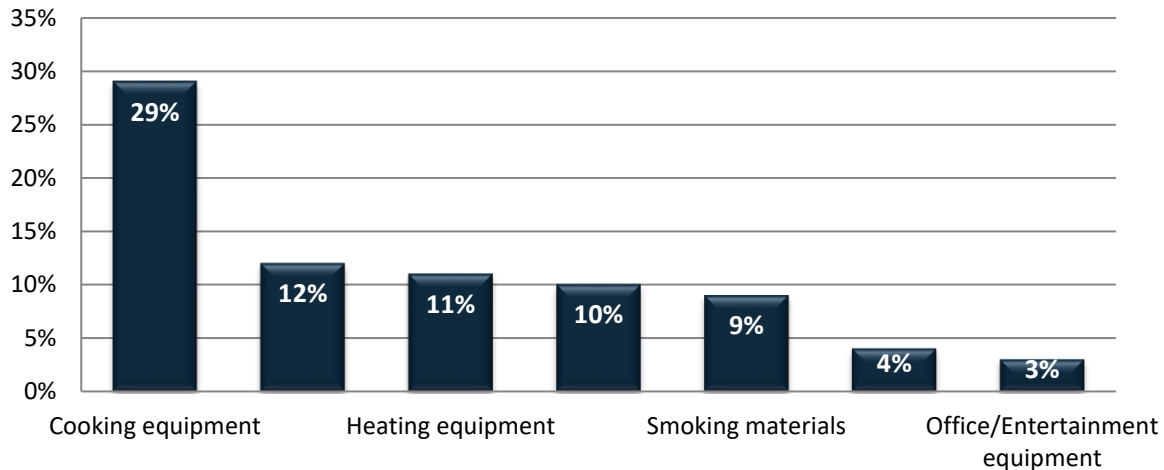


Figure 6-3: Leading Causes of Office Fires [7]

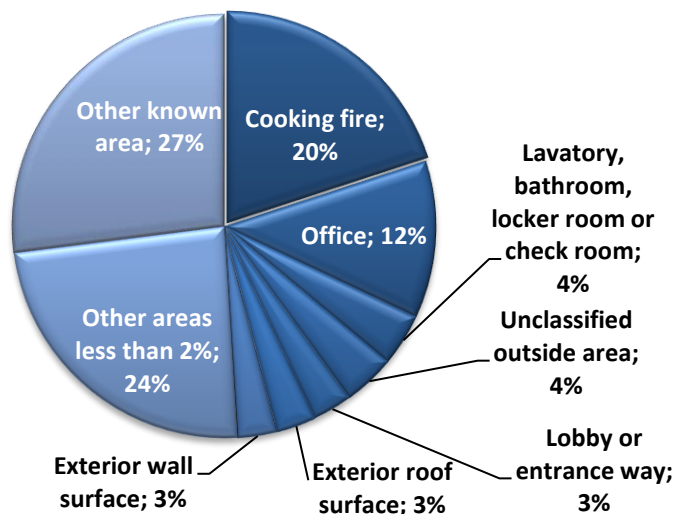


Figure 6-4: Areas of Origin for Office Fires [7]

6.3 SPRINKLER EFFECTIVENESS & RELIABILITY

The effectiveness of automatic fire sprinklers in general in limiting fire spread and growth is supported by statistics and studies undertaken into the effects of automatic fire sprinklers within buildings. These studies show that fire sprinkler systems operate and control fires in 81% to 99.5% of fire occurrences [3]. The lower reliability estimates of 81.3% [16] as well as some of the higher values of 87.6% [17] appear to reflect significant bias in data in terms of the small number of fire incidents and the lack of differentiation between fire sprinklers and other fire suppression systems. A number of the lower figures are results of dated studies.

It must be noted that the higher reliability of fire sprinklers reported by Marrayatt [19] of 99.5% reflect fire sprinkler systems where inspections, testing and maintenance exceeded normal expectations and applies to installations specifically in Australia and New Zealand. The statistical data indicate that sprinklers with

appropriate maintenance are highly effective in reducing the loss of life and limiting fire spread and in particular the storage (ESFR) system has an exemplary record.

With reference to FM Global data sheet (2-2) as of 2002 [14] there had been six known fires involving suppression mode sprinkler protection.

In all of these incidents, the sprinkler system was successful in suppressing the fire and no more than four sprinkler heads operated. Therefore, for the purposes of this assessment, on the activation of the ESFR fire sprinkler system, the fire growth is considered to be suppressed within the area of activation.

FM Global Data Sheet 2-0 states, “loss history over the past twenty years indicates approximately 25% of the time, the operation of a single sprinkler will control or suppress a fire if the sprinkler system has been properly designed and installed.” This percentage increases to approximately 50% of the time with the operation of 3 or fewer sprinklers, and 75% of the time with the operation of nine or fewer sprinklers.

In addition, analysis of the likelihood of sprinkler failure shows that most sprinkler system failures are due to impaired water supplies such as closed valves, blocked pipes, impaired sources, etc., which tend to affect sections of or the entire system [17]. As such, system reliability can be increased by active monitoring of water supplies and controls. The general consensus within the fire protection industry is that problems with individual sprinkler heads are rare. This information combined with sprinkler reliability data is favourable when compared with the reliability of fire compartmentation [3].

Moinuddin and Thomas [17] have found that masonry fire rated construction had a reliability of 81-95%, and gypsum 69-95%, with the upper level in both instances having been reported within the IFEG [3]. Both reported ranges are considered to be less than that offered by automatic sprinkler systems. Table 6-2 lists the effectiveness of sprinkler systems in the event of a fire growing to a size that facilitates sprinkler head activation [17].

Table 6-2: Effectiveness of Sprinkler systems

| PROPERTY TYPE | EFFECTIVENESS OF SPRINKLERS IN EVENTS WHERE SPRINKLERS OPERATE |
|-----------------------------------|--|
| Public Assembly | 90% |
| Educational | 93% |
| Health care / Correctional Centre | 95% |
| Residential (average) | 97% |
| Office / Retail | 91% |
| Manufacturing | 93% |
| Storage | 86% |
| Cold Storage | 89% |

Statistics for general sprinkler effectiveness in storage properties is provided in the table below which is drawn from the research of Rohr [20]. The data indicates over 77% of storage fires and 84% of manufacturing facility fires are confined to the area of fire origin where sprinklers are fitted.

Table 6-3: The Effectiveness of Sprinkler in Storage Facilities

| EXTENT OF FLAME DAMAGE | FIRES WITH SPRINKLER PROTECTION | FIRES WITHOUT SPRINKLER PROTECTION |
|--|---------------------------------|------------------------------------|
| Confined to object of origin | 50.0% | 19.9% |
| Confined to area of origin | 27.8% | 14.1% |
| Confined to room of origin | 6.7% | 4.9% |
| Confined to fire-rated compartment of origin | 1.1% | 0.6% |
| Confined to floor of origin | 2.4% | 1.1% |
| Confined to structure of origin | 10.0% | 45.0% |
| Extended beyond structure of fire origin | 2.2% | 14.3% |
| Total: | 900 fires | 29,330 fires |

According to the tests undertaken by FM Global Property Loss Prevention Data Sheets [14], automatic smoke exhaust systems would operate prior to an installed sprinkler system. This would result in the removal of hot smoke from the ceiling causing a critical delay in sprinkler operation. As such, FM Global recommends that a sprinkler system should not be installed in conjunction with automatic smoke exhaust systems.

It is considered likely that the BCA DTS smoke management would hinder and prevent the activation of the sprinkler system as discussed in the FM Global Property Loss Prevention Data Sheets. The failure of the sprinkler system would allow fire development and cause uncontrolled spread throughout the building leading to a more rapid onset of untenable conditions, significant property loss, and restriction of fire fighter access into the building.

Furthermore, rapid fire development and spread could eventually overrun the sprinkler system by resulting in the activation of several fast response sprinkler heads, over and above the system design requirement, potentially depleting the water supply. In this instance, the system may be rendered ineffective and unable to hydraulically perform as intended. As such, it is recommended that the removal of the BCA DTS smoke management system would allow hot smoke to build up in the ceiling leading to the activation of the sprinkler system as intended by design parameters which are based on tested systems and therefore improving the likelihood of fire control and/or suppression.

6.4 FIRE LOAD

The fire load within a room or compartment will influence the duration and severity of a fire and resultant hazard to occupants. The effective fire load for the building has been estimated by consideration of the typical spaces within the building.

The following fire loads have been extracted from Chapter 3.4 of the International Fire Engineering Guidelines [3] and are listed in Table 6-4. This data is derived from Switzerland, however is also deemed applicable to buildings in Australia of similar use.

The warehouses are considered to generally contain mixed types of commodities, where in some cases cellulosic materials are mixed with plastics and non-combustible materials on the same racks. There is a large amount of data concerning the burning rates of items and materials; however, this information is not often presented such that it is sufficiently generic to be universally adopted.

Also, while the current tenant and stored commodities may be known during the design stages of the development the length of their occupancy cannot be definitively identified. Therefore, while what can be representative of the current fuel loadings for the enclosure, these may not be the case in the future use of the building. Therefore, it would be a rare assessment in which the specific items forming the fuel load had been tested to provide the fire heat release data. As such it is considered that the application of generic burning rates, translated through simplified mathematical expression (time squared growth rates) is a suitable means of estimating fire development.

Table 6-4: Fire Load Densities

| TYPE OF OCCUPANCY | AVERAGE FIRE LOAD |
|--|---|
| Office, Business | 800 MJ/m ² |
| Forwarding facility dealing in; Beverages, food, furniture, glassware, plastic product, printed goods, varnish/polish. | Range from: 200 MJ/m ² - 1700 MJ/m ² |
| Storage of rubber products | 5000 MJ/m ² per metre stored height |
| Storage of paper | 1000 MJ/m ² per metre stored height |

6.5 FIRE GROWTH RATE AND INTENSITY

As the fire increases in size, the rate of fire growth accelerates. The growth rate of a fire can result in various hazards for occupants due to the following:

- Protective and preventative measures may not be adequate.
- Occupants may have insufficient time to evacuate.
- Occupants may perceive a reduced threat from slow growing fires.

The rate of fire growth is generally expressed in terms of an energy release rate. The most commonly used relationship is what is commonly referred to as a quadratic time-squared fire. The basis of the time squared fire arises from the fact that the growth during the flaming stage can be approximated by a smooth curve that can be expressed mathematically. The rate of heat release is given by the expression:

$$Q = (t/k)^2$$

Where: t = time from after ignition of the fire (seconds)
 K = the growth time (seconds)
 Q = a heat release output of 1.055 MW.

Studies of actual fires have led to the adoption of five (5) standard fire growth rates covering a wide range of potential fire scenarios and fuel loads. It should be noted; the times of fire incubation are not included in the time-squared growth fire models. National Fire Protection Association Standard NFPA 92B [17] provides information on the relevance of time-squared approximation to real fire as depicted in the figure below.

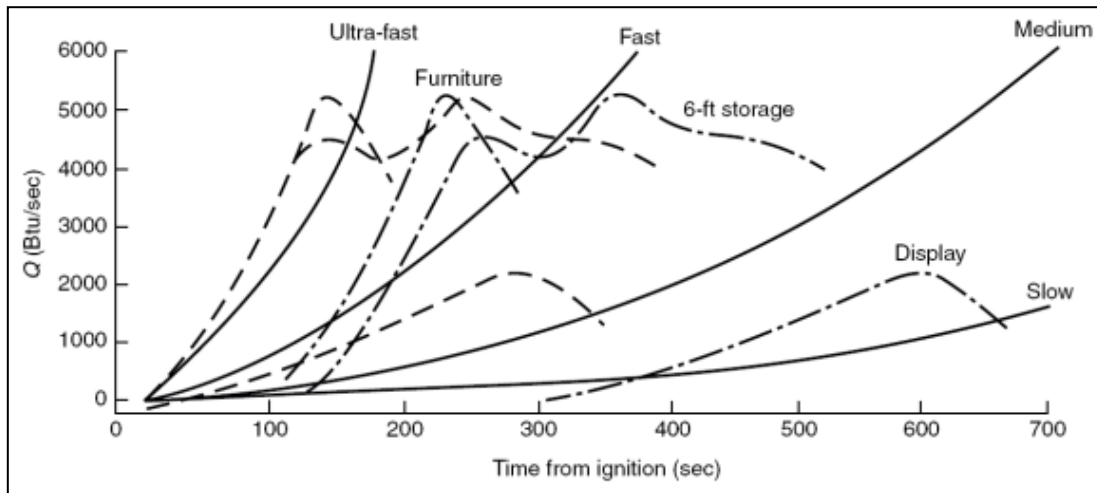


Figure 6-5: NFPA 92B: T-squared fire, rates of energy release

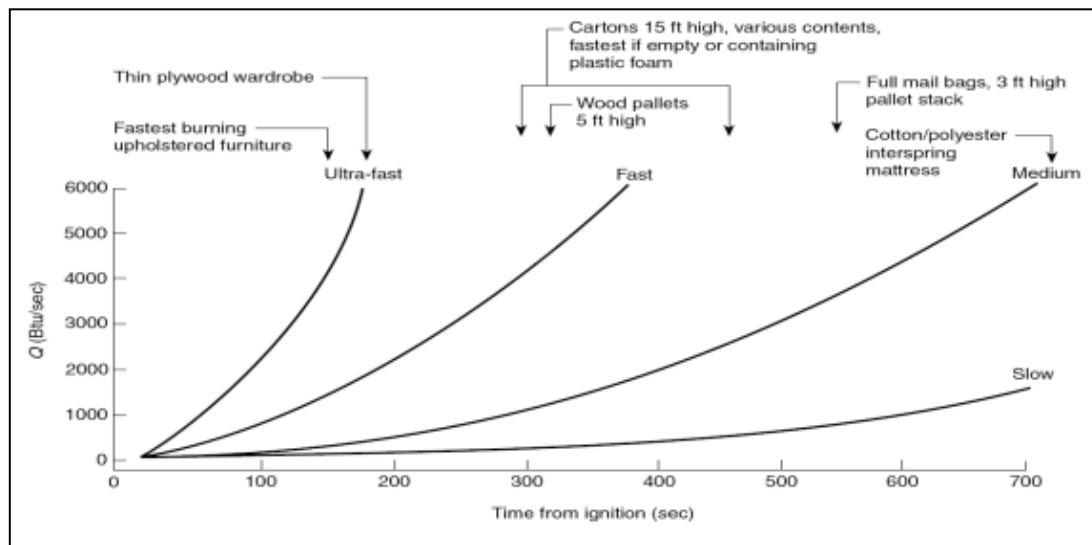


Figure 6-6: NFPA 92B: Relation of t-squared fires to some fire tests

The rate of fire growth can also be estimated from data published in British Standard (BS) 9999:2008 [4] as shown below in Table 6-5, and Table 6-6.

Table 6-5: Summary of Fire Growth Rates per Building Type

| BUILDING AREA PROVIDING FUEL | GROWTH RATE | BUILDING AREA PROVIDING FUEL | GROWTH RATE |
|------------------------------|---------------------|------------------------------|-------------|
| Reception area | Slow | Restaurant/Canteen | Medium |
| Office | Medium | Teaching Laboratories | Fast |
| Shop | Fast | Meeting Room | Medium |
| Warehouse | Medium – Ultra Fast | Waiting Room | Slow |

The variation in warehouse growth rates can be understood from the following table illustrating the types of stored items.

Table 6-6: Fire Growth Rates as described in BS 9999:2008

| FIRE RATE | GROWTH | STORED MATERIALS |
|---------------------------------|---------------|---|
| Slow t ² | | Banking hall, limited combustible materials. |
| Medium t ² | | Stacked cardboard boxes, wooden pallets. |
| Fast t² | | Baled thermoplastic chips, stacked plastic products, and baled clothing. |
| Ultra-Fast t² | | Flammable liquids, expanded cellular plastics and foam. |

From the above tables (and figures) it is concluded that the likely fire scenarios in the high bay racking may be approximated by an Ultra-Fast standard time-squared fire growth rate curve, while the office areas can be approximated with a Medium time-squared fire growth rate.

6.6 FIRE SOOT YIELD

The materials that make up the fuel load will determine the soot yield of a fire. The fire soot yield should be assessed with respect to hazard due to the following:

- Soot yield can affect visibility for occupants trying to escape a fire.
- Soot yield can be directly related to other products of combustion which may cause untenable conditions.

The NFPA Fire Protection Handbook provides test values of soot yield for some common plastics which vary from 0.012 to 0.23kg/kg [9]. Data for polyurethane is provided in the SFPE handbook which quotes a range between 0.104-0.227kg/kg [8]. As the quantity of fuel in any particular building is expected to be of mixed type, taking the upper value in the range of plastics is considered overly conservative in representing the entire fuel load. The soot yield, quoted by various sources, for wood is 0.015kg/kg which confirms that utilising 0.1kg/kg is a conservative average for fire modelling in pre-flashover conditions where a mixture of plastic and cellulosic fuel is expected.

6.7 FIRE HAZARDS

Subsequent to a review of the relevant fire statistics and hazards presented in Section 6.2, the fire hazards are specific to this building are summarised below.

6.7.1 General Layout

Exits are provided around the buildings' perimeter to allow for multiple alternative egress opportunities. Due to the open nature of the warehouse, there are limited dead end travel routes to exits, however due to the building's large area, extended travel distances to the nearest exit and between alternative exits are present.

No hazards to adjoining buildings have been identified and internal hazards are minimal. Due to the open space and multiple egress opportunities, internal fire exposures are also expected to be minimal as occupants in the area of fire origin are likely to immediately become aware of fire and are likely to commence evacuation.

6.7.2 Activities

It is not expected that regular hot work processes, use of highly flammable materials, manufacturing processes or operation of high friction or high temperature machinery will be performed within the building. The development is a storage facility likely to contain a large number of high piled and racking containing combustibles.

6.7.3 Ignition Sources

Based on the statistical review contained in Section 6.2 ignition sources relevant to this site, in order of occurrence:

Warehouse

- Intentional
- Electrical distribution / lighting
- Heating equipment
- Shop tools / industrial equipment

6.7.4 Fuel Sources

Quantity of Materials

- Warehouse - The racked storage areas are likely to have the densest fire load, with between 200MJ/m²-1700MJ/m² expected depending on the type of items stored.
- Office - 800MJ/m² with isolated peak values reaching 1600MJ/m².

Location of Materials

Products in high storage racking, store room, waste and rubbish containers. The lobbies, stairways and corridors are to be maintained clear of furniture, stored items and the like and constructed with materials and assemblies in accordance with C1.10 to reduce fire spread and smoke production in the event of fire in common areas. Significant fuel loads will therefore be generally limited to the warehouse and offices.

Fire Behaviour

Fire growth rates will vary with fuel type and conditions of ventilation and compartmentation. The most likely outcome of any fire outbreak within the building is a sprinkler controlled fire. This would be expected to grow at an ultra-fast time-squared fire growth rate until sprinkler activation in the warehouse areas, at which point the sprinklers are expected to suppress or control the fire. A medium t^2 fire growth rate is expected in the office areas.

6.7.5 Dangerous Goods

Dangerous Goods cannot be discounted from being present in the 1A, 1B and 1C warehouse buildings. Where present, the quantity will be limited by the space available and relevant workplace health and safety regulations will apply governing storage allowances (quantity) and requirements.

However, it is proposed to store Dangerous Goods within the Tenancy 2 of Warehouse 1D as per the Preliminary Hazard Analysis (prepared by RiskCon Engineering) and the design brief for the facility. The classes and quantities of Dangerous Goods stored are summarised as follows in Table 6-7. As identified within the PHA, these quantities are below that which would constitute their storage to be classified as a Major Hazard Facility.

Relevant to these identified classes of Dangerous Goods, Table 6-8 includes a discussion on each class present and their potential impact in a fire scenario.

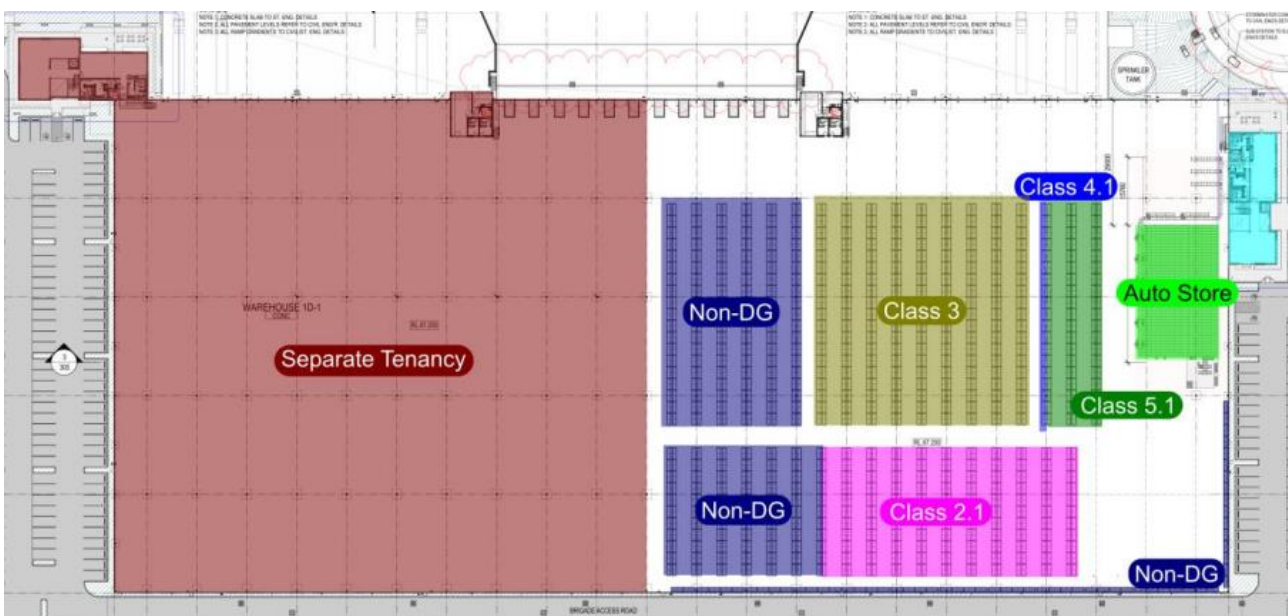


Figure 6-7: Warehouse 1D Site Layout & Proposed Storage Arrangement of Dangerous Goods

Table 6-7: Dangerous Goods Stored within Tenancy 2 of Warehouse 1D

| AREA | CLASS | PACKING GROUP | QUANTITY (L or kg) |
|-------------------|----------------|---------------|-------------------------|
| General Warehouse | 2.1 (aerosols) | -- | 556,554 L / 139,139 kg* |
| | 3 | II & III | 494,678 L |
| | 4.1 | II & III | 7,051 |
| | 5.1 | III | 58,724 |
| Autostore | 2.1 (aerosols) | -- | ~290 kg* |
| | 3 | II & III | 16,750 L |
| | 4 | II & III | 70 L |
| | 5.1 | II & III | 450 L |
| | 8 | II & III | 5 L |
| | 9 | III | 72 L |

*Assuming a density of 1,000 kg/m³ and that 25% of the aerosol product is propellant (LPG)

Within the Preliminary Hazard Analysis, RiskCon Engineering notes the following measures to ensure that all appropriate standards are met:

- The volume of the identified Class 3 (small retail) packages are generally less than 20 L and will be in accordance with AS/NZS3883:2007 to manage the risk of spills and flammable vapour hazards.
- Class 2 aerosols shall be stored in a separate caged enclosure.
- In-rack sprinkler protection is to be provided where required to accommodate the storage of Class 2 & 3 Dangerous Goods adjacent to the intertenancy wall. Otherwise, the storage of these materials is to be excluded from this zone.
- Additional features and training are to be provided to meet the details for control of risks associated with Dangerous Goods in accordance with AS/NZS3883 and AS1940.

These and any further measures are to be confirmed with the Dangerous Goods consultant to ensure that suitable provisions are incorporated, as documented within the PHA.

Table 6-8: DG Classifications Present

| CLASS | DESCRIPTION |
|--------------------------------------|---|
| 2.1 Flammable Gases (Aerosols) | <p>This Class encompasses compressed gases, liquefied gases, dissolved gases, refrigerated liquefied gases, mixtures of one or more gases with one or more vapours of substances of other classes, articles charged with a gas and aerosols.</p> <p>Class 2.1 flammable gases are defined by dangerous goods regulations as substances which have a vapour pressure of 300 kPa or greater at 50°C, or which are completely gaseous at 20°C at standard atmospheric pressure.</p> <p>Generally, the base products have a high water content and alone are not highly flammable, however those products are projected from a nozzle of the can using compressed liquefied petroleum gas (LPG). LPG is a flammable gas that is heavier than air.</p> <p>In the event of a can rupturing, the LPG could ignite resulting in a fire or explosion. The quantity of LPG in each aerosol can is generally relatively small and as a result a fire from a single can would be localised and short in duration. The heat generated from a single can explosion could however also cause a chain reaction rupturing adjacent cans and facilitating a series of small explosions.</p> |
| 3 Flammable Liquids | <p>Paint, paint related materials (e.g. thinners), lacquers, ethanol, perfume, etc., are classified as Class 3 flammable liquids. Gels/foams may also be classified as flammable liquids but are predominantly non-dangerous goods.</p> |

| CLASS | DESCRIPTION |
|---------------------------|---|
| | <p>Flammable liquids are defined by dangerous goods regulations as liquids, mixtures of liquids or liquids containing solids in solution or suspension which give off a flammable vapour (have a flash point) at temperatures of not more than 60-65°C.</p> <p>Flammable liquids contain component chemicals that vaporise when exposed to air. The vaporisation rate is a function of the ambient temperature at the time of the release, the temperature of the flammable liquid released and the flash point of the liquid.</p> <p>When released flammable vapours could form clouds that mix with ambient air that may ignite and burn forming a flash fire, explosion or pool fire over the liquid released. When a container is ruptured, the liquid will spill onto the stock below before forming a pool on the ground. This potentially flaming pool may then spread to the adjoining materials and facilitate in fire spread, through which the fire can grow beyond a size easily manageable by personnel.</p> |
| 4.1 Flammable Solids | <p>Class 4.1 materials are solids that are readily combustible, or are self-reactive to undergo an exothermic reaction.</p> <p>Items under this classification include matchsticks or firelighters. In the unlikely event that one of these packages ignites, the minimal package size should reduce the likelihood of a sustained fire and the resulting possibility of facilitating fire spread to adjacent packages</p> |
| 5.1 Oxidising Agents | <p>Oxidizers are defined by dangerous goods regulations as substances which may cause or contribute to combustion, generally by yielding oxygen as a result of a redox chemical reaction.</p> <p>Oxidising agents are manufactured in solid form (such as powders, granules or tablets) and liquid form (such as sprays, gels or foams). By themselves oxidising agents are not flammable or combustible and as a result pose no fire risk. However when introduced to a flammable or combustible material fire (e.g. pallets, packaging, etc.) the oxidising agent will act as a catalyst by providing additional oxygen to enhance the fire intensity.</p> |
| 6.1 Toxic Substances | <p>These are substances liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact. These materials do not pose a risk to fire ignition, however when released they may pose a threat to occupants in the building or the surrounding area, and the environment.</p> |
| 8 Corrosive Substances | <p>Class 8 corrosive materials incorporate both acidic and alkaline substances. A corrosive material is a liquid or solid that causes destruction of a material when coming in contact for a specified period of time. Corrosives cause severe damage when in contact with living tissue or, in the case of leakage, damage or destroy surrounding materials. These materials do not pose a risk to fire ignition, however when released they may pose a threat to occupants in the building or the surrounding area, and the environment.</p> |
| 9 Miscellaneous DGs | <p>Miscellaneous dangerous goods are substances and articles which during transport present a danger or hazard not covered by other classes. The definition of this class encompasses, but is not limited to, environmentally hazardous substances, substances that are transported at elevated temperatures, miscellaneous articles and substances and (depending on the method of transport) magnetised materials and aviation regulated substances. Similarly to Class 8 goods, these items will not pose an additional risk to fire ignition.</p> |

The potential risk of a fire presented by the Dangerous Goods items on site shall be minimised through the following fire safety measures:

- The caged enclosure for the storage area dedicated to Class 2 aerosols.
- In-rack sprinkler protection is to be provided where required to accommodate the storage of Dangerous Goods.
- Limited package sizes, being small retail packages.

- The containers (totes) within the Autostore storage each function as their own bund, reducing the likelihood of spills.
- Automated functions within the Autostore are to automatically shut down upon fire trip within Warehouse 1D.

Considering the above discussion on the various classes of Dangerous Goods, it can be seen that their presence within the Warehouse 1D enclosure and potential impact in a fire scenario have been suitably addressed.

6.8 PREVENTATIVE AND PROTECTIVE MEASURES

6.8.1 Fire Initiation and Development and Control (Sub-System A)

To minimise the risk of fires initiating and growing to a size which may impact on building occupants, fire safety systems are provided within the building as listed in the following sections, as well as the below measures:

6.8.2 Smoke Development and Spread and Control (Sub-System B)

It is recognised that smoke is one of the most serious threats to life safety in the event of a fire. To address this risk, the following is considered:

- The volume of each building acts as a large smoke reservoir to increase the available evacuation time for occupants.
- A manual smoke clearance system is provided in each of Warehouses 1A, 1B, 1C and Tenancy 1 of Warehouse 1D.
- An automatic smoke exhaust system is provided within Tenancy 2 of Warehouse 1D.

6.8.3 Fire Spread and Impact and Control (Sub-System C)

To limit the extent and impact of fire spread through the buildings, the following are implemented in the building.

- Type C construction.
- Caged enclosure for aerosol storage (within Warehouse 1D).
- Sprinkler systems documented in Sub System D.
- Automated functions within the Autostore shut down automatically on fire trip.

6.8.4 Fire Detection, Warning and Suppression (Sub-System D)

The following active systems provided within the buildings to facilitate occupant warning and suppress a potential fire.

- Occupant Warning System.
- Detection within Tenancy 2 of Warehouse 1D (as Dangerous Goods are proposed to be stored).
- Ceiling-level storage mode sprinkler system to warehouses.
- In-rack sprinkler protection to Warehouse 1D where required to accommodate Dangerous Goods storage.
- Sprinkler system to offices and beneath awnings.
- Fire Hose Reels.
- Fire Extinguishers.

6.8.5 Occupant Evacuation and Control (Sub-System E)

The building is provided with the following systems to assist in the evacuation of occupants:

- Emergency Lighting.
- Exit Signage.

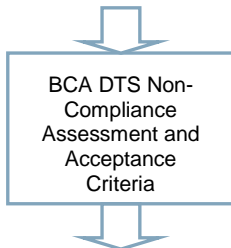
6.8.6 Fire Services Intervention (Sub-System F)

The building is provided with the following systems to assist in fire brigade intervention:

- Fire Hydrants.
- Automatic Link to Fire Brigade.
- Vehicular perimeter access with minor non-conformances.
- Control & Indicating Equipment.

7 BCA DTS NON-COMPLIANCE ASSESSMENT

7.1 OVERVIEW



In this instance the BCA DTS non-compliances have been formulated based on the regulatory review as provided by the principal certifying authority. Where not listed herein the building is required to achieve compliance with relevant DTS provisions or if existing, comply with relevant codes, reports and / or Standards approved at the time of consideration.

The following table lists the departures from the DTS provisions of the BCA for the proposed building and the analysis methodology proposed for the Fire Engineering assessment, which is to be generally in accordance with the IFEG [3].

7.2 BCA DTS NON-COMPLIANCE ASSESSMENT

Table 7-1: Summary of Alternative Solutions

| BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT | PERFORMANCE BASED SOLUTION |
|--|--|
| <p>Vehicular Perimeter Access</p> <p>BCA DTS Provisions C2.4: Requirements for open spaces and vehicular access</p> <p>Performance Requirement(s) CP9</p> | <p>BCA DTS Provision <u>Clause C2.4</u>: The building must be provided with continuous perimeter vehicular access with no part of the roadway less than 6m in width and no more than 18m from the building. The pathway must also permit the passage and operations of fire brigade appliances.</p> <p>DTS Non-conformance The following non-conformances have been identified:</p> <ul style="list-style-type: none"> Access paths along Estate Road and some hardstands are greater than 18m from the buildings (Lot 1A, 1B, 1C and 1D). Continuous vehicular access is not provided around the entire building (to the north of Lot 1A). <p>Alternative Solution The acceptance of the above non-conformances is based on the following fire safety systems/measures provided.</p> <ul style="list-style-type: none"> The areas greater than 18m from the building are accessible for pedestrians and smaller vehicles via the carpark hardstand and dedicated pathways. For Lot 1A, access is provided in a forward direction around the remaining three sides, with access on the eastern side being via on Lot 1B. For Lot 1C, access is available to the Lot via Estate Road 02 before Estate Road 07, reducing the reliance upon traveling via the south-western which is greater than 18m from the building. <p>Assessment Methodology The assessment methodology follows Clauses A0.5(b)(i), A0.9(b)(ii) and A0.10 of the BCA. An absolute and qualitative approach fire safety engineering assessment shall be completed to establish that the design matches the relevant Performance Requirement in facilitating direct adequate access and entry into the building to undertake fire and emergency intervention activities.</p> |
| <p>Extended Travel Distances & Smoke Hazard Management – Non-Dangerous</p> | <p>BCA DTS Provision <u>Clause D1.4</u> travel distance to the nearest exit must not exceed 40 metres. <u>Clause D1.5</u> travel distance between alternative exits must not exceed 60 metres. <u>Clause E2.2 (Table E2.2a)</u> requires an automatic smoke exhaust system be installed in the buildings exceeding 108,000m³ in volume.</p> |

| BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT | PERFORMANCE BASED SOLUTION | | | | | | | | | | | | | | | |
|--|---|---|----------------------------------|---|----|-----|------|----|-----|------|----|-----|------|------------------------|-----|------|
| <p>Goods Tenancies</p> <p>BCA DTS Provisions</p> <p>Clause D1.4: Distance to the nearest exit.</p> <p>Clause D1.5: Distance between alternative exits.</p> <p>Clause E2.2: Smoke hazard management</p> <p>Performance Requirement(s)</p> <p>DP4 & EP2.2</p> | <p>DTS Non-conformances</p> <p>The following non-conformances have been identified in the following warehouses:</p> <ul style="list-style-type: none"> The travel distances to nearest exits and between alternative exits exceed 40m and 60m respectively. <table border="1" data-bbox="416 501 1378 797"> <thead> <tr> <th>LOT</th> <th>TRAVEL DISTANCE TO NEAREST EXITS</th> <th>TRAVEL DISTANCE BETWEEN ALTERNATIVE EXITS</th> </tr> </thead> <tbody> <tr> <td>1A</td> <td>65m</td> <td>130m</td> </tr> <tr> <td>1B</td> <td>80m</td> <td>160m</td> </tr> <tr> <td>1C</td> <td>95m</td> <td>180m</td> </tr> <tr> <td>1D (Tenancy 1 only)</td> <td>85m</td> <td>175m</td> </tr> </tbody> </table> <ul style="list-style-type: none"> A manual smoke clearance system shall be installed in each warehouse, in lieu of the DTS required automatic smoke exhaust. <p>Alternative Solution</p> <p>The Alternative Solution will rely upon the volume of the warehouse enclosure to act as a smoke reservoir for hot combustion products with significant reserve so as to provide the population with adequate time to safely evacuate the building prior to the onset of untenable conditions. Furthermore, exits are evenly distributed around the perimeter access.</p> <p>Assessment Methodology</p> <p>The assessment methodology will adhere to Clauses A0.5(b)(i), A0.9(b)(ii), and A0.10 of the BCA. The analysis will be absolute and quantitative where the results of the deterministic assessment are measured directly against the agreed acceptance criteria, with a supporting qualitative argument.</p> <p>Computational Fluid Dynamic (CFD) programs will be used to simulate the fire development and smoke spread in the warehouses with these results utilised in an ASET/RSET time-line analysis.</p> | LOT | TRAVEL DISTANCE TO NEAREST EXITS | TRAVEL DISTANCE BETWEEN ALTERNATIVE EXITS | 1A | 65m | 130m | 1B | 80m | 160m | 1C | 95m | 180m | 1D (Tenancy 1 only) | 85m | 175m |
| LOT | TRAVEL DISTANCE TO NEAREST EXITS | TRAVEL DISTANCE BETWEEN ALTERNATIVE EXITS | | | | | | | | | | | | | | |
| 1A | 65m | 130m | | | | | | | | | | | | | | |
| 1B | 80m | 160m | | | | | | | | | | | | | | |
| 1C | 95m | 180m | | | | | | | | | | | | | | |
| 1D (Tenancy 1 only) | 85m | 175m | | | | | | | | | | | | | | |
| <p>Extended Travel Distances & Smoke Hazard Management – Warehouse 1D Tenancy 2 (Dangerous Goods)</p> <p>BCA DTS Provisions</p> <p>Clause D1.4: Distance to the nearest exit.</p> <p>Clause D1.5: Distance between alternative exits.</p> <p>Clause E1.10: Provision for special hazards</p> | <p>BCA DTS Provision</p> <p><u>Clause D1.4</u> travel distance to the nearest exit must not exceed 40 metres.</p> <p><u>Clause D1.5</u> travel distance between alternative exits must not exceed 60 metres.</p> <p><u>Clause E1.10</u> suitable additional provision must be made if special problems of firefighting could arise because of the nature or quantity of materials stored.</p> <p><u>Clause E2.2 (Table E2.2a)</u> requires an automatic smoke exhaust system be installed in the buildings exceeding 108,000m³ in volume.</p> <p><u>Clause E2.3</u> Additional smoke hazard management measures may be necessary due to the special characteristics, special function, special type or quantity of materials stored, or special mix of classifications within a building or fire compartment.</p> <p>DTS Non-conformances</p> <p>The following non-conformances have been identified in Tenancy 2 of Warehouse 1D:</p> <ul style="list-style-type: none"> The travel distances to nearest exits and between alternative exits are up to 85 m and 175 m in lieu of 40m and 60m, respectively. Smoke exhaust rates are to be rationalised. Smoke zones exceed an area of 2,000 m². <p>Alternative Solution</p> <p>The volume of the warehouse enclosures act as a smoke reservoir for hot combustion products, providing the population with adequate time to safely evacuate the building</p> | | | | | | | | | | | | | | | |

| BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT | PERFORMANCE BASED SOLUTION |
|--|---|
| <p>Clause E2.2: Smoke hazard management</p> <p>Clause E2.3: Provision for special hazards</p> <p>Performance Requirement(s) DP4 & EP2.2</p> | <p>prior to the onset of untenable conditions. Additionally, the sprinkler system is expected to limit the fire growth upon activation, whilst the automated smoke exhaust system is seen to increase the tenability period for occupant evacuation. Furthermore, exits are evenly distributed around the perimeter access and occupants are provided with prompt occupant warning due to the smoke detection system.</p> <p>Assessment Methodology</p> <p>The assessment methodology will adhere to Clauses A0.5(b)(i), A0.9(b)(ii), and A0.10 of the BCA. The analysis will be absolute and quantitative where the results of the deterministic assessment are measured directly against the agreed acceptance criteria, with a supporting qualitative argument.</p> <p>Computational Fluid Dynamic (CFD) programs will be used to simulate the fire development and smoke spread in the warehouse tenancy with these results utilised in an ASET/RSET time-line analysis.</p> |
| <p>Exit Sign Height</p> <p>BCA DTS Provisions Clause E4.6 – Direction signs (inter-alia AS2293.1: 2005)</p> <p>Performance Requirement(s) EP4.2</p> | <p>BCA DTS Provision</p> <p>BCA DTS Clause E4.6 (NSW) states that if an exit is not readily apparent to persons occupying or visiting the building, then exit signs must be appropriately provided in accordance with AS2293.1.</p> <p>AS2293.1 Clause 6.8.1 requires exit signs be mounted not less than 2m and not more than 2.7 above floor level.</p> <p>DTS Non-conformance</p> <p>The exit lighting design shall incorporate directional signage in the warehouse positioned above a height of 2.7m to permit the passage of picking machinery below. Exit sign height to be up to 4.5m above ground level.</p> <p>Final exit signs, located above warehouse doors, may be positioned up to 1m above the door to allow greater visibility of the signs past the block storage arrangement.</p> <p>Alternative Solution</p> <p>The Alternative Solution shall rely upon the volume of the warehouse enclosures to provide an improved duration compared to a DTS design to allow the building population to evacuate prior to the directional exit signs becoming compromised by the hot smoke layer.</p> <p>Further to this, the simplicity of the racking layouts and the familiarity of the occupants within the building shall provide for a rapid evacuation along familiar egress routes.</p> <p>Jumbo size exit signs shall be provided in locations where signage is required above 2.7m from FFL.</p> <p>Assessment Methodology</p> <p>The assessment methodology will adhere to Clauses A0.5(b)(ii), A0.9(b)(ii) and A0.9(c), and A0.10 of the BCA. The analysis will consist of a semi quantitative and qualitative comparative discussion to demonstrate compliance with the relevant Performance Requirements. The assessment will demonstrate that the risk associated with obscuration of the exit signs is equivalent to the risk in a DTS Solution.</p> |

8 PROPOSED FIRE SAFETY STRATEGY

8.1 OVERVIEW



The fire safety strategy outlined below has been proposed to satisfy the fire and life safety objectives specified for this project by the relevant stakeholders. In addition, the fire safety strategy is required to adequately address the specific fire and life safety hazards identified for the proposed development, and as such have been generally derived from the preventative and protective measures outlined within the BCA, and fire engineering literature and research. Where items of non-compliance have not been identified by the design team in the concept design it is considered that those items are expected to be deemed-to-satisfy solutions.

This Section provides guidance for the design and application of fire safety measures. It highlights specific design considerations for a range of fire safety measures that will undergo analysis as part of the Fire Engineering Report to ascertain whether the relevant Performance Requirements of the BCA are satisfied. Design guidance (general informative details and specific requirements) for a range of specific fire safety measures is provided. This list is not exhaustive and the use of other fire safety measures including new technologies will require additional review.

8.2 PASSIVE FIRE PROTECTION

8.2.1 Type of Construction Required

Each building shall be built as a large-isolated building, and therefore in accordance with the BCA DTS provisions for Type C fire-resisting construction.

- Within tenancy 2 of Warehouse 1D, aerosols are to be stored in a separate caged enclosure.

8.3 EGRESS PROVISIONS

8.3.1 Evacuation Strategy

Activation of any sprinkler heads or detectors shall initiate the evacuation of all areas of each building. Dedicated fire wardens from each warehouse and office shall ensure that all clients, visitors, and staff are promptly evacuated.

8.3.2 Egress Provisions

In each warehouse, travel distances to the nearest exit and between alternative exits must be compliant with the BCA DTS requirements with the following exceptions identified and illustrated in the following figures:

- The travel distances to nearest exits and between alternative exits exceed 40m and 60m respectively.

Table 8-1: Non-conformant Travel Distances

| LOT | TRAVEL DISTANCE TO NEAREST EXITS | TRAVEL DISTANCE BETWEEN ALTERNATIVE EXITS |
|-----|----------------------------------|---|
| 1A | 65m | 130m |
| 1B | 80m | 160m |
| 1C | 95m | 180m |
| 1D | 85m | 175m |

These non-conformances shall be addressed through an Alternative Solution.

Additional exits shall be provided as necessary to ensure that occupant travel distances do not exceed the limitation defined by Fire & Rescue NSW, **“no point in a fire compartment is to be more than 100 m from a hydrant external to that compartment”**.

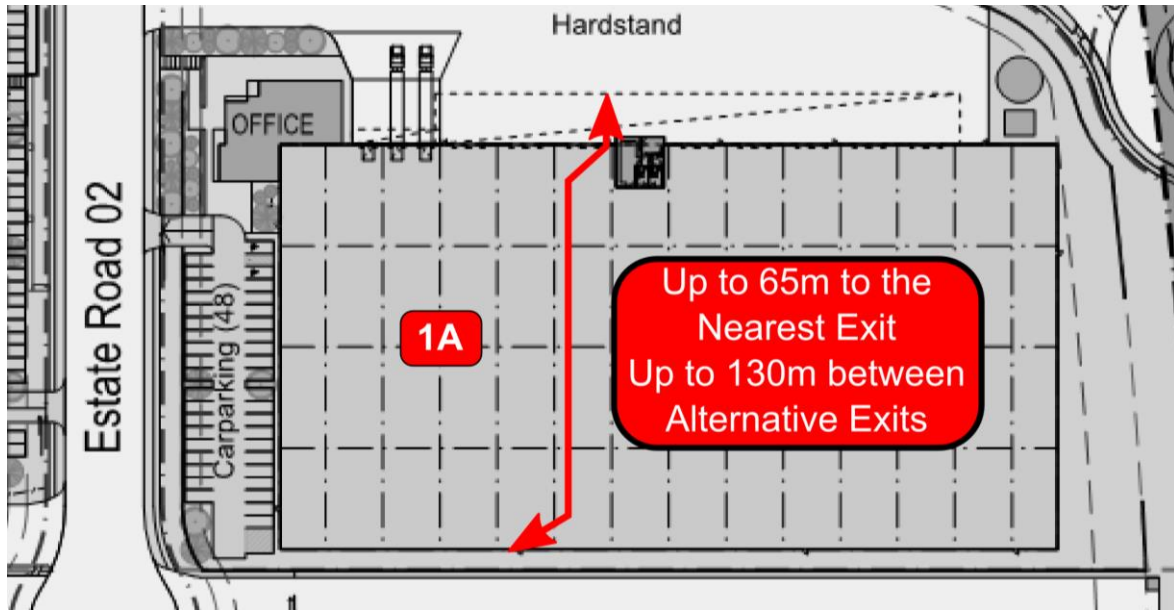


Figure 8-1: DTS Non-Compliant Travel distances on Lot 1A

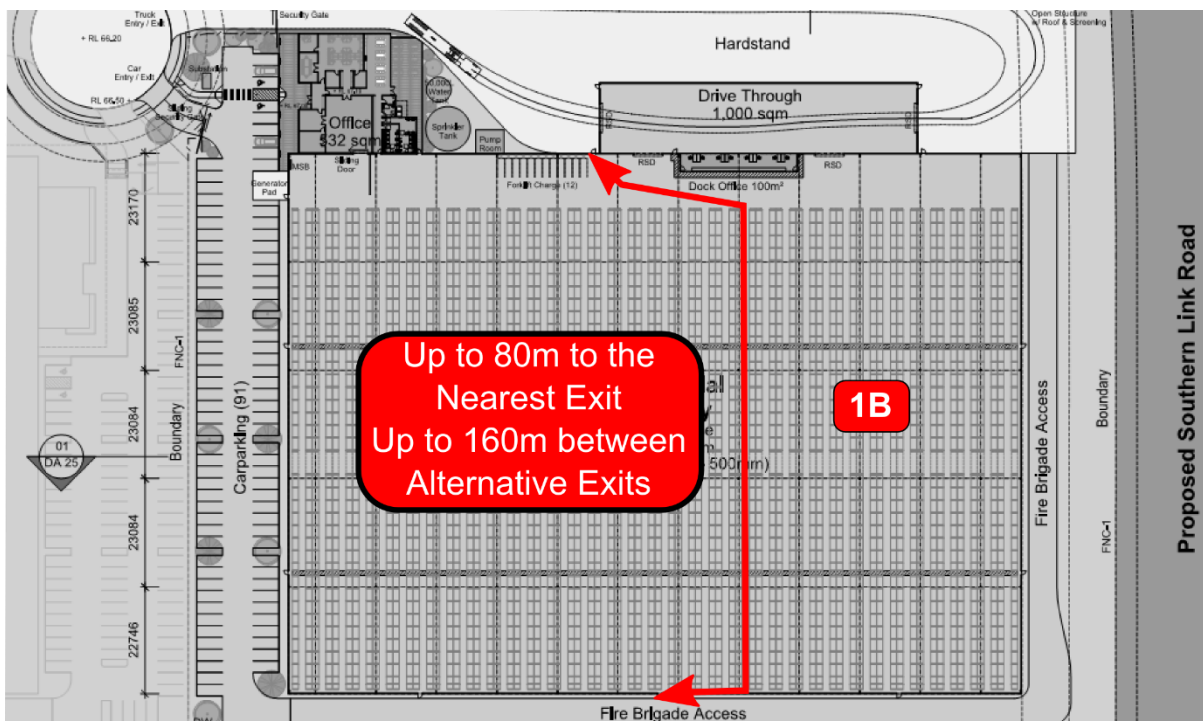


Figure 8-2: DTS Non-Compliant Travel distances on Lot 1B

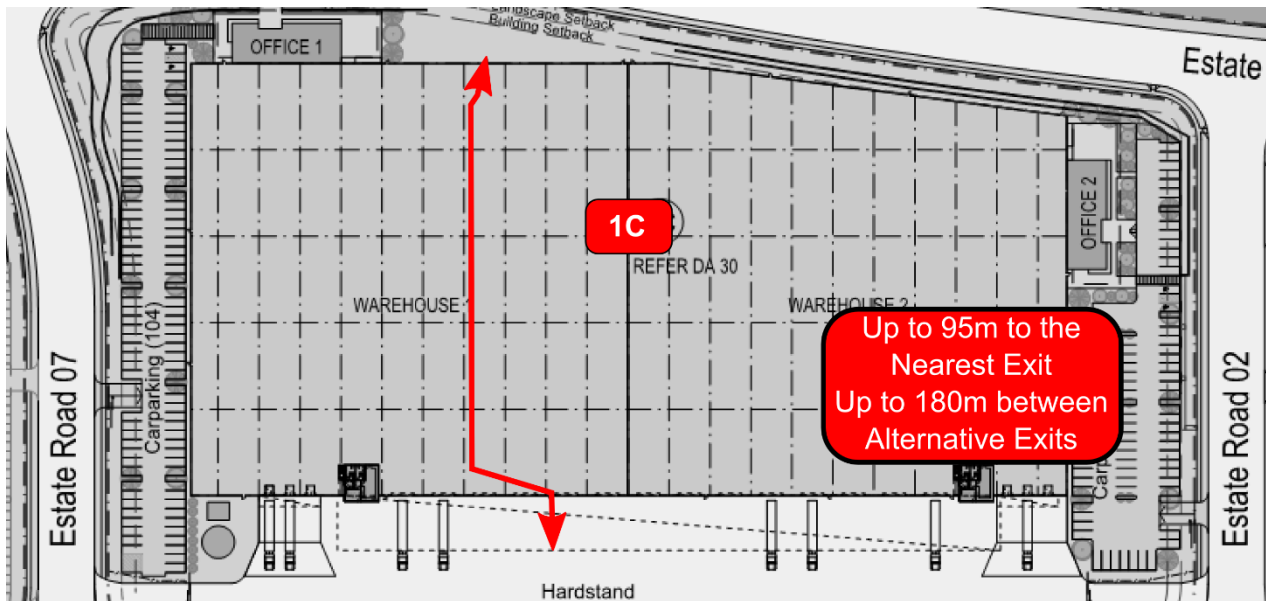


Figure 8-3: DTS Non-Compliant Travel distances on Lot 1C

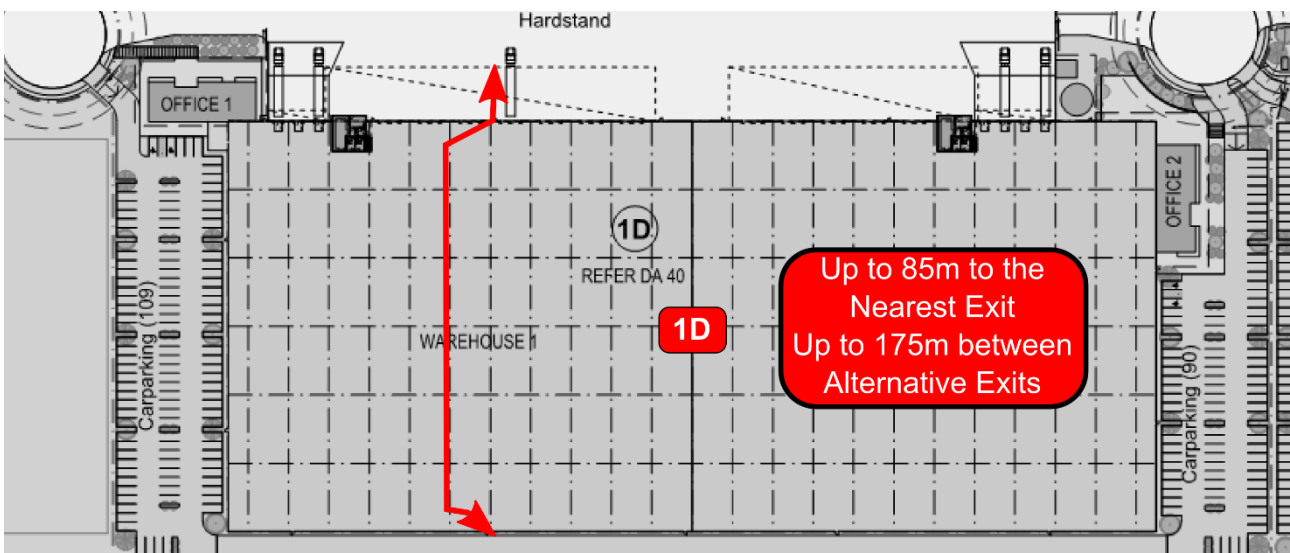


Figure 8-4: DTS Non-Compliant Travel distances on Lot 1D

8.3.3 Door Hardware, Operation and Mechanisms

All exit doors and doors in a path of travel to an exit are required to be DTS compliant throughout each building. This includes the swing of doors, the applied latching and locking mechanisms and the force required on mechanism used to open sliding doors.

8.3.4 Signage and Lighting

Emergency lighting is to be provided throughout each building in accordance with DTS Provisions E4.2 and E4.4 of the BCA 2015 and AS2293.1:2005.

Exit signage is to be provided throughout each building in accordance with the DTS Provisions E4.5, E4.6, E4.8 of the BCA 2015 and AS2293.1:2005 with the directional signage at the end of the racking aisles and above block storage areas permitted to be installed at a height greater than 2.7m.

- Exit signs and directional signs shall be “Jumbo size” to increase the visibility to occupants.
- The final height and location of the directional exit signs shall be determined through the fire engineering analysis.

8.4 ACTIVE FIRE PROTECTION SYSTEMS

8.4.1 Building Occupant Warning System

A building occupant warning system shall be provided throughout all parts of each warehouse building. The system shall be in accordance with the prescriptive requirements of Specification E1.5 and Clause 6 of Specification E2.2a of the BCA and AS1670.1:2015.

- The occupant warning alarm shall be sounded throughout all areas of each warehouse building upon activation of the smoke detection or sprinkler systems.

8.4.2 Smoke Detection System

It is our experience that a smoke detection system for occupant warning is unlikely to be required throughout the warehouses due to their large volume. This is to be confirmed through detailed fire engineering analysis, but it is expected that:

- In the event of future subdivisions of warehouse buildings into smaller tenancies, there might arise a need for smoke detection.
- In the event of travel distances in excess of the DtS Provisions being present in the building offices, detection will likely be required throughout each affected office in accordance with AS1670.1:2015.

Within Tenancy 2 of Warehouse 1D, an automatic detection system is required due to the storage of Dangerous Goods, provided to activate automatic smoke exhaust and occupant warning.

- Given the nature of the tenancy, it is recommended that roof level detectors will be required for the benefit of occupant evacuation. The following design requirements are expected, and should be reviewed and confirmed through the detailed fire engineering analysis:
 - These detectors shall be spaced in accordance with DtS Specification E2.2b Clause 8 and Specification E2.2a Clause 5, i.e. no greater than 20 m apart and no greater than 10 m from a wall or bulkhead.
 - Within specific Dangerous Goods enclosures, detectors shall be located on 10 m maximum spacings (5 m from walls or baffles).
- The detector obscuration threshold installed must not exceed 8% smoke obscuration per metre.
- Throughout the warehouse areas, detection shall activate the smoke exhaust as per Specification E2.2b (Clause 8) in the area of activation.
- Any detector activation shall sound the occupant warning system throughout the building.
- Any smoke detector activation shall initiate direct brigade notification.

8.4.3 Fire Sprinkler System

A fire sprinkler system shall be provided throughout each building in accordance with the relevant regulatory requirements. The site shall have an independent system with dedicated fire pump, water supply tanks and booster assemblies. Confirmation of the below requirements should be sought from a qualified fire services designer.

- In the offices and beneath the warehouse awnings the system shall comply with BCA Specification E1.5 and AS2118.1:1999.
- In the warehouse a storage mode system shall be provided in accordance with BCA Specification E1.5 and AS2118.1:1999, with the sprinkler head location, spacing and design capacity in accordance with Factory Mutual Guidelines 2-0 and 8-9 (or NFPA regulations). Sprinkler activation temperature must be no greater than 101°C and have a Response Time Index (RTI) of less than $50\text{m}^{1/2}\text{s}^{1/2}$ (i.e. fast response type).
- In-rack sprinkler protection is to be provided where required to accommodate the storage of Dangerous Goods.

Upon detection of a fire the building occupant warning alarm shall be initiated throughout the affected building and the direct brigade notification activated. Additionally, automated functions within the Autostore are to automatically shut down upon fire trip within Warehouse 1D.

Note that at the time of the construction certificate application, the adoption of the new sprinkler standard AS2118.1:2017 will be necessary.

8.5 FIRST AID FIRE FIGHTING

8.5.1 Fire Hose Reels

Fire hose reel shall be provided throughout each building in accordance with Clause E1.4 of the BCA and AS2441:2005.

Locations should be signposted and readily accessible to occupants. Use of facilities should be monitored for abuse, mistreatment and servicing. The fire hose reels shall be located within 4m of an exit and provide coverage to all areas of each building based on a 36m hose length with a 4m water stream (i.e. maximum 40m coverage from the hose location).

Where coverage is not achieved by fire hose reels located at exits, additional fire hose reels shall be provided along travel paths to ensure coverage.

8.5.2 Portable Fire Fighting Equipment

Portable fire extinguishers are to be provided throughout each building in accordance with Table E1.6 of the BCA and selected, located, and distributed in accordance with AS2444:2001. As a guide:

| | | |
|--|-----------------------|--------|
| • General office areas | Dry Powder (ABE type) | 2.5Kg |
| • Computer/server rooms | CO ₂ | 3.5 Kg |
| • Plant rooms | Dry Powder (ABE) | 2.5 Kg |
| • Designated exits | Dry Powder (ABE) | 4.5 Kg |
| • Adjacent each fire hose reel cabinet | Dry Powder (ABE) | 4.5 Kg |

8.6 FIRE BRIGADE INTERVENTION

8.6.1 Fire Indicator Panels

A Fire Control Centre will be provided to Lot 1A, 1B, 1C and 1D. Each lot shall be provided with a Main Fire Indicator Panel (FIP) within a compliant fire control centre.

The Main FIPs must be installed in accordance with BCA Specification E2.2a and AS1670.1:2015 and have the following capabilities.

- The FIP panel must be capable of isolating, resetting, and determining the fire location within each building.
- A red strobe shall be installed at the entry door to the FIP to alert arriving fire brigade of the fire alarm origin and FIP location.
- Smoke clearance fan controls shall be provided at the FIP, if a separate fire fan control panel is provided it shall include a display to indicate the operation or otherwise of the fans.
- The panel shall include clear signalling of the operational status of the fans. A local fire fan control panel shall include override controls of smoke clearance and supply fans.
- Sub-FIP panels shall be provided to:
 - Office 1 on Lot 1C.
 - Office 1 on Lot 1D.

8.6.2 Fire Hydrants

A dedicated hydrant system, with independent booster assembly, must be provided for each lot.

The fire hydrant system shall be in accordance with BCA Clause E1.3 and AS2419.1:2005 with the following specifications:

- Hydrants located beneath the warehouse awnings shall be considered as *internal hydrants*.
- The systems must be capable of providing coverage to all parts of the building based on a 30m (internal hydrant connections) and a 60m (external hydrants) hose length with an additional 10m water stream.
- As far as possible the hydrant system should consist of external hydrant points, with internal hydrants only provided to achieve coverage to those areas not able to achieve coverage from external hydrant points.
- Each system shall incorporate a ring main with isolation valves that are external to the building and numbered with the corresponding numbers indicated on the blockplan at the booster assembly.

- External hydrant connections shall be provided with the heat shields per the requirements of AS2419.1 (i.e. FRL 90/90/90 2m either side, and 3m above the hydrant connection point) or be setback more than 10m from the building.
- All hydrant connection points and the booster assembly must be fitted with Storz hose couplings which comply with Clause 7.1 and 8.5.11 AS2419.1:2005. Further information is available from the FRNSW Guide Sheet No.4 'Hydrant system connectors' available at www.fire.nsw.gov.au.
- Per the request of FRNSW, where internal hydrants are installed within the warehouse these shall be designed to allow progressive movement through the building such that an internal hydrant is within 50m of an external hydrant and 25m of an internal hydrant.
- If within or affixed to the external wall of the building, the booster shall be within sight of the main entrance to the building and separated from the building by a 90/90/90 FRL construction for a distance of not less than 2m each side and 3m above the upper hose connections in the booster assembly.
- If remote from the building, the hydrant booster shall be located not less than 10m from the external wall of the building, adjacent to the principal vehicular access to the site, at the boundary of the site, and be within sight of the main entrance of the building.

8.6.3 Manual Smoke Clearance System

In lieu of the BCA required automatic smoke exhaust system, Warehouse 1A, 1B, 1C and Tenancy 1 of Warehouse 1D shall be provided with a manually operated smoke clearance system. The smoke clearance system shall be designed to achieve the following minimum performance requirements.

- Initiation switches shall be located on the Main FIP, or an adjacent panel, at the office's main entry.
- Signs alerting the Fire Brigade to the operation of the smoke clearance system must be provided.
- Fire rated fans and fire rated cabling shall be designed to operate at 200°C for a period no less than 60 minutes.
- System capacity must be capable of an exhaust rate equal to one enclosure air change per hour.
- It is recommended that multiple fans be provided and be evenly distributed to otherwise comply with the requirements of Specification E2.2b Clause 5 of the BCA.
- Adequate make-up air shall be provided at low level to facilitate the clearance system's designed operational capacity. The make-up air shall be provided at low level by:
 - Permanently open natural ventilation louvers; and/or
 - Perforated roller shutters; and/or
 - Mechanically operated louvers that open upon activation of the fans. All motors and cables to automatic louvers, vents or supply fans must be fire rated to operate at 200°C for a period of 60-minutes.

Note that manual opening of the dispatch rollers doors is not considered an acceptable method of achieving the required makeup air supply.

8.6.4 Automatic Smoke Exhaust System

Specific to Tenancy 2 of Warehouse 1D only, an automatic smoke exhaust system shall be provided with requirements as follows:

- On-Auto-Off switches should be located at the FIP.
- Signs and a mechanical block plan alerting the fire brigade to the operation of the smoke exhaust system must be provided.
- The system capacity must be capable of an exhaust rate equal to one enclosure air change per hour. Note that this exhaust rate is subject to change following completion of the detailed fire engineering analysis.
- The make-up air for the enclosure is to be designed on the basis of limiting the inlet velocity to less than 2.5 m/s.
- Fire-rated fans and fire rated cabling should be designed to operate at 200°C for a period no less than 60 minutes.
- The system shall be connected to an essential power supply.
- It is recommended that multiple fans be provided and be evenly distributed to otherwise comply with the requirements of Specification E2.2b Clause 5 of the BCA.

- It is not anticipated that AS1940 mechanical ventilation systems will be required in this instance. However, should they be provided, these systems are to automatically shut down upon activation of smoke exhaust system.

8.6.5 Vehicular Perimeter Access

The vehicular perimeter access pathway shall be provided around the whole of the building. These shall be designed and constructed in all-weather surface capable of supporting all FRNSW appliances in accordance with BCA Clause C2.4 and NSW Fire Brigade Policy No. 4 '*Guidelines for emergency vehicle access*', available at http://www.fire.nsw.gov.au/gallery/files/pdf/guidelines/vehicle_access.pdf with the following exception permitted:

- Access paths along Estate Road and some hardstands are greater than 18m from the buildings (Lot 1A, 1B, 1C and 1D).
- Continuous vehicular access is not provided around the entire building (to the north of Lot 1A).

To facilitate the perimeter access non-conformances, the following measures shall be provided as part of the Alternative Solution:

- The areas greater than 18m from the building are accessible for pedestrians and smaller vehicles via the carpark hardstand and dedicated pathways.
- All gates, security fencing and boom gates shall be readily openable by the fire authorities. This can be achieved through one, or a combination of, the following –
 - Fitted with locks that are openable with a 003 key; and/or
 - Fitted with locks / latches that are openable with a master key, swipe or badge with copies of these keys/swipes/badges provided to the two local fire brigade stations; and/or
 - Mechanical gates and boom gates shall open on fire trip and power failure.

8.7 BUILDING MANAGEMENT PROCEDURES

The ongoing management of each building is as important in maintaining a high level of life safety as the provisions recommended during the design phase of each building.

8.7.1 Maintenance of Fire Safety Equipment

The fire detection systems, fire sprinkler systems, emergency warning systems, fire hydrants, hose reels, portable fire extinguishers, emergency lighting and any other fire safety equipment shall be tested and maintained in accordance with Australian Standard AS1851 or other relevant testing regulatory.

The smoke clearance system shall be tested in accordance with the AS1851 requirements for an automatic smoke clearance system as applicable.

8.7.2 Evacuation Plan

An evacuation plan should be developed for the sites in accordance with AS3745:2010. Standard fire orders should be displayed throughout each building.

9 REFERENCES

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