FIRE SAFETY STRATEGY

Augusta Street Huntingwood

Report Number:

222026_FSS_06

Date:

29/08/2023

The Trustee for Huntingwood Property Trust
Level 46, 1 Macquarie Place, Sydney NSW 2000

Affinity Fire Engineering (UK) Ltd
40 Bowling Green Lane
London, EC1R 0NE
+44 (0) 20 3384 0050
enquiries@affinity-eng.com

Affinity Fire Engineering
Suite 6.03, 65 Berry Street
North Sydney NSW 2060
+61 2 9194 0590
enquiries@affinity-eng.com

Affinity Fire Engineering
Suite 123, 757 Bourke Street
Docklands VIC 3008
+61 3 8616 0686
enquiries@affinity-eng.com

REPORT DETAIL

Project:	Warehouse & Distribution Facility
Address:	Augusta Street Huntingwood
Document:	Final Issue - Fire Safety Strategy
Report No. & Ref.:	222026_FSS_06

Report Revision History

Rev	Date	Comment	Prepared By
01	21/06/2023	Draft Issue	**Thomas O'Dwyer** *BE (Building), Grad Dip (Performance Based Building & Fire Codes)* *C10 Accreditation BDC0766*
02	30/06/2023	Final Issue	
03	05/07/2023	Final Issue	
04	18/07/2023	Updated Final	
05	28/08/2023	Updated Final	
06	28/08/2023	FINAL	

EXECUTIVE SUMMARY

Affinity Fire Engineering Pty Ltd, has been commissioned by The Trustee for Huntingwood Property Trust to prepare this Fire Safety Strategy report in support of the State Significant Development Application (SSD-36138263) for the proposed multi warehouse and distribution centre at Augusta Street in Huntingwood, NSW.

This Fire Safety Strategy (FSS) outlines the fire engineering principles that will be utilised in ensuring that the prescriptive non-compliances with the Deemed-to-Satisfy (DTS) provisions of the Building Code of Australia 2022 (BCA) [1], as noted herein, are resolved through a fire engineered Performance Solution in order to conform to the building regulations at a construction certificate stage.

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

CONTENTS

1 INTRODUCTION & SCOPE

1.1 Overview

This Fire Safety Strategy has been undertaken and nominates Performance Solutions for assessing compliance with the nominated Performance Requirements of the BCA [1] in accordance with the methodologies defined in the AFEG [3] and provide a workable and safe Fire Safety Strategy.

1.2 Fire Safety Objectives

The objective of the Fire Engineering Assessment is to develop a Fire Safety System, which satisfied the Performance Requirements of the National Construction Code (NCC) 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 NCC, *"Compliance with the NCC is achieved by satisfying the Performance Requirements"*. In addition to this, certain non-regulatory objectives exist as detailed below.

1.2.1 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) [14] as per the Fire Services State and Territory Acts and Regulations.

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

1.2.2 Building Regulatory Objectives

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

- **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.

1.2.3 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. The client and stakeholders for the design have not requested any additional nonprescribed objectives are required to be met through the preparation of the FER.

1.3 Regulatory Framework of the Fire Engineering Assessment

1.3.1 National Construction Code Series - Building Code of Australia

One of the goals of the BCA [1] 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 A2.1 of the BCA [1] outlines how compliance with the Performance Requirements can be satisfied. These are as follows:

1. Performance Solution; or
2. Deemed-to-Satisfy Solution; or
3. Combination of (1) and (2).

Sections A2.2 of the BCA provides several different methods for determining that a Performance Solution complies with the Performance Requirements. These methods are summarised as follows:

1) A Performance Solution is achieved by demonstrating-

   (a) Compliance with all relevant Performance Requirements; or

   (b) The solution is at least equivalent to the Deemed-to-Satisfy Provisions.

2) A Performance Solution must be shown to comply with the relevant Performance Requirements through one or a combination of the following Assessment Methods:

   (a) Evidence of suitability in accordance with Part A5 that shows the use of a material, product, plumping and drainage product, form of construction or design meets the relevant Performance Requirements.

   (b) Verification Methods including the following:

      (i) The Verifications Methods in the NCC

(ii) Other Verification Methods accepted by the appropriate authority that show compliance with the relevant Performance Requirements.

(c) Expert Judgment.

(d) Comparison with the Deemed-to-Satisfy Provisions.

3) Where a Performance Requirement is satisfied entirely by a Performance Solution, in order to comply with (1) the following method must be used to determine the Performance Requirement or Performance Requirements relevant to the Performance Solution:

(a) Identify the relevant Performance Requirements from the Section or Part to which the Performance Solution applies.

(b) Identify Performance Requirements from the other Section or Parts that are relevant to any aspects of the Performance Solution proposed or that are affected by the application of the Performance Solution.

4) Where a Performance Requirement is proposed to be satisfied with a Performance Solution, the following steps must be undertaken:

(a) Prepare a performance-based design brief in consultation with relevant stakeholders.

(b) Carry out analysis, using one or more of the Assessment Methods listed in (2), as proposed by the performance-based design brief.

(c) Evaluate results from (b) against the acceptance criteria in the performance-based design brief.

(d) Prepare the final report that includes-

(i) All Performance Requirements and/or Deemed-to-Satisfy Provisions identified through A2.2(3) or A2.4(3) as applicable: and

(ii) Identification of all Assessment Methods used; and

(iii) Details of steps (a) and (c); and

(iv) Confirmation that the Performance Requirement is met; and

(v) Details of conditions or limitations, if any exist, regarding the Performance Solution.

Section A2.3 of the BCA states that a solution that complies with the Deemed-to-Satisfy Provisions is deemed to have met the Performance Requirements. A Deemed-to-Satisfy Provision can be shown compliance with the Deemed-to-Satisfy Provisions through one or more of the following Assessment Methods:

(a) Evidence of suitability in accordance with Part A5 that shows the use of a material, product, plumping and drainage product, form of construction or design meets the relevant Performance Requirements.

(b) Expert Judgement.

As described in Section A2.4 a combination of Performance Solutions and Deemed-to-Satisfy Solutions may be used to satisfy the Performance Requirements. When using a combination of solutions, compliance can be shown through the following, as appropriate:

(a) Section A2.2 for assessment against the relevant Performance Requirements.
(b) Section A2.3 for assessment against the relevant Deemed-to-Satisfy Provisions.

Where a Performance Requirement is satisfied by a Performance Solution in combination with a Deemed-to-Satisfy Solution, in order to comply with (1), the following method must be used to determine the Performance Requirement or Performance Requirements relevant to the Performance Solution:

(a) Identify the relevant Deemed-to-Satisfy Provisions of each Section or Part that are to be the subject of the Performance Solution.

(b) Identify the Performance Requirements from the same Sections or Parts that are relevant to the identified Deemed-to-Satisfy Provisions.

(c) Identify Performance Requirements from other Sections or Parts that are relevant to any aspects of the Performance Solution proposed or that are affected by the application of the Deemed-to-Satisfy Provisions that are subject of the Performance Solution.

1.3.2 Australian Fire Engineering Guidelines (AFEG)

The AFEG [4] document has been developed for use in fire safety design and assessment of buildings and reflects Australia'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 Performance Solution against the Performance Requirements of the BCA. The prescribed methodology set out in the AFEG has been generally adopted in this Fire Engineering Report (FER) for the assessment of each individual deviation from the prescriptive provisions as identified by the Principal Certifier. With the design of each deviation developed with a holistic understanding of the impact of the requirements and deviations assessed on the overall risk of fire spread, and occupant and fire fighter life safety.

AFFINITY have not undertaken a BCA compliance review of the project. There are professionals employed in the building process that determine the level of compliance with the Deemed-to-Satisfy (DtS) provisions of the BCA. Conformation of compliance with the applicable BCA is the role of the BCA consultant / Principal Certifier. Where not commented on within this report it is the expectation that the design complies with the BCA.

1.4 Stakeholders

The Performance Solution has been developed collaboratively with the relevant stakeholders as identified in Table 1-1.

Table 1-1: Relevant Stakeholders

Role	Organisation	Contact Name
Developer	Logos Group	Athlene Kyle
Architecture	Pace Architecture	Patrick Pace
Civil Engineer	Costin Roe	Mark Wilson
Structural Engineer	Costin Roe	Grant Roe
Mechanical Engineer	Grosvenor Engineering Group	Peter Souflias
Fire Services	Force Fire	Aaron Mugica Ryan Williamson
Hydraulic Engineer	Argent Consulting	Peter Argent
Traffic Consultant	Colston Budd Rogers & Kafes	Stan Kafes
BCA Consultant	McKenzie Group Consulting	Michael Krogh
Fire Safety Consultant	Affinity Fire Engineering	Thomas O'Dwyer

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.

1.5 Sources of Information

The following sources of information have been relied upon in the preparation of this document:

- BCA Compliance Report prepared by McKenzie Group Consulting (Ref: Reference 220323-01BCA, Revision: V1, Dated: 05/07/2023).
- Architectural plans provided by Pace Architecture (ref: 220207, Date: 21/08/23, Issued for SSDA)

1.6 Limitations and assumptions

In this instance, this Fire Safety Strategy has been developed based on applicable limitations and assumptions for the development which are listed as follows:

- This report is specifically limited to the project described in Section 2.
- This report is based on the information provided by the team as listed in Section 1.4.
- Building and occupant characteristics are as per Section 2 and 3 of this document. Variations to these assumptions may affect the Fire Engineering Strategy and therefore they should be reviewed by Affinity Fire Engineering 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 5. 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. Logos has confirmed that DGs are not proposed as part of the SSDA.
- The development complies with the DtS provisions of the NCC [1] with all aspects relating to fire and life safety unless otherwise specifically stated in this report. Where not specifically mentioned, the design is expected to meet the NCC DtS requirements of all relevant codes and legislation at the time of construction and / or at the time of issue of this report.
- It is not the role of Affinity Fire Engineering to review the design for compliance with the prescriptive provisions of the BCA, Australian Standard or applicable regulations.
- The assessment is limited to the objectives of the NCC 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 NCC. 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.
- This Fire Safety Strategy (FSS) 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 0 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.
- This Fire Safety strategy is provided for the purpose of ensuring the design is capable of compliance with the building code based on the preliminary documentation received and hence must not be used for any form of construction documentation.

2 BUILDING CHARACTERISTICS

2.1 Overview

Building characteristics are assessed as part of the Fire Safety Strategy 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 fire-fighting 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, classification and height will dictate passive and active fire safety systems.

2.2 Site Description

The site is located at 3 Augusta Street, 426 Flushcombe Road, remaining subject to Council Street numbering allocation), within the City of Blacktown Local Government Area (LGA). The site comprises multiple parcels of land that is legally described as per the following:

- Lot 1 DP835264
- Lots 218-219 DP457024
- Lot 2151 DP135859
- Lot 2 DP516449
- Lot 163-164, 168-188 and 216 DP8716
- Lot 1 DP119616
- Lots 4-6 DP226294
- Lots 50-52 DP1144623
- Lot 7 DP803359
- Lots 6-10 DP801210
- Lot 4 DP585492
- Lot 4 DP583442
- Lot 2 DP1263824

The site is identified in the following figure.

Figure 2-1: Aerial View of the Site (Source: google maps)

Key features of the site are as follows:

- The site has frontage to the Great Western Highway and the Western Motorway of approximately 940 metres and frontage to Flushcombe Road of approximately 250 metres. Augusta Street dissects part of the western portion of the site and is vested to Blacktown Council.
- Access to the site is currently available from Augusta Street which connects to Flushcombe Road to the west. Flushcombe Road intersects with the Great Western Highway, providing east-west access to the metropolitan road network, with right-in and right-out movements available via the existing signalised intersection.
- The eastern part of the site slopes to the west, while the western part of the site slopes to the east, with the central low point at Blacktown Creek adjacent to the easement for water supply
- The site is affected by multiple easements and restrictions including:
    - Multiple easements up to 30 metres wide for transmission lines along the southern part of the site. The site features high voltage power lines along the southern side.
    - An 10m wide easement for water supply which runs north-south within the central part of the site, with associated 9 metre wide and 3 metre wide easements for construction purposes
- Lot 164 in DP8716 is identified as being owned by Amplitel as the land accommodates a Telstra mobile telecommunications facility which is proposed to be relocated.
- The site has been cleared but is undeveloped with scattered trees across the western boundary and southern boundaries and in the north-eastern corner. Blacktown Creek runs north-south through the central part of the site with riparian vegetation along the corridor.

Key features of the locality:

- The site is approximately 34km west of the Sydney CBD and approximately 3.3km south of the Blacktown commercial centre.
- The region features a mix of land uses, including residential and employment-generating activities. The Huntingwood and Pemulwuy industrial estates are located to the west and south-east.

- The Prospect Reservoir is approximately 1km south of the site adjacent to the Western Sydney Parklands.

The surrounding locality is described as follows:

- North: The site adjoins the Great Western Highway. The land further to the north primarily comprises residential development including detached single and double storey dwellings. A small natural reserve known as Timbertop Reserve separates the residential development and associated landscaping.
- East: The land immediately to the east of the site is vacant. The Prospect Highway is located further east, providing access to the M4 Motorway and Great Western Highway. St Bartholomew's Church and Cemetery is located on the eastern side of the Prospect Highway.
- South: The M4 Motorway runs along the southern boundary of the site, with boundary landscaping providing visual screening of the site. The land on the opposite side of the Motorway comprises recreational and entertainment facilities in the form of a water park and a drive in movie theatre.
- West: The land to the west comprises an animal holding facility and industrial development, characterised by large warehouse buildings

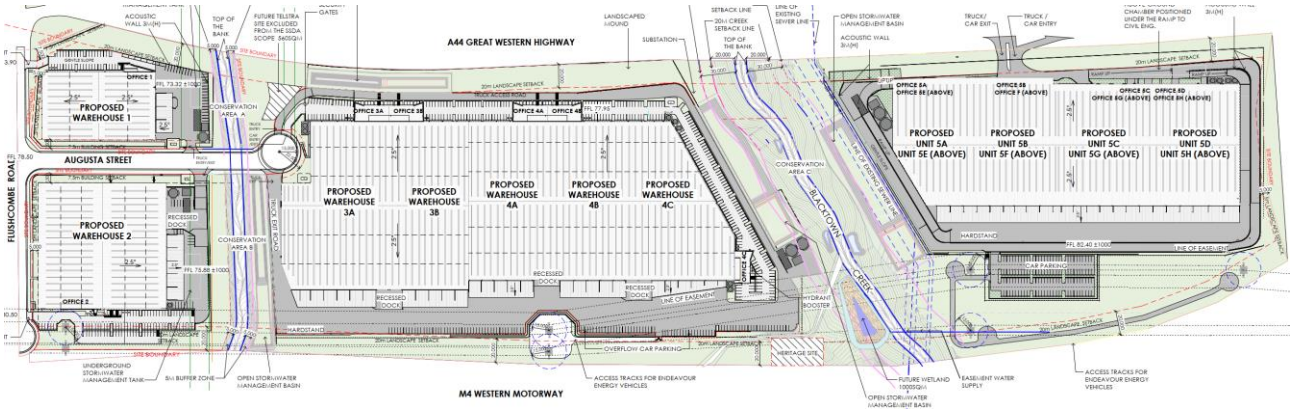


Figure 2-2: Masterplan Site Plan

2.3 Building Descriptions

2.3.1 Warehouse 1 Site Description:

Warehouse 1 is located in the north-western corner of the site and has access from both Flushcombe Road and Augusta Street with northern frontage to the Great Western Highway. The site will accommodate the warehouse, associated 2 storey offices, dispatch and loading areas and staff and visitor car parking. The building shall be approximately 5,935m^2 in floor area, with a height of 16.8m and be constructed in accordance with Type C construction as required for a large isolated building.

The following figure provides an understanding of the site:

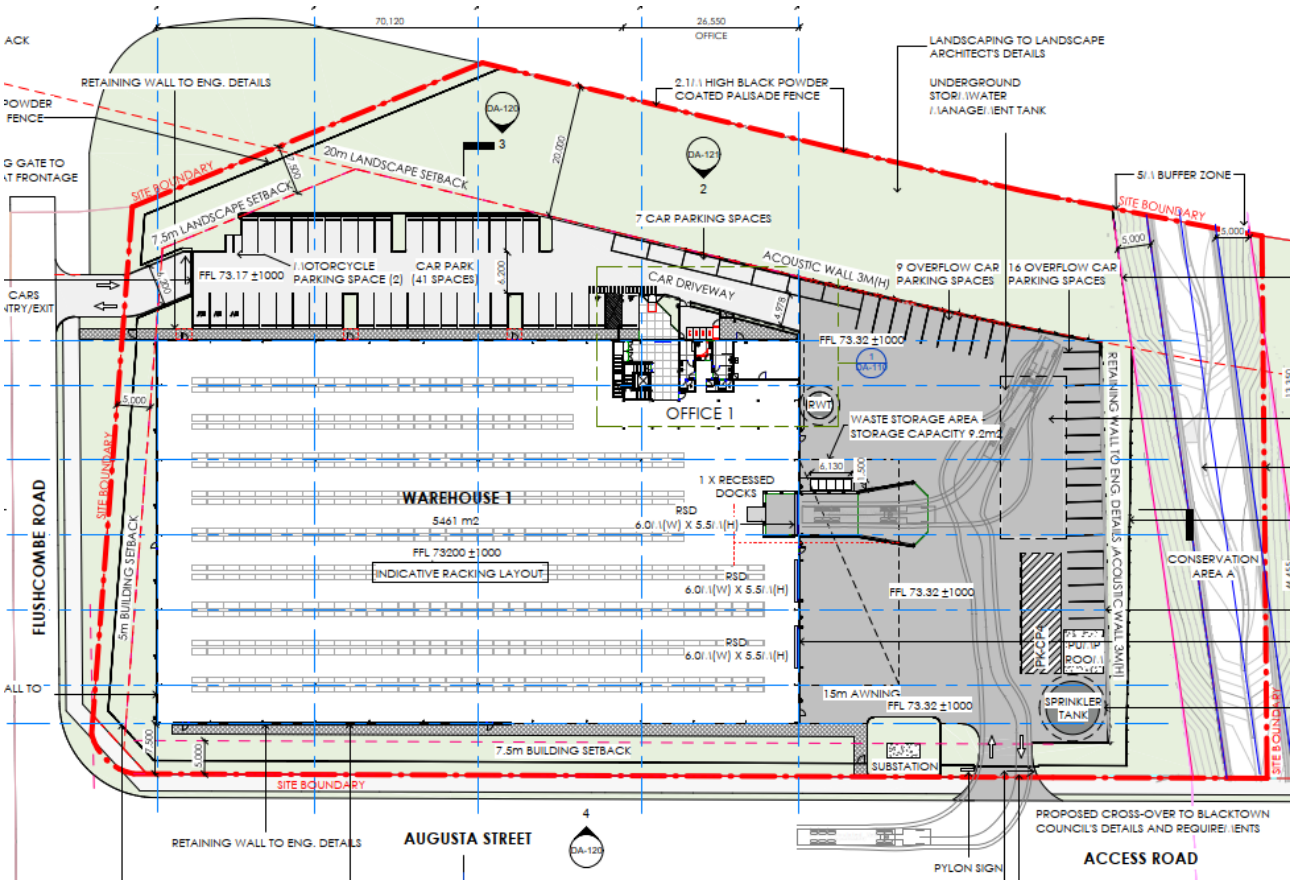


Figure 2-3: Warehouse 1 Site plan

2.3.2 Warehouse 2 Site Description:

Warehouse 2 is located in the South-western corner of the site and has access from both Flushcombe Road and Augusta Street with southern frontage to the powerline easement and the Western Motorway. The site will accommodate the warehouse, associated 2 storey offices, dispatch and loading areas and staff and visitor car parking. The building shall be approximately 12,031m^2 in floor area, with a height of 16.8m and be constructed in accordance with Type C construction as required for a large isolated building.

The following figure provides an understanding of the site:

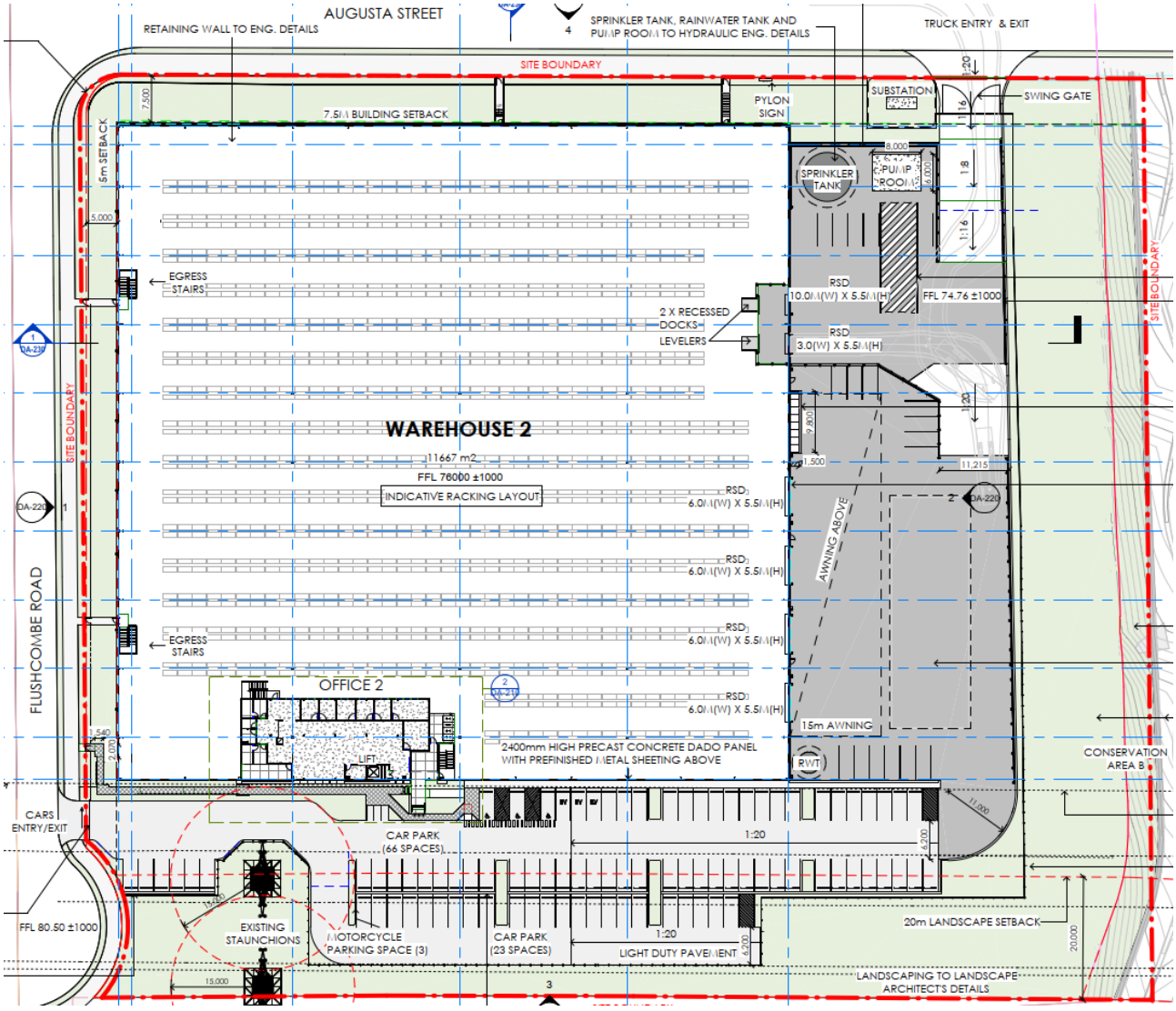


Figure 2-4: Warehouse 2 Site plan

2.3.3 Warehouse 3 & 4 Site Description:

Warehouse 3 and 4 are a combined building operating as a single large isolated building and is located centrally within the site and has access from Augusta Street only with the northern frontage being the Great Western Highway, the southern frontage being the powerline easement and the Western Motorway and the eastern fronting the conservation area. The site will accommodate the warehouse which is proposed to be split into multiple tenancies that each have associated 2 storey offices, dispatch and loading areas and staff and visitor car parking. The warehouse shall be approximately 51,866m^2 in floor area, with a height of 16.8m and be constructed in accordance with Type C construction as required for a large isolated building.

The following figure provides an understanding of the site:

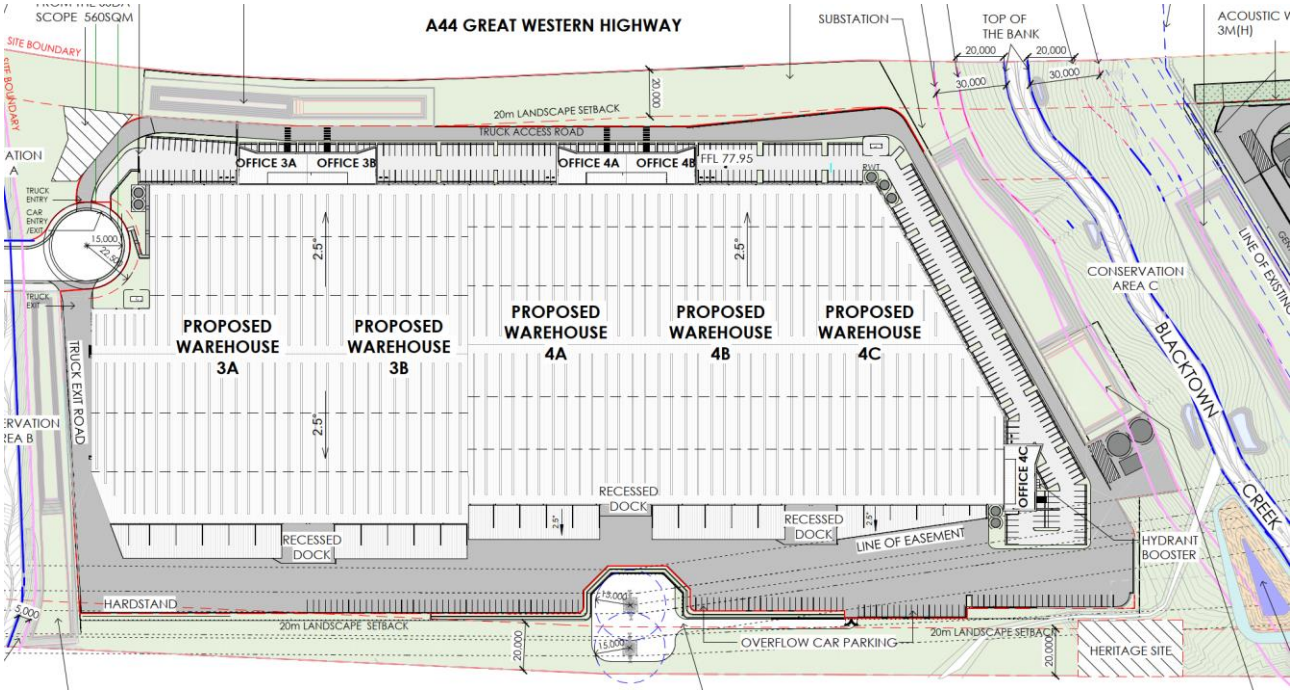


Figure 2-5: Warehouse 3 Site plan

2.3.4 Warehouse 5 Site Description:

Warehouse 4 is located to the eastern end of the site and has access from the Great Western Highway only with the southern frontage being the powerline easement and the Western Motorway, the eastern frontage being the Prospect Highway and the western side fronting the conservation area. The site will accommodate a multi-level warehouse with car parking under. The warehouse is to be split into multiple tenancies that each have associated 2 storey offices, dispatch and loading areas. The multi-level warehouse shall be approximately 64,733m^2 in floor area, with a building effective height of 21.1m and a ridge height of 31.1m. The subject building will be constructed of Type A construction as is required of a multi-level warehouse of this size and scale (unless assessed through fire safety engineering as described within this fire safety strategy

The following figures provides an understanding of the site:

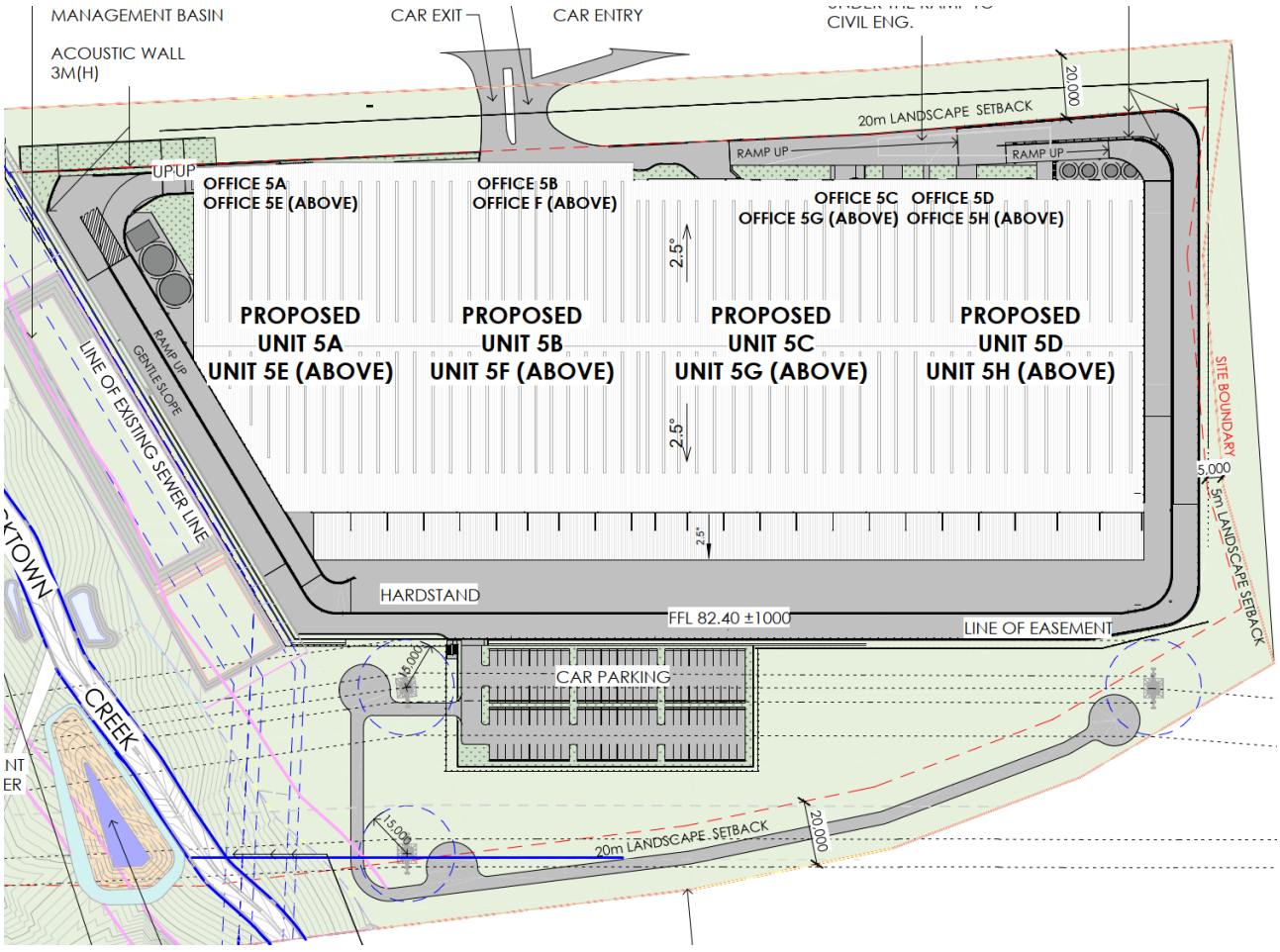


Figure 2-6: Warehouse 5 Site plan

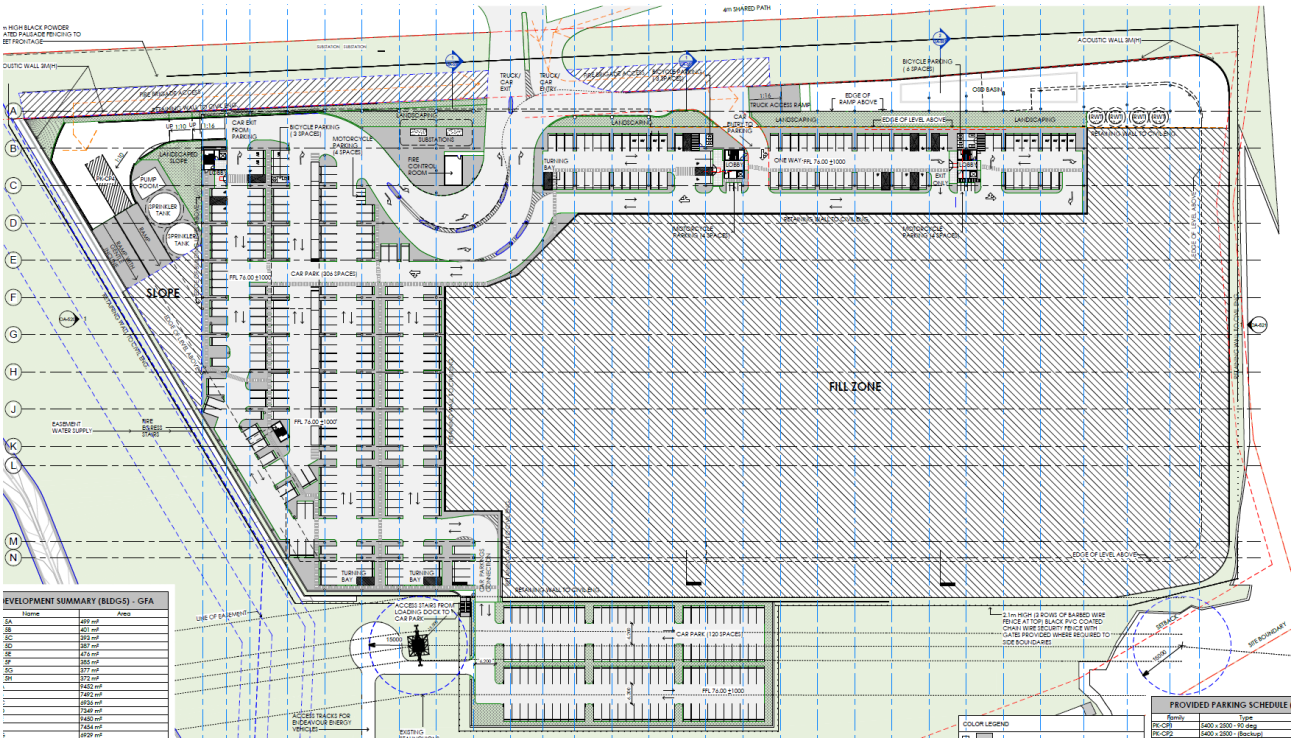


Figure 2-7: Lower Ground Floor Plan (car park and office entry lobbies)

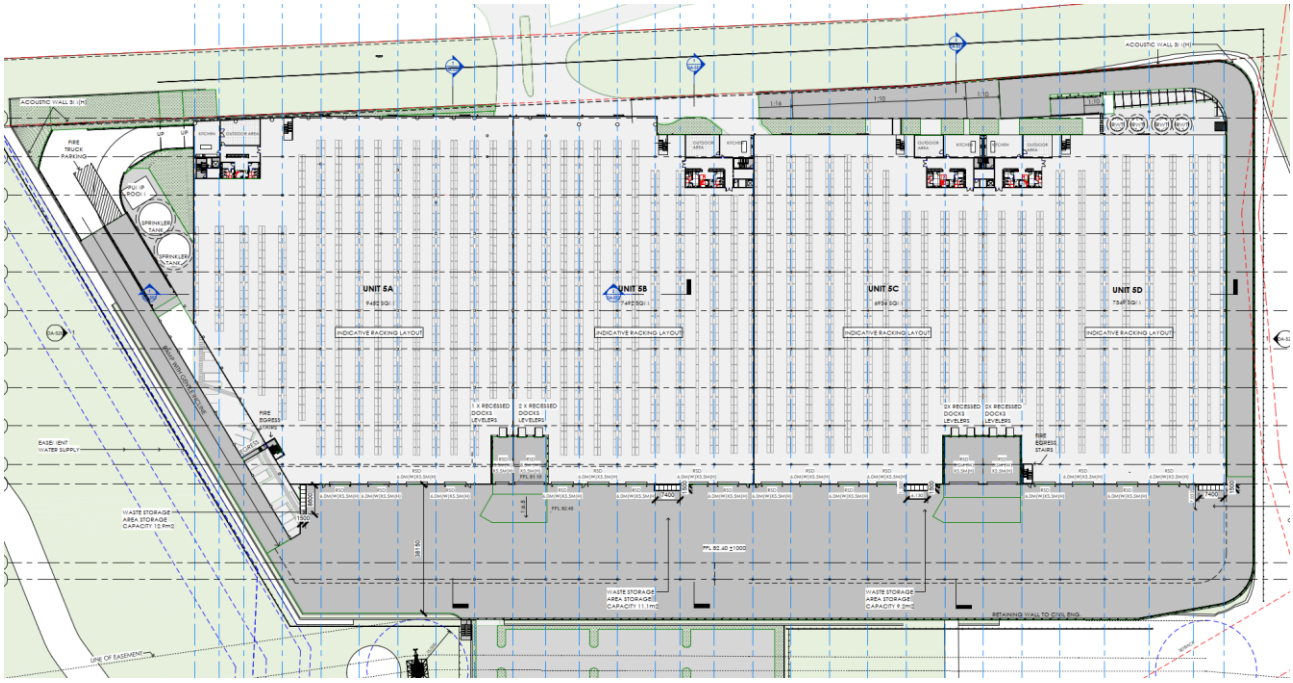


Figure 2-8: Ground Warehouse Floor Plan

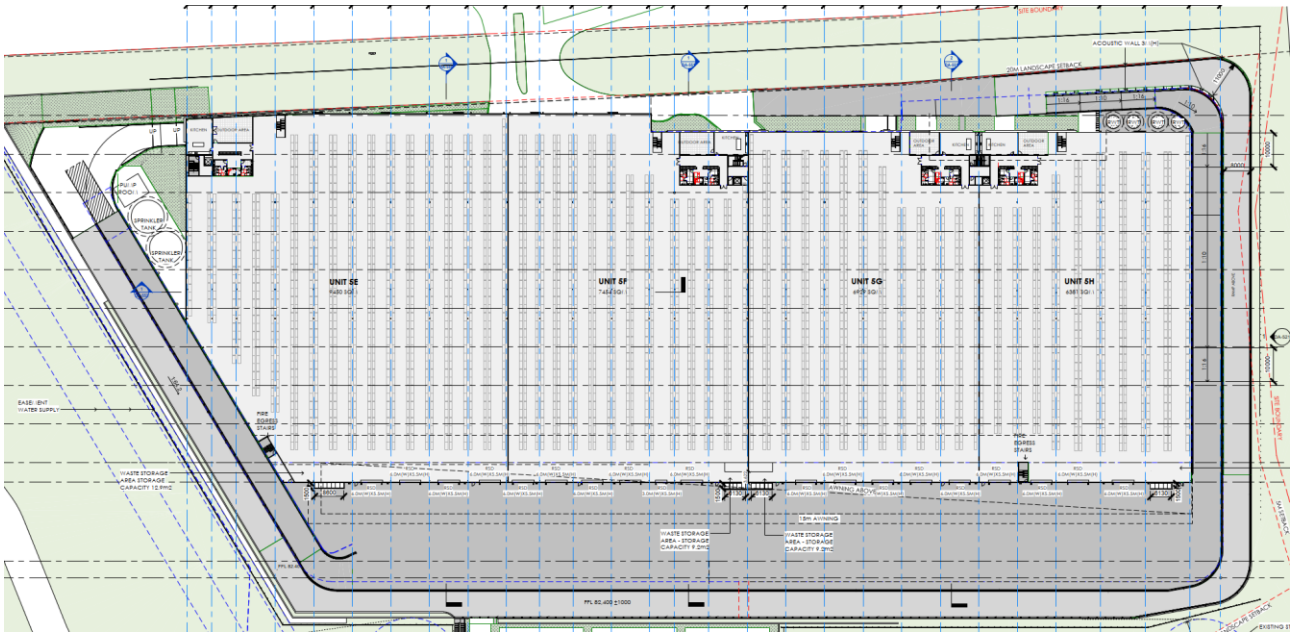


Figure 2-9: Level 1 Warehouse floor

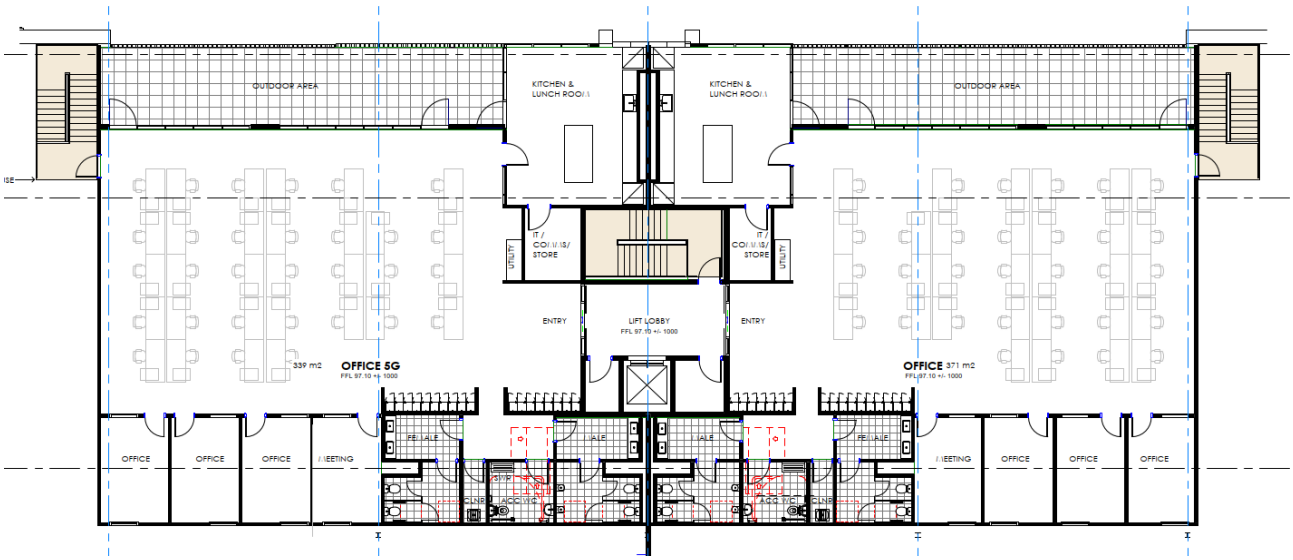


Figure 2-10: Typical Mezzanine office Floor Plan (office G and H)

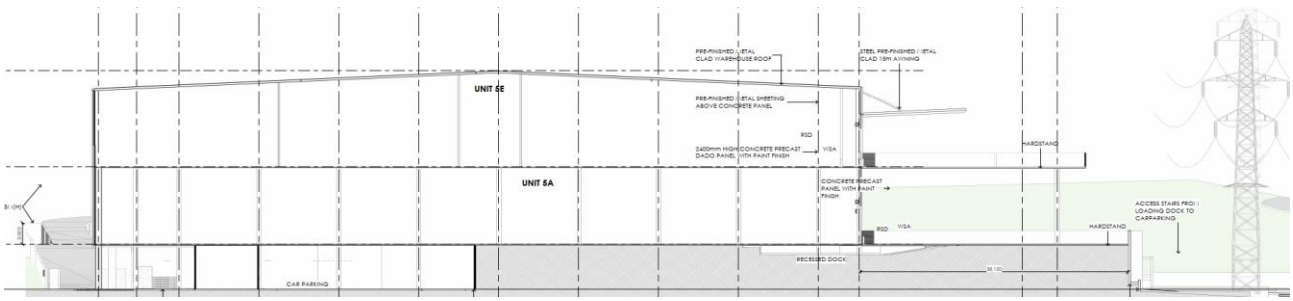


Figure 2-11: Building Section

3 OCCUPANT CHARACTERISTICS

3.1 Overview

The occupant characteristics are assessed as part of the Fire Engineering Review 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 affects 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.

3.2 Dominant Occupant Characteristics Assessment

Characteristic	Description
Population numbers	To ensure conservatism in the fire engineering, the occupant numbers in the building is to be based on the occupant densities (m^2/person) as listed in the NCC Table D1.13 for the various areas and the building layout which are listed as follows: ▸ 1 person per 30m^2 in the storage, plant and carpark and lobby areas ▸ 1 person per 10m^2 in the office areas.
Physical and mental attributes	**Staff** Staff in the building are expected to be awake and alert at all times. Staff are expected to have a level of understanding where they can recognise an emergency situation and have the ability to take and implement decisions independently. In addition, staff are expected to respond at all times, and to be unaffected by physical or sensory disabilities. Staff are not expected to be mentally impaired by drugs, alcohol, fatigue or other adverse conditions to degrees greater than in other business places. **Visitors** This occupant group is expected to be awake and alert. Visitors may also exhibit physical and mental disabilities to the degree and frequency of the general public. It should be noted that some visitors may consist of young

Characteristic	Description
	children as well as elderly occupants and these occupant groups are expected to be accompanied by an adult. **Firefighters** This occupant group will be equipped with breathing apparatus and specialist equipment to prevent them from being adversely affected by fire hazards. They are expected to be trained in emergency response and be capable of undertaking fire suppression and coordination of evacuation of the building. **Maintenance personnel** This occupant group is expected to awake and alert at all times. Maintenance personnel are expected to be able-bodied individuals who are capable of making independent decisions and evacuate themselves.
Familiarity with the building	**Staff** Staff are expected to have a complete knowledge of the building layout and be able to coordinate evacuation of other occupant groups in an emergency. **Visitors** Visitors may not have complete knowledge of evacuation routes in the subject building and are likely to choose to exit via the route they entered the building if not directed/guided by staff to the nearest exit. **Firefighters** This occupant group is not expected to have any familiarity of the building layout, however are assumed to obtain the required information from the site block 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. **Maintenance personnel** 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.
Pre-movement time	Pre-movement times can vary and is highly dependent on a combination of a variety of factors [4] such as: ▸ Familiarity with building ▸ Commitment to activity being undertaken at the time of fire ignition

Characteristic	Description
	▸ Mental capabilities (ability to assess risks and make appropriate decisions, alertness) ▸ Physical capabilities ▸ Group dynamics ▸ Occupant relationships / social affiliations ▸ Frequency of false alarms Documents such as PD7974-6:2004 [9] and CIBSE Guide E [12] provide guidance on estimating pre-movement times for various occupancies.
Travel speed	Travel speeds for individuals can vary depending on factors such as: ▸ Age and sex, ▸ Physical capabilities (ambulant, semi-ambulant, bed-ridden) ▸ Occupant density / crowding ▸ Perceived danger Based on a literature review of work carried out by Boyce et al. [15], Nelson and Mowrer [16], Pauls [15], Milinskii, Pelecheno [16], Pretechskii [17] and Shi et al. [18], the following travel speeds are adopted for an average horizontal travel speed: ▸ 1.2m/s is assumed for an able-bodied adult where congestion is unlikely [12] such as in the breezeway and carpark areas; and ▸ 1.0m/s is assumed for an able-bodied adult where congestion is likely [12] such as in the warehouse areas; and ▸ 0.8m/s for semi-ambulant occupants requiring assistance to evacuate, walking aid or wheelchair users [16] such as in the administration and office areas.

4 HAZARDS AND PROTECTIVE MEASURES

4.1 Overview

The fire hazard analysis forms the basis for the review of non-compliances within the buildings. 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 in fire engineering assessments.

4.2 Fire hazards

4.2.1 Building layout and egress

Exits are provided around the perimeter of each building to allow for multiple alternative egress opportunities. Due to the open nature of the tenancies, there are limited dead end travel routes to exits.

Notwithstanding the various egress opportunities, extended travel distances to the nearest exit and between alternative exits are present within each warehouse building and in a number of the their associated offices areas.

4.2.2 General activities

The building will be used for general goods storage and distribution and 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 offices will all contain general office activities with a variety of dedicated office suites, open work areas and meeting rooms. The office will also be connected by open stairs to enhance connectivity between levels.

4.3 Fuel loads

Quantity of Materials

Due to the nature of the facility the fire loads within the warehouse will change over time as the tenant changes or business structure of the same tenant evolves. As such it is not suitable to provide specific fire load densities for the product and materials being stored within the facility.

The fire load densities with the office and carparking areas should however remain consistent and as such the following fire load densities in those parts shall be utilised in the fire engineering analysis where suitable.

4.4 Dangerous Goods

Dangerous goods are not expected to be stored on the site in significant quantities. It is however noted that all commercial buildings will contain a degree of flammable materials for maintenance purposes (i.e. paints, oil, aerosols etc.) and where they are they shall be stored in accordance with the Regulatory requirements.

This Fire safety Strategy has been developed based on there being no significant degree of Dangerous Goods stored on site other those required for daily maintenance purposes. Any storage of Dangerous Goods will require review and assessment by a suitably qualified Risk Consultant to determine the associated hazards and required preventive measures to meet BCA Clause E1.10 and E2.3.

4.5 Insulated Sandwich Panels

The current design is for base building cold shell tenancies and as such does not account for future use as a temperature controlled storage facility. Where future tenancy fit outs will contain temperature controlled areas with freezers and cool rooms and the like, these enclosures shall be constructed using Insulated Sandwich Panels (ISPs) that meet the following requirements to ensure a suitable degree of fire protection and life safety is incorporated into the design;

- All sandwich panels must be installed in accordance with the "Insulated Panel Council Australasia (IPCA) Code of Practice (CoP) - Version 4.3".
- The panels must be installed by an accredited installer as recognised by the Code of Practice prepared by IPCA (refer website: http://www.insulatedpanelcouncil.org/code-compliant-companies).
- Certification must be provided from the accredited installer prior to final occupation certificate being issued for the building.
- Signage indicating the location and type of sandwich panels installed to the building must be provided at the FDCIE. This shall include;
    - Location of all sandwich panels installed.
    - Type of sandwich panels installed (commercial brand and core material).

4.6 Rooftop Solar Panels

Solar photovoltaic systems contribute to an increased probability of a fire event, primarily due to electrical risks [8]. Additionally, should the solar panels be subjected to a fire event, attending fire brigade can be exposed to hazardous toxins from the combustion of the panel materials.

Storage battery systems pose a significant risk to attending brigade with coming in to contact with the photovoltaic system. Drenching with hoses may disconnect or expose wiring to water in which create live current exposure to personnel or possibly additional fires through sparks or short circuits.

As the design incorporates provisions for rooftop solar panels to offset the building's energy requirements, the following design measures shall be included to mitigate the risk to the attending fire fighters in the event of a fire as per FRNSW requirements.

- An A4 notice on fade resistant material must be displayed at the FDCIE notifying attending fire fighters as to the existence of the Photovoltaic Solar Panel Array on the roof of the building. The notice must include:
  - A figure detailing the location of the panels
  - A floor plan detailing the location of all associated isolation switches, AC and DC isolators for the shut-off of generated electricity
  - Notification that the PV do not automatically isolate on fire trip
  - A statement in 8mm font stating (or similar wording):

    "**Photovoltaic (PV) Panels Present — PV panels are mechanically fixed to the roof as shown below"**
- As per the requirements of AS5033:2021 Clause 5.4 green 'PV' signage is to also be provided adjacent to isolation switches in the MSB and Inverter boards.
- As per the requirements of AS5033:2021 Clause 5.7, a shut down procedure must also be detailed at the PV equipment that is to be operated in the event of a shutdown.

4.7 Electric Vehicle Charging Units

There are known hazards associated with the large lithium-Ion batteries used in Electric Vehicles and their associated charging units. Where EV and their associated charging units are installed in the carparking areas, the following fire safety measures must be incorporated into the Building Design.

Power Isolation

- All electric vehicle charging equipment must automatically shut down and be isolated from the mains power on the general fire alarm anywhere within the building.
- All fixed-installed electrical vehicle charging bays must include an emergency stop / isolating switch on each charging unit. The e-stop / isolation switch must isolate the mains power supply to that specific charger.
  - Notification signage must also be provided at the charging units and also at the e-stop button (if located remotely) to indicate the button's purpose and relative location.

Warning Signs for Fire Fighters

- Signage must be displayed at the main FDCIE to indicate the properties of the electric car charging bays and include the following minimum measures;
  - The location of the charging bays.
  - The location of manual isolation switches/boards with wayfinding from the FDCIE and operating instructions on how to isolate the charging unit; including who to contact to arrange shutdown.
  - The power rating (kW capacity) of the chargers.
  - Notification that the EV charging systems automatically cease operation and are isolated from the power supply on general fire alarm.
  - The contact details of a suitably qualified electrician that is on call and able to respond to an emergency and assists firefighters with system isolation.

4.8 Review of relevant fire statistics

The following discussion is based on the fire statistics attached in APPENDIX A.

4.8.1 Warehouse

From the National Fire Protection Association (NFPA) report on 'Structure Fires in U.S. Warehouses' [31] 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 4-1 illustrates the leading cause of structure fires in warehouses, while Figure 4-2 indicates the leading areas of origin.

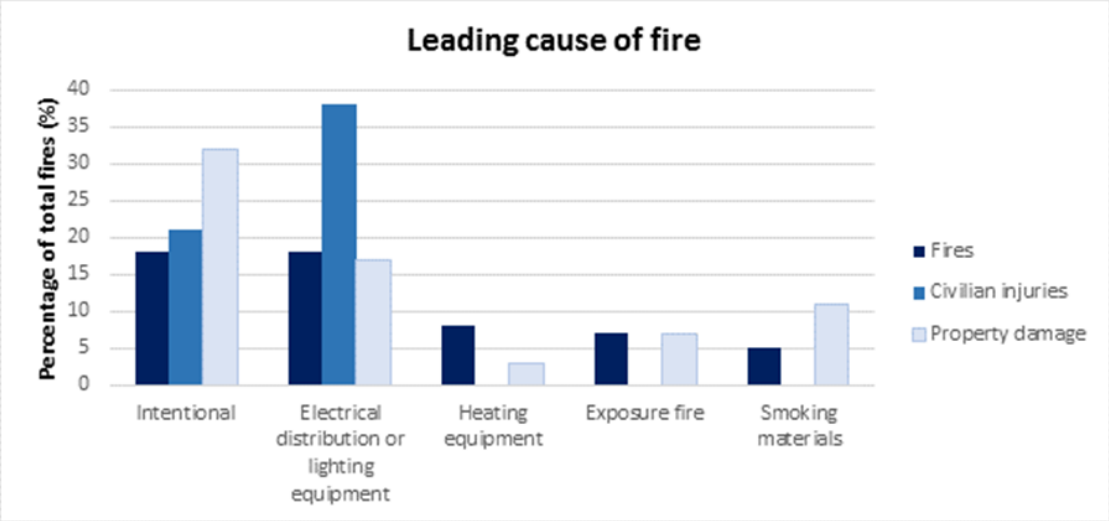


Figure 4-1: Leading Causes of Structure Fires in Warehouses

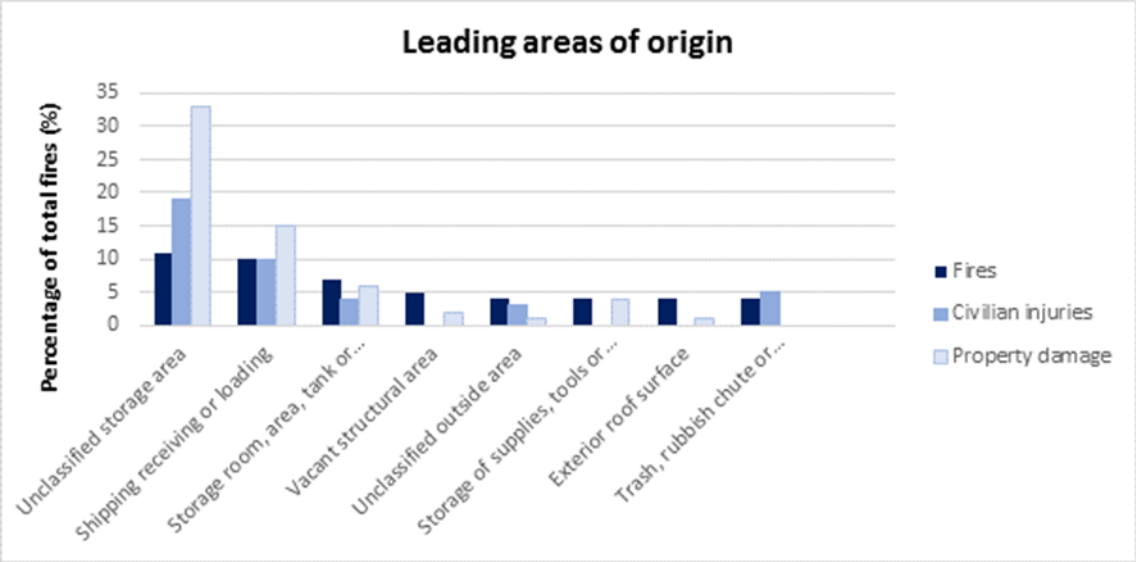


Figure 4-2: Structure fires in warehouses by area of origin

The most common ignition sources in order of likelihood in warehouse structure fires are:

- Intentional (18%)
- Electrical distribution or lighting equipment (18%)
- Heating equipment (8%)
- Exposure fire (7%)
- Smoking materials (5%)

The most common fire origins in order of likelihood in warehouse structure fires are:

- Unclassified storage area (11%)
- Shipping receiving or loading(10%)
- Storage room, area, tank or bin (7%)
- Vacant structural area (5%)
- Unclassified outside area (4%)
- Storage of supplies, tools or dead storage (4%)
- Exterior roof surface (4%)
- Trash, rubbish chute or container (4%)

4.8.2 Office

NFPA statistics published for the years 2007-2011 estimates an average of 3,340 structure fires in office properties per year. Fires in office properties accounted for less than one in every 100 (0.7%) reported structure fires from 2007-2011. These fires caused annual averages of 4 civilian deaths and 44 civilian injuries. One in every four fires was caused by cooking. Electrical distribution and lighting equipment was the second leading major cause. The percentage of fires, civilian injuries and deaths that occurred in 2007-2011 at different times of the day are presented in the figure below.

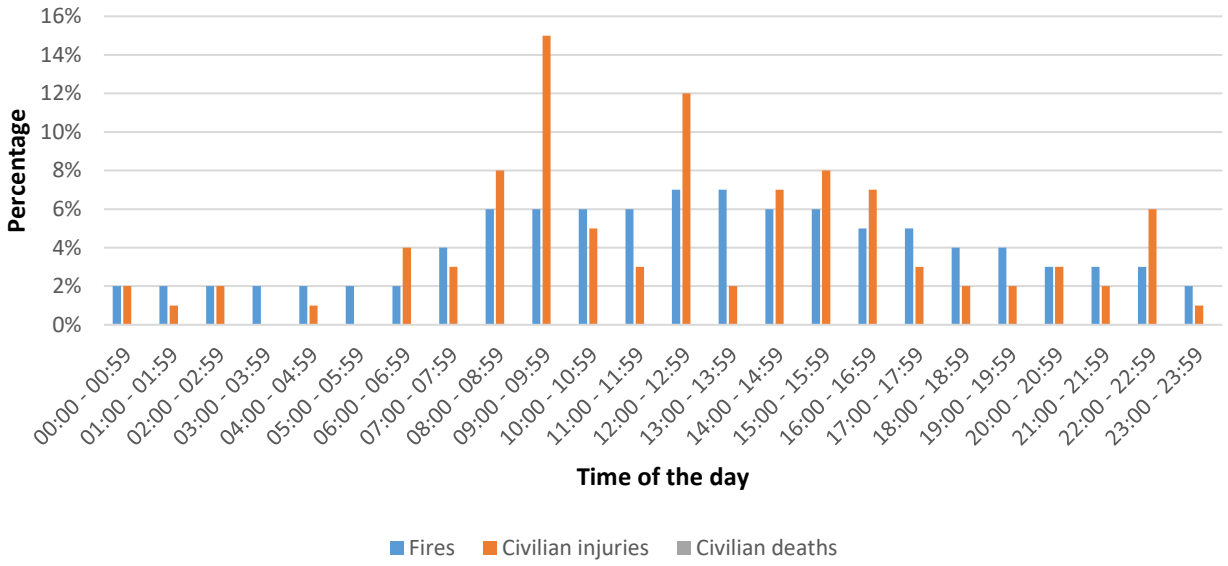


Figure 4-3: Percentage of fires, civilian injuries and deaths at different times of the day (offices)

The following graph that shows the ratio of injuries and deaths to total number of fires has been developed from the data presented in the previous figure. It can be noted that the number of fires during the day is almost four times as many as those during the night. The number of fires peak at midday and are the lowest in the night. This is likely due to the fact that office tenancies are generally unoccupied during the night.

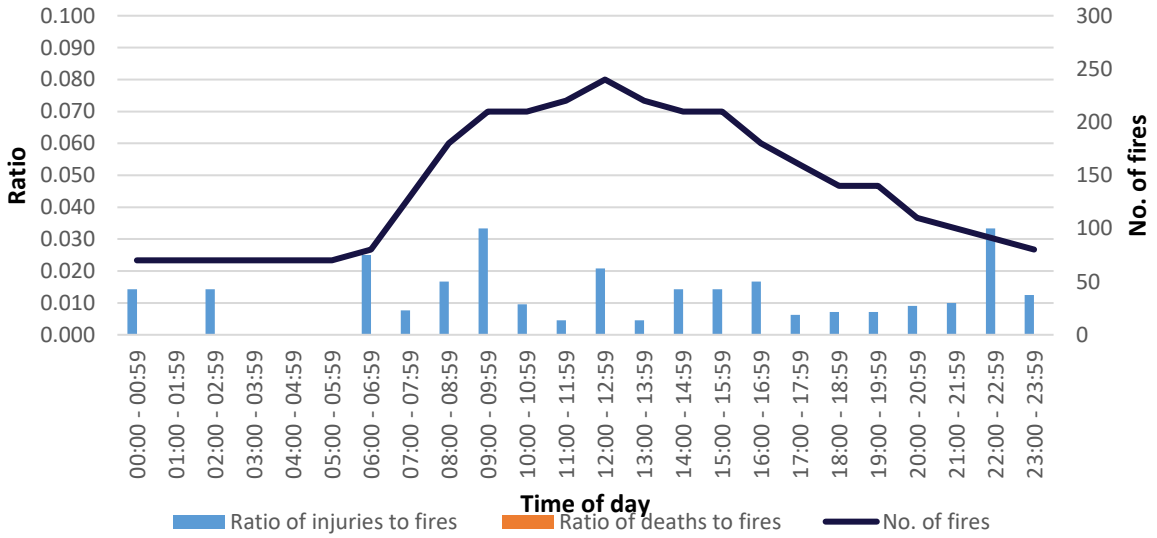


Figure 4-4: Number of fires, ratio of injuries/fires and deaths/fires for different times of the day (offices)

The most common ignition sources in order of likelihood in office structure fires are:

- Cooking equipment (29%)
- Electrical distribution and lighting equipment (12%)
- Heating equipment (11%)
- Intentional (10%)

- Smoking materials (9%)

The most common fire origins in order of likelihood in office structure fires are:

- Kitchen or cooking area (22%)
- Unclassified outside area (4%)
- Lavatory, bathroom, locker room (4%)
- Lobby or entrance way (3%)
- Attic or ceiling/roof assembly or concealed space (2%)
- Duct for HVCA, cable, exhaust, heating or AC (2%)
- Machinery room or elevator machinery (2%)
- Unclassified storage area (2%)

5 BCA DTS NON-COMPLIANCE REVIEW

5.1 Overview

In this instance, the BCA DTS non-compliances have been formulated based on a regulatory review undertaken by the project building surveyor and/or design team and through Affinity Fire Engineering's experience of similar buildings of the size and nature of the subject development. Where not listed herein the building is required to achieve compliance with relevant DTS provisions and relevant codes, reports and Standards.

The following table lists the proposed departures from the DTS provisions of the BCA for the development and the relevant Performance Requirements.

5.2 BCA DTS Non-Compliance Assessment and Acceptance Criteria

Table 5-1: Summary of Performance Solutions

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA
Building 5 - Rationalised Fire Rating to Secondary supporting structure
Relevant Regulatory Requirement: BCA Clause C2D2 requires the building to be constructed in accordance with Type A construction per BCA Specification 5. Table 3 of BCA Specification 5 requires all structural load bearing elements and compartment slabs to be fire rated to achieve 240/240/240. **Performance Requirement** The relevant Performance Requirements is C1P1 **Non-compliance with DTS provisions:** It is proposed to reduce the FRL of the following elements: ▸ The secondary beams that support the floor to maintain the serviceability of a flat slab only (i.e. do not reduce the FRL of the floor) shall be provided with NIL FRL. ▸ The office mezzanines floors wholly located within each warehouse tenancy shall have the floors and columns (where the column is only provided to support the office mezzanine floor) reduced in FRL to achieve an FRL of 60/-/-. ▸ Internal and External warehouse columns that support the upper level roof to be reduced to an FRL of -/-/-

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

Building 5 - Combustible Building Elements – Roof Sheeting and External Signage

Relevant Regulatory Requirement:

BCA Clause C2D2 requires the building to be constructed in accordance with Type A construction per BCA Specification 5. Table 3 of BCA Specification 5 requires a roof to be fire rated, however, also affords a concession under Spec 5, Clause 3.5 that allows the FRL to be omitted if the roof covering is non-combustible and the building sprinkler protected throughout.

BCA Clause C2D4 requires any sign attached to the external face of the external wall to be;

- Non-combustible; or
- Achieve a Group Number rating of 1 or 2 provided it does not extend beyond one storey, nor extend beyond one fire compartment.

Performance Requirement

The relevant Performance Requirement is C1P2.

Non-compliance with DTS provisions:

- The roof covering incorporates polycarbonate translucent roof sheeting to allow natural light to pass down into the general warehouse floorplate. These roof lights are not non-combustible and therefore have been deemed non-compliant.
- Signage shall be fitted to the external face of the external walls (e.g. Developer/Tenant signage and also directional wayfinding signage). These signs shall contain acrylic and polycarbonate components that have not been tested to achieve a Group 1 or 2 rating under AS5637.1:2015.

Building 5 - Fire Rating to Service Penetrations

Relevant Regulatory Requirement:

BCA Clause C4D15 requires service penetrations to be sealed to ensure that the fire and smoke-resisting performance of the element through which it passes is maintained. The fire sealing is required to be in accordance with the tested prototype for that service and specific wall makeup or alternatively compliant with BCA Specification C4D15.

Performance Requirement

The relevant Performance Requirements are C1P2 & C1P8

Non-compliance with DTS provisions:

The warehouse floor slabs are required to achieve a 240/240/240 FRL, however, due to the limited availability of tested fire collars and sealing available on the market for various service penetrations, several penetrations will achieve a maximum --/120/120 FRL.

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

Warehouse 5 - Airlocks into Fire-Isolated Exits

Relevant Regulatory Requirement:

BCA Clause D1D8 specifies the following measures relative to fire-isolated exit design and discharge paths;

- A doorway must not open directly into a stairway that is required to be fire-isolated unless it is from a public corridor, public lobby or the like, a sanitary compartment, airlock or the like, or an SOU occupying the entirety of the storey.

Performance Requirement

The relevant Performance Requirements are D1P4 & E2P2

Non-compliance with DTS provisions:

- Warehouse 5 on the upper levels have fire isolated stairs that open directly into the warehouse in lieu of being via an airlock, public lobby or the like.

Warehouse 5 - Discharge of Fire Isolated Stairs

Relevant Regulatory Requirement:

BCA Clause D1.7 requires all stairs to discharge directly to a road or open space.

Performance Requirement

The relevant Performance Requirement is D1P4 and D1P5

Non-compliance with DTS provisions:

The north-western fire isolated stair discharges within the open central courtyard created by the curved ramp design which requires the discharging occupants to travel back under the ramp in order to reach open space.

All Warehouses - Perimeter Vehicular Access

Relevant Regulatory Requirement:

BCA Clause C3D5 requires vehicular access as a continuous means of passage for emergency vehicles in a forward direction around the entire building. Further to this, the roadway is required to have a width of no less than 6m, be located within 18m of the building and have nothing constructed on the pathway that obstructs passage.

Performance Requirement

The relevant Performance Requirement is CP9

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

Non-compliance with DTS provisions:

Vehicular perimeter access has been identified as non-compliant in each site to allow for the following;

- The vehicular perimeter access road is greater than 18m from each building.
- Portions of the perimeter access road have a clear width of less than 6m.
- There shall also be security gates that cross the vehicular access path where the vehicular access road connects to the public road.

All Warehouses - Egress Distances

Relevant Regulatory Requirement:

BCA Clause D2D5 states that in a Class 5 and 7 building the travel distance to the point of choice must not exceed 20m and to the nearest exit must not exceed 40m where more than one exit is available.

BCA Clause D2D6 states that the travel distance between alternative exits must not exceed 60m.

BCA Clause D2D14 States that:

- The total travel distance to reach a final exit via a non-fire-isolated stair to be no greater then 80m total distance.
- A required non-fire-isolated stair must discharge to ground floor in a location that is no more than 40m from the nearest alternative exit where two or more exits direct to outside are available; and

Performance Requirement

The relevant Performance Requirements are D1P4, D1P5 & E2P2

Non-compliance with DTS provisions:

Travel distances exceed the DtS limitations throughout various areas of the building, with the following maximum distances to be rationalised through fire engineering;

- Warehouse 1 -4:
    - Up to 100m to an exit &
    - Up to 200m between exits.
- Warehouse 5
    - Warehouse Areas:
        - Up to 100m to an exit &
        - 200m between alternative exits.
    - Mezzanine Office Areas:
        - The travel paths from the mezzanine level offices adopt a required non-fire isolated stair which discharge on to the warehouse floor in lieu of the ground floor and require the following worst case travel distances
        - 128m to reach the exit.
        - Overall distance to a road or open space of approx. 150m (note this is avoiding the nearest alternative exit that is fire isolated)

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

All Warehouses - Fire Hydrant System Design

Relevant Regulatory Requirement:

BCA Clause E1D2 requires that a fire hydrant system is provided and installed in accordance with AS2419.1:2021.

AS2419.1:2021 requires:

- A fire hydrant to be located externally of the building and provide coverage within 70m or internally and provide coverage within 40m.
- A fire hydrant under an external awning that is wider than 3m is required to be classified as an internal hydrant
- Also, the hydrant booster assembly must be located as follows when remote from the building:
  - At the boundary of the site
  - Within sight of the main entrance of the building; and
  - Adjacent to the principal vehicular access to the site; and
  - Not less than 10m from the external wall of any building served.

Performance Requirement

The relevant Performance Requirement is E1P3

Non-compliance with DTS provisions:

The following non-conformances have been identified and intended to be addressed through a Performance-Based Solution:

- Fire Hydrant coverage is to be achieved as per the following:
  - Additional Internal hydrants within the warehouse tenancies are to be positioned within 50m of hydrant located externally of the roofed area over or
  - Additional internal hydrants within Warehouse 5 that are to be positioned within 25m of an internal hydrant within a fire stair connected directly to a warehouse tenancy and
  - for both cases above any further additional internal hydrant may daisy chain to the next additional internally hydrant that is to be positioned not more than 25m away. The last of the additional internal hydrant can provide coverage with 40m.
- Hydrants located under the roofed awnings over are to be considered as external hydrants for the purpose of fire hydrant coverage.
- The hydrant boosters for each site are not located within sight of Building 4A main entrance and is therefore deemed a non-compliant location.

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

All Warehouses - 50m Fire Hose Reels

Relevant Regulatory Requirement:

BCA Clause E1P3 requires that fire hose reels are installed in accordance with AS2441 within a building having a fire compartment greater than 500m^2. This requires that all points on the floor are to be within reach of a 4m hose stream issuing from a nozzle at the end of the hose, with the hose length not exceeding 36m.

Performance Requirement

The relevant Performance Requirement is E1P1

Non-compliance with DTS provisions:

Due to the large floor areas of each warehouse tenancy and the central dispatch hardstands, hose reels with a length of 50m in lieu of 36m are proposed to be used to achieve coverage within the warehouse and hardstand areas.

All Warehouses - Sprinkler System Infrastructure

Relevant Regulatory Requirement:

BCA Clause E1D4 requires that the fire sprinklers to installed in accordance with AS2118.1:2017 of which under Clause 4.14.1 and 4.14.2, the fire sprinkler booster assembly and tank suction connection respectively must be in accordance with the requirements of the fire hydrant standard being AS2419.1:2005. This hydrant standard states that if remote from the building, the booster must be on the site boundary, adjacent to the principle vehicular access and in sight of the main building entry

Performance Requirement

The relevant Performance Requirement is E1P4

Non-compliance with DTS provisions:

- The fire sprinkler infrastructure is located at the rear of each building and hence these fire services are not:
  - Located on the site boundary; and
  - Adjacent to the principle vehicle access; and
  - Within sight of the building main entrance.
- Omission of sprinkler protection to the fire separated switch rooms.

VARIATIONS, ASSOCIATED METHODOLOGY AND ACCEPTANCE CRITERIA

All Warehouses - Automatic Smoke Exhaust System

Relevant Regulatory Requirement:

In a building under 25m in effective height BCA Clause E2D4, Table E2 General Provisions requires in a Class 5, 6, 7, 8 or 9 building, which exceeds 18,000m^2 in floor area or 108,000m^3 in volume, the building must be provided with an automatic smoke exhaust system in accordance with Specification 6 throughout.

Performance Requirement

The relevant Performance Requirement is E2P2

Non-compliance with DTS provisions:

Offices and Dispatch Hardstands

- Automatic smoke exhaust is to be omitted from the offices, and externally open dispatch hardstands (that operate as awnings.

Warehouse Areas

- An automatic smoke exhaust system shall be provided to each warehouse tenancy of the building in accordance with the DTS provisions and AS1668.1:2015 with the following exceptions:
    - A smoke extraction rate of equivalent to 1 tenancy volume air change per hour in lieu of extraction rates defined in BCA Specification E2.2b.
    - Each tenancy shall form a single smoke reservoir resulting in several tenancies forming a single smoke reservoir exceeding 2,000m^2.

6 PROPOSED FIRE SAFETY STRATEGY

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.

The specified fire safety strategy will undergo analysis as part of a Fire Engineering Report to ascertain whether the relevant Performance Requirements of the BCA are satisfied. The information herein is therefore pending completion of the fire engineering analysis and as such is possible to change and or modification through the detailed design phase of the project.

6.1 Passive Fire Construction

6.1.1 Fire Resisting Construction and Compartmentation.

Warehouse 1-4 shall be provided with Type C construction in accordance with the requirements of BCA Clause C1.1, Specification C1.1.

Warehouse 5 shall be constructed in accordance with the requirements of BCA Clause C1.1, Specification C1.1 for Type A Construction with the exception of the deviations allowed as part of the future Fire Engineering.

As part of the above Performance Solution, the following minimum fire-resisting construction must be incorporated into the Warehouse 5 design:

- The structure must achieve a floor-by-floor fire separation of 240/240/240 (inclusive of external columns).
- The secondary beams that support the floor to maintain the serviceability of a flat slab only (i.e. do not reduce the FRL of the floor) shall be provided with NIL FRL.
- The office mezzanines floors wholly located within each warehouse tenancy shall have the floors and columns (where the column is only provided to support the office mezzanine floor) reduced in FRL to achieve an FRL of 60/-/-.
- The upper level internal and external columns that only support the roof may have their FRL reduced to --/--/--.

6.1.2 Separation of Equipment

Rooms containing equipment listed below must be fire separated from the remainder of the building by construction in accordance with Specification C1.1 or 120/120/120 FRL construction, whichever is greater, with any door opening into that room consisting of a --/120/30 FRL self-closing fire door.

- Lift motors and lift control panels (unless the lift installation does not have a machine-room); or
- Emergency generators are used to sustain emergency equipment operating in emergency mode; or
- Central smoke control plant (other than smoke exhaust systems designed for high-temperature operation); or
- Boilers; or
- A battery system installed in the building that has a total voltage of 12 volts or more and a storage capacity of 200kWh or more.

Electricity supply systems inclusive of electricity substations located within a building and main switchboard located within the building which sustains emergency equipment operating in the emergency mode (i.e. the smoke exhaust fan switchboard) must meet the requirements of BCA Clause C2.13. This includes the requirements of being separated from any other part of the building by construction having:

- An FRL of not less than 120/120/120: and
- Any doorway in that construction is protected with a self-closing fire door having an FRL of not less than --/120/30.

6.1.3 Service Penetrations

All service penetrations with Warehouse 5 are to be sealed in accordance with BCA Clause C3.15 and Specification C3.15 to ensure that the fire and smoke-resisting performance of the element through which it passes is maintained with the following exceptions;

- The warehouse floor slabs are required to achieve a 240/240/240 FRL, however, due to the limited availability of tested fire collars and sealing available on the market various service penetrations will only achieve a --/120/120 FRL.
    - The exact location and specifics of these penetrations shall be determined through the detailed design phase of the project. The intent is to provide compliant fire sealing to the penetrations wherever practicable, and thus this Performance Solution allowing a reduced FRL to --/120/120 is only incorporated where there are no available systems on the market.

As part of the above Performance Solution, the following fire safety measures shall be incorporated into the building design;

- A full penetration register is to be prepared for the development in accordance with the Schedule in Appendix B of AS4072.1:2005. The register must detail the following as a minimum:
    - Evidence of fire-rated protection provided to the penetration is to be documented in the form of installation certificates (AS 4072.1:2005 – Appendix B exemplar) detailing:
        - Project name and address.

- Name, address and contact phone number of installing company or party.
- Date of final inspection of the installation.
- Description of service or control joint.
- Identification of the position of installation.
- Description of the system used or schedule of systems.
- Description of product or system used to maintain the FRL of the building element of each installation (these are to be numbered).

6.1.4 Finishes and Linings

Internal finishes, internal linings and internal materials used throughout the building should be non-combustible to reduce the spread of fire and the generation of toxic smoke products.

All wall, floor and ceiling, and roof and ceiling assemblies must be tested and rated for their fire hazard properties in accordance with the prescriptive requirements of BCA Clause C1.10 and Specification C1.10.

6.1.5 Non-Combustible Materials

As part of the requirements for Type A Construction, roof covering, lift pits and external walls including their components and any attachments (both internal and external), are to be non-combustible and/or compliant with BCA Clause C1.9 and C1.14 with the following exceptions;

- In Warehouse 5 the roof covering incorporates polycarbonate translucent roof sheeting to allow natural light to pass down into the general warehouse floorplate. These roof lights are not non-combustible and therefore have been deemed non-compliant.
- Signage shall be fitted to the external face of the external walls of Warehouse 5 (e.g. Developer and Tenant signage). These signs shall be constructed of a polycarbonate material that has not been tested to achieve a Group 1 or 2 rating under AS5637.1:2015.

As part of the above Performance Solution, the following fire safety measures shall be incorporated into the building design;

- The translucent roof sheeting must consist of polycarbonate material.
- The total quantity of translucent roof sheeting must not exceed 20% of the total roof covering.
- The translucent roof sheet locations must be coordinated with the fire sprinkler design to ensure there are no roof sheets located directly above sprinkler heads.
- The illuminated exits signs must not be installed directly above any exit door.

6.1.6 Insulated Sandwich Panels

Where future tenancy fit-outs contain temperature-controlled areas with Freezers and Cool Rooms and the like, these enclosures shall be constructed using Insulated Sandwich Panels (ISP) that meet the following requirements to ensure a suitable degree of fire mitigation;

- All sandwich panels must be installed in accordance with the “Insulated Panel Council Australasia (IPCA) Code of Practice (CoP) - Version 4.3”.
- The panels must be installed by an accredited installer as recognised by the Code of Practice prepared by IPCA (refer to the website: Installers (insulatedpanelcouncil.org)).

- Certification must be provided by the accredited installer prior to the final occupation certificate being issued for the building.
- Signage indicating the location and type of sandwich panels installed in the building must be provided at the FDCIE(s). This shall include;
    - Location of all sandwich panels installed.
    - Type of sandwich panels installed (commercial brand and core material).

6.1.7 Rooftop Solar Panels

The following measures shall be provided due to the inclusion of the solar panels installed on the roof of the building;

- A minimum of an A3-sized block plan shall be provided at the Main-FDCIE to alert the attending fire fighters of the presence of all key components inclusive, but not limited to the location of the solar panels, inverters, operating voltage and current, location of storage equipment and respective battery type.
- The location of all associated isolation switches, AC and DC isolators for the shut-off of generated electricity shall be displayed at the Main-FDCIE with brief instructions on the safe process to subdue the hazard.
- The notification shall also be provided detailing whether the solar panels are programmed to automatically shutdown on fire trip, or whether manual isolation is required by attending fire fighters.

Where the battery storage devices are incorporated for the solar array, the batteries shall be contained within a dedicated enclosure incorporating the following minimum fire safety measures;

- The room shall be separated from other areas of the building by a minimum of 120/120/120 FRL. Doors within a fire-rated wall to be a fire door achieving a --/120/30 FRL per AS1905.1:2015.
- The enclosure shall have direct access to the outside.
- The room shall be protected with an automatic fire sprinkler system in accordance with AS2118.1:2017.
- An external fire hydrant, located no closer than 10m from the room, shall be located outside to provide coverage of the enclosure.

6.2 Egress Provisions

6.2.1 Evacuation Strategy

Activation of any sprinkler head, smoke detection device or manual call point shall initiate the building occupant warning alarm tones throughout the building.

Dedicated fire wardens from each tenancy shall ensure that all clients, visitors, maintenance contractors and staff are promptly evacuated if a fire is identified anywhere in the building.

6.2.2 Egress Provisions

With exception of the following items being addressed through a fire-engineered Performance Solution, travel distances to a point of choice or single exit to be not more than 20m, the distance to the nearest of two or more alternative exits must not exceed 40m and the distance between alternative exits must be no further apart than 60m. and in relation to the internal required non-fire isolated stairs the distances must meet the following requirements unless addressed through a performance solution:

- The total travel distance to reach a final exit via a non-fire-isolated stair to be no greater then 80m total distance.
- A required non-fire-isolated stair must discharge to ground floor in a location that is no greater than 20m from a final exit, or no more than 40m from the nearest alternative exit where two or more exits direct to outside are available; and
- The flights and landings of a non-fire-isolated stair must be continuous to the point where it discharges to the level of egress to a road or open space.

The fire engineering assessment shall address travel distances that have been identified as being non-compliant in the following locations;

- Warehouse 1 -4:
    - Up to 100m to an exit &
    - Up to 200m between exits.
- Warehouse 5
    - Warehouse Areas:
        - Up to 100m to an exit &
        - 200m between alternative exits.
    - Mezzanine Office Areas:
        - The travel paths from the mezzanine level offices adopt a required non-fire isolated stair which discharge on to the warehouse floor in lieu of the ground floor and require the following worst case travel distances
        - 128m to reach the exit.
        - Overall distance to a road or open space of approx. 150m (note this is avoiding the nearest alternative exit that is fire isolated)

Design Note: *Additional exit and egress doors may be required and/or modification to accommodate future fitout and ensure the travel distance limitation defined by Fire & Rescue NSW, "No point in a fire compartment is to be more than 100m from a hydrant external to that compartment". This shall be determined through the detailed design phase of the project. It is highlighted that each of the proposed warehouse designs of the subject master plan are capable of achieving this FRNSW requirement.*

6.2.3 Construction of Fire Isolated exits in Warehouse 5

The Warehouse 5 shall incorporate four (4) fire isolated stairs for egress of the upper levels warehouse tenancies and offices.

The internal required non-fire isolated stairs must be constructed in accordance with BCA Clauses C1.10 and D2.8.

Access Provisions into Fire-Isolated Exits (Airlocks)

Warehouse tenancies and associated offices provided with fire-isolated stair access without an airlock, public lobby or the like the door must be fitted with medium-temperature smoke seals.

Discharge of Fire-Isolated Stair

Each fire-isolated stairway must be provided independent egress from each storey served and discharge directly;

- Open space; or
- The fire stairs can be into a location that is via a building awning or a car park and the discharge location can be adjacent to the glazing of the office lobby entry.

6.2.4 Door Hardware, Operation and Mechanisms

All doors serving as required exits shall have the hardware, door swings, latch operations and signage in accordance with the prescriptive requirements of BCA Clauses D2.19, D2.20, D2.21 and D2.23.

6.2.5 Signage and Lighting

Exit and emergency lighting are to be provided throughout the building in accordance with the prescriptive DtS provisions of BCA Clause E4.2, E4.4, E4.5, E4.6, E4.8 and AS2293.1:2018.

- Exit signs are to be pictograph 'running man' signs as per the prescriptive requirements of AS2293.1:2018.
- All exit and directional exit signs are to power-operated illuminated signs.

6.3 Active Fire Protection Systems

The following figure provides an over of the fire infrastructure on the project to support the design specification for those systems in the subsequent Sections.

6.3.1 Fire Control & Indicating Equipment and Fire Control Centre

Each site shall be served by the Fire Control & Indicating Equipment (FDCIE) located within a dedicated Fire Control Centre that is in clearly identifiable location from the fire hydrant booster location. The Fire Control Centre shall be designed and installed in accordance with BCA Specification E1.8 and the requirements of AS1670.1:2018 and at a minimum contain the following;

- The Main FDCIE;
- The fan control panel;
- Emergency Warning & Intercom Panel
- Tactical fire plans;

Main FDCIE:

The Main FDCIE for the building shall be located within the Fire Control Centre must incorporate;

- The ability to enable, disable & reset ALL zones/alarms within the building.
- The building controls for the smoke hazard management systems shall be on the Main FDCIE.
- Contain the EWIS Panel for the building.
- The site ASE shall be located at this FDCIE.

6.3.2 Fire Brigade Alarm Signalling Equipment

Each warehouse shall have an automatic link directly to an approved monitoring centre on activation of the fire sprinkler system, smoke detection system or manual call points installed in the building in compliance with DTS Provisions and AS1670.3:2018.

6.3.3 Building Occupant Warning System (BOWS)

A BOWS shall be provided throughout each building. The system shall be in accordance with the prescriptive requirements of Specification E1.5, Specification E2.2a, AS1670.1:2018 and AS1670.4:2018.

Activation of any fire sprinkler head, smoke detector or manual call point shall initiate the building alarm tones throughout the building. The system must not incorporate any cascade.

6.3.4 Automatic Fire Sprinkler System

A fire sprinkler system shall be provided throughout each building in accordance with the prescriptive requirements of BCA Specification E1.5 and AS2118.1:2017 with the exception of the sprinkler booster not being located at the front of the site or within site of the principle entrance.

As part of the fire sprinkler system design, the following must be incorporated:

- Omission of sprinkler protection from within the fire separated switch room.
- The fire sprinkler booster assembly must ensure an adequate staging area for pumping appliances as per FRNSW Fire Guideline requirements *"Access for fire brigade vehicles and firefighters"* available at https://www.fire.nsw.gov.au/ and AS2118.1:2017.
- The system must ensure a compliant water supply – with a specific note of the building being over 25m in effective height.
- The design of any fixed suction provided for a fire brigade pumping appliance to draught from a below-ground water supply is to satisfy Clause 4.4 of Australian Standard AS2419.1:2021. The maximum length of the dry pipe between the lowest section water level and the large bore suction connection must not exceed 2.8m (due to the limitations of the primer on the fire brigade pumping appliances).
- The required diesel pumpsets are to be configured to allow FRNSW personnel to safely fill the fuel tanks whilst the pumps are running (i.e. using a 20L portable fuel container).

Fire & Rescue NSW Hardstand Requirements

As detailed in FRNSW Fire Guideline requirements *"Access for fire brigade vehicles and firefighters"*, any hardstand serving a suction-connection outlet is to have a working space that extends a minimum of 18m from the point of connection to allow a semi-rigid suction hose to be connected to the rear of the fire appliance. This is demonstrated in Figure 6-1.

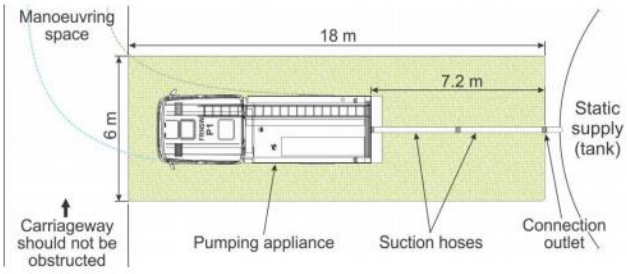


Figure 14 Hardstand area serving a suction-connection outlet

Figure 6-1: FRNSW Access For Fire Brigade Vehicles & Firefighters Excerpt (State Govt NSW 2019)

The preliminary fire engineering assumes that the fire sprinkler suction point is located inward facing to the hardstand and hence necessitate an appliance to back up against it. The orientation of the suction point may be adjusted so long as the design reflects the FRNSW requirements as detailed in FRNSW Fire Guideline requirements *"Access for fire brigade vehicles and firefighters"*. Connection orientations are as per excerpt from the aforementioned FRNSW document per Figure 6-2.

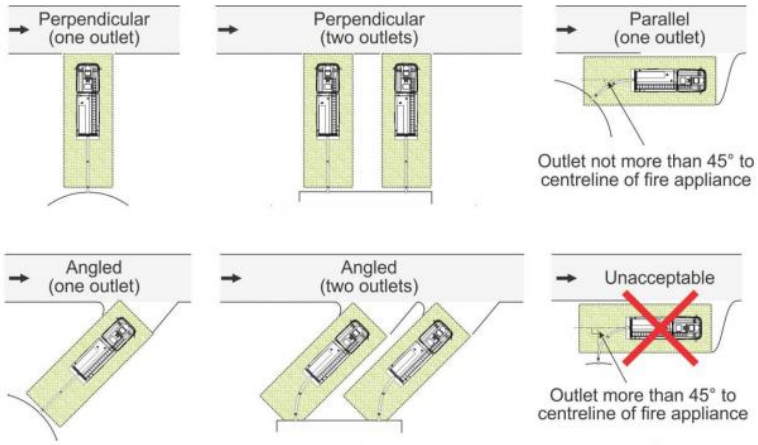


Figure 15 Example of orientation of hardstand area for suction-connection outlets

Figure 6-2: FRNSW Access For Fire Brigade Vehicles & Firefighters Excerpt (State Govt NSW 2019)

6.3.5 Automatic Smoke Detection System

An Automatic smoke detection is required to be installed throughout Warehouse 5 portions. The smoke detection and alarm system shall have the following minimum requirements:

- The system shall be designed to activate the smoke exhaust within the tenancy of fire only, the building alarm system, and the ASE signal to brigade and any ancillary trips such as door latch release, mechanical shutdown and/or shutdown of carpark EV chargers.
- This smoke detection system within each warehouse tenancy must be installed in accordance with BCA Specification E2.2a and AS1670.1:2018.
- The Office Levels shall be provided with an automatic smoke detection system in accordance with AS1670.1:2018 Section 5.
- No smoke detection is required to be installed on the dispatch loading areas or the vehicular access ramp due to the significant external openings provided.

6.3.6 Automatic Smoke Exhaust System

A site-specific automatic smoke exhaust system shall be provided to each building in accordance with prescriptive DtS provisions of AS1668.1:2015 with the following exceptions addressed through a fire engineered Performance Solution:

Offices and Dispatch Hardstands

- Automatic smoke exhaust is to be omitted from the offices, dispatch hardstands and vehicular ramps.

Warehouse Areas

- An automatic smoke exhaust system shall be provided to each warehouse tenancy within the building in accordance with the DTS provisions and AS1668.1:2015 with the following exceptions:
    - The smoke extraction rate shall not less than 1 air change per hour for the full tenancy volume in lieu of extraction rates defined in BCA Specification E2.2b.

- Each tenancy shall form a single smoke reservoir resulting in several tenancies forming a single smoke reservoir exceeding 2,000m^2.

As part of the fire-engineered Performance Solution for Smoke Hazard Management, the following must be provided

- The automatic smoke exhaust system must be designed in accordance with AS1668.1:2015 unless noted otherwise herein.
- The smoke exhaust provided to each tenancy shall include a ducted exhaust system with a fan within the tenancy that is then ducted to an external riser that discharges at the roof. Each external riser and system shall be independent of all other warehouse tenancy smoke exhaust systems.
- Sufficient make up air shall be provided to each warehouse tenancy and be evenly distributed around the perimeter. The make up air must achieve a capacity equal to 100% the exhaust rate of the tenancy.
- A mechanical blockplan shall be provided at the Main FDCIE and incorporate;
  - Signs alerting the Fire Brigade to the operation of the smoke exhaust system.
  - A schematic of the system detailing fan extraction rates, make-up air locations and free area requirements.
  - Reference the Fire Engineering Report.
  - Make notification that no smoke exhaust is provided to the office, carparking and breezeway areas.
- The automatic smoke exhaust system must be connected to the site's essential power source, and the board separated from the remainder of the building as per the requirements of BCA DtS Provisions.
- All fans and wiring must be fire rated in accordance with AS1668.1:2015.

6.4 Occupant Fire Fighting Facilities

6.4.1 Fire Hose Reel

Fire hose reels are to be provided throughout the building in accordance with the prescriptive DtS provisions of BCA Clause E1.4 and AS2441:2005 with exception of the following;

- Due to the large floor areas of each warehouse tenancy and the central dispatch hardstands, hose reels with a length of 50m in lieu of 36m are proposed to be used to achieve coverage within the warehouse and hardstand areas.

As part of the fire-engineered Performance Solution for Smoke Hazard Management, the following must be provided;

- Where 50m long hoses are used;
  - They must be tested to meet the requirements of AS1221:1997 other than the specification of a maximum hose length of 36m.
  - Coverage to any part of the warehouse by a 50m long hose line must be achieved with no more than 2 bends.
  - Where the coverage distance required is less than 36m a 50m hose reel may be used however no restriction of bends can be applied in the design.

- To ensure that the provision of 50m hose reels does not impact life safety, on-site staff training in the use of the hose reels is to be undertaken by the nominated fire wardens.

The location of all fire hose reels should be readily accessible to occupants. The 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 the building based on a 50m or 36m hose length with a 4m water stream.

6.4.2 Portable Fire Fighting Equipment

Portable fire extinguishers are to be provided throughout the building in accordance with Table E1.6 of the BCA with the type of extinguisher selected in accordance with AS2444:2001.

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

6.5 Fire Brigade Intervention

6.5.1 Fire Hydrant System

A fire hydrant system shall be provided throughout the building in accordance with the prescriptive requirements of Clause E1.3 and AS2419.1:2021 with the following exceptions which shall be addressed through a fire engineered Performance Solution:

- Fire Hydrant coverage is to be achieved as per the following:
  - Additional Internal hydrants within the warehouse tenancies are to be positioned within 50m of hydrant located externally of the roofed area over or
  - Additional internal hydrants within Warehouse 5 that are to be positioned within 25m of an internal hydrant within a fire stair connected directly to a warehouse tenancy and
  - for both cases above any further additional internal hydrant may daisy chain to the next additional internally hydrant that is to be positioned not more than 25m away. The last of the additional internal hydrant can provide coverage with 40m.
- Hydrants located under the roofed awnings over are to be considered as external hydrants for the purpose of fire hydrant coverage.
- The hydrant boosters for each site are not located within sight of Building 4A main entrance and is therefore deemed a non-compliant location.

As part of the Performance Solution and typical Fire & Rescue NSW requirements, the system shall incorporate the following measures:

- The fire hydrant booster for each site must face the main street adjacent to the principal entrance.

- The system shall incorporate a ring main and associated isolated valves as required for a large isolated building. Isolation valves shall be numbered with those corresponding numbers indicated on the hydrant block plan.
- All connection points must be fitted with Storz hose couplings which comply with Clause 7.1 and 8.5.11 of AS2419.1:2005, as well as comply with FRNSW Technical Information D15/45534 for *"FRNSW compatible Storz hose connections"*. Further information is available from FRNSW available at www.fire.nsw.gov.au.
- The hydrant system is to be connected to a pressurised town mains water supply to ensure a continuous water supply for firefighting.
- Fire hydrant pumps and tanks are also provided on-site tanks are required, the tank must have a refill functionality linked direct from the pressurised town main supply.
- The diesel pumpsets installed shall be configured to allow FRNSW personnel to safely fill the fuel tanks whilst the pumps are running (i.e. using a 20L portable fuel container).
- Travel distances within the warehouse from the most remote location to an external Fire Hydrant must not exceed 100m

6.5.2 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 from www.fire.nsw.gov.au).

The following variations from the prescriptive requirements shall be addressed through a fire engineered Performance Solution for each warehouse;

- The vehicular perimeter access road is greater than 18m from each building.
- Portions of the perimeter access road have a clear width of less than 6m.
- There shall also be security gates that cross the vehicular access path where the vehicular access road connects to the public road.

As part of the fire-engineered Performance Solution for perimeter vehicular access, the following must be incorporated into the design;

- To facilitate access for Fire & Rescue NSW while still maintaining suitable site security, any perimeter fencing shall have gates positioned across the vehicular access pathway designed per the following;
  - Manually openable gates: Secured with a loose chain and padlock unlockable by fire brigade 003 keys; or
  - Mechanically driven gates: Are to have a manual overdrive provided at the gate motor to disengage the gearing and allow the manual opening of the gate by FRNSW
    - Operational instructions and diagrams illustrating the gate gear override mechanism will be provided at the Main FDCIE with copies of any keys required to activate the gate motor override.
- Roadway gradients shall not hinder vehicle response and must be suitable for heavy vehicles in accordance with Australian Standards and FRNSW Fire Safety Guideline *"Access for fire brigade vehicles and firefighters"*.

- The fire appliance access road and surface are all-weather and are capable of supporting the maximum appliance weights expected during fire conditions. The roadway should be designed to withstand a uniformly distributed load over the entire area as per the Fire and Rescue requirements. This would provide the necessary stability for fire-fighting appliances (pumping), and if necessary, the use of heavier firefighting (aerial) appliances.

6.6 Building Management Procedures

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

6.6.1 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 another relevant testing regulatory.

6.6.2 No Smoking Policy

A no-smoking policy shall be implemented and enforced throughout all internal areas of the building.

6.6.3 Fire Safety Manual

A fire safety manual shall be developed for the site to provide an overview of all fire safety procedures and systems within the building. The manual should also record false alarms, and outcomes from fire drills and provide details of the ongoing maintenance and inspection procedures. The manuals should be reviewed annually and lessons-learned exercises undertaken. Any conclusions drawn from this exercise should be implemented into the fire safety procedures.

6.6.4 Emergency Management Plan

An Emergency Management Plan (EMP) must be developed in accordance with AS3745:2010 Amd 2:2018. The EMP must;

- Developed by an emergency planning committee (EPC).
- Implement emergency control organisation (ECO) procedures for the building.
- Specifically address the types of emergencies that may arise from the industry and/or activities associated with the business operations.
- Ongoing training, education and execution of the emergency management procedures are to be regularly conducted with all building occupants.

An evacuation plan should be developed for the site in accordance with AS3745:2010 Amd 2:2018 and standard fire orders should be displayed throughout the building.

6.6.5 Electric Vehicle Charging Units

Where electric vehicle charging units are installed in the carparking areas, the following fire safety measures must be incorporated into the Building Design.

Power Isolation

- All electric vehicle charging equipment must automatically shut down and be isolated from the mains power on the general fire alarm anywhere within the building.
- All fixed-installed electrical vehicle charging bays must include an emergency stop / isolating switch on each charging unit. The e-stop / isolation switch must isolate the mains power supply to that specific charger.
    - Notification signage must also be provided at the charging units and also at the e-stop button (if located remotely) to indicate the button's purpose and relative location.

Warning Signs for Fire Fighters

- Signage must be displayed at the main FDCIE to indicate the properties of the electric car charging bays and include the following minimum measures;
    - The location of the charging bays.
    - The location of manual isolation switches/boards with wayfinding from the FDCIE and operating instructions on how to isolate the charging unit; including who to contact to arrange shutdown.
    - The power rating (kW capacity) of the chargers.
    - Notification that the EV charging systems automatically cease operation and are isolated from the power supply on general fire alarm.
    - The contact details of a suitably qualified electrician that is on call and able to respond to an emergency and assists firefighters with system isolation.

6.6.6 Dangerous Goods

Should future use of the facility incorporate the use and/or storage of dangerous goods outside the purpose of frequent maintenance purposes, the site will require review and assessment by a suitably qualified Risk Consultant to determine the associated hazards and required preventative measures to meet BCA Clause E1.10 and E2.3. The fire engineering strategy shall be required the following requirements:

- Storage of dangerous or hazardous goods on this site will require re-assessment of the fire engineering analysis by a registered C10 Fire Safety Engineer.
- Where the storage quantity trigger requirements for a fire safety study, the above re-assessment of fire engineering analysis must also be submitted to Fire and Rescue NSW for the key stakeholder's review and support.

6.6.7 Hot Works Policy

A hot works policy should be put in place and rigorously enforced to ensure that all hot works, including grinding and welding, are managed to avoid the accidental ignition of fires.

6.6.8 Fire Drills and General Fire Safety Training

All fire wardens are to be trained in first-aid firefighting and emergency response. All staff shall be inducted with a fire safety brief including the actions necessary for the activation of the building emergency warning system and the location of all emergency egress paths and fire exits. In addition, periodic fire drills should be undertaken and any lessons learned included in future fire safety procedures.

7 REFERENCES

1. Australian Building Codes Board, "NCC - Building Code of Australia – Volume One, 2022", Canberra ACT 2022."
2. Australian Building Codes Board, "NCC - Guide to Volume One", Canberra ACT 2019.
3. Australian Building Codes Board, "International Fire Engineering Guidelines", Canberra ACT 2005.
4. Australian Building Codes Board, "Australian Fire Engineering Guidelines", Canberra, 2021.
5. Brzezinska. D & Bryant. P., Performance-Based Analysis in Evaluation of Safety in Carparks under Electric Vehicle Fire Conditions, Energies 2022, 15, 659.
6. Society of Fire Protection Engineers, "The SFPE Handbook of Fire Protection Engineering", 4th edition, 2008.
7. Drysdale D, "An Introduction to Fire Dynamics", 3rd edition, John Wyley & Sons, UK, 2011.
8. Davis R. (2014), "Fire Concerns With Roof-Mounted Solar Panels", SFPE Fire Protection Engineering Emerging Trends Newsletter, Issue 92, 2014.
9. PD7974-6:2004, "The application of fire safety engineering principles to fire safety design of buildings – Part 6: Human factors", BSI British Standards.
10. PD7974.7:2003, "Application of fire safety engineering principles to the design of buildings – Part 7: Probabilistic risk assessment", BSI British Standards.
11. Spearpoint, M., "Fire Engineering Design Guide", 3rd edition, New Zealand Centre for Advanced Engineering, May 2008.
12. The Chartered Institute of Building Services Engineers, "Fire Safety Engineering CIBSE Guide E", 3rd Edition, May 2010.
13. Drysdale D, "An Introduction to Fire Dynamics", 3rd edition, John Wiley & Sons, UK, 2011.
14. "Fire Brigade Intervention Model V2.2", Australasian Fire Authorities Council, October 2004.
15. Boyce, K., Shields, T., and Silcock, G., "Toward the Characterization of Building Occupancies for Fire Safety Engineering: Capabilities of Disabled People Moving Horizontally and on an Incline", Fire Technology, Vol. 35, No. 1, February 1999, pp. 51-67.
16. Nelson, H.E. "BUD" and Mowrer, F.W., "Emergency Movement", The SFPE Handbook of Fire Protection Engineering (3rd Edition), National Fire Protection Association, Quincy, MA 02269, 2002 pp. 3/367-380.
17. Pauls, J. L. "Movement of People in Building Evacuations", Human Response to Tall Buildings, Chap 21. Dowden, Hutchinson and Ross, Stroudsburg, PA, 1977.
18. Pelecheno N, Malkawi A, "Evacuation simulation models: Challenges in modelling high rise building evacuation with cellular autometa approaches", Automation in Construction Journal 2008 (Vol. 17), pp.377-385.

19. Predtechenskii, V.V. and Milinskii, A.I., Planning for foot traffic in buildings (translated from Russian). Stroizdat publishers, Moscow, 1969. English translation published for National Bureau of Standards and the National Science Foundation, Washington, by Amerind Publishing Co. Pvt. Ltd, New Delhi, India, 1978.
20. Shi, L, Xie, Q, Cheng, X, Chen, L, Zhou, Y, Zhang, R, "Developing a database for emergency evacuation model", pp. 1724-1729 Building and Environment, 2009.
21. Hall, J.R. "U.S. Experience with Sprinklers", National Fire Protection Association, June 2013.
22. Turner, M. "Fire Brigade's Fight for Sprinklers in New Underground Car Park." Fire, 79 (972): 32-34, 1986.
23. Thomas, IR., "Fires in Carparks", Fire Australia February 2004, Eastside Printing, 2004.
24. BHP Steel: Structural steel Development Group, Report No MRL/Ps69/89/006. "Fire Safety in Car Parks".
25. Li, Y and Spearpoint, M. Analysis of vehicle fire statistics in New Zealand parking buildings. Fire Technology, Vol. 43, No. 2, 2007, pp.93-106.
26. BS EN 1991-1-2:2002, 'Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire', British Standards, March 2009.
27. AS 1530.4, "Methods for fire tests on building materials, components and structures, Part 4: Fire resistance tests of elements of construction", Standards Australia, 2005.
28. Bushfire CRC, "Window and Glazing Exposure to Laboratory-Simulated Bushfires", Doc: 2006-205, May 2006.
29. Rakic J, "The Performance of Unit Entry Doors when Exposed to Simulated Sprinkler Controlled Fires", Lorient International, Lindfield, NSW, Australia.
30. England JP, Chow V, Yunlong Liu, (2007) Modelling Smoke Spread through Barrier Systems Retrieved from http://www.yunlong.com.au/pdf/PEngland.pdf
31. Campbell, R., 'Structure Fires in Warehouse Properties', NFPA Research, January 2016.

APPENDIX A FIRE STATISTICS

PROBABILITY OF FIRE STARTS

The probability of a fire start in a range of building uses, based on UK data, can be established using the data presented in Table 7-1 [10]; the applicable occupancy type is highlighted.

Table 7-1: Overall probability of fire starts for various occupancies, UK data

Occupancy	Probability Of Fire Starts (% Per Year)
Industrial	4.4
Storage	1.3
Offices	0.6
Assembly entertainment	12.0
Assembly non-residential	2.0
Hospitals	30.0
Schools	4.0
Dwellings	0.3

PROBABILITY OF CIVILIAN INJURY AND FATALITY

The probability of injuries and deaths for various occupancy types based on UK data [10] is presented in the following table.

Table 7-2: Probability of occupant injury and fatality by occupancy type, UK data averages for the years 1995 and 1997-1999

Type Of Occupancy	No Of Fires	Probability Of Occupant Injury Per Fire Event (%)	Probability Of Occupant Death Per Fire Event (%)
Further education	535	3.18	0.00
Schools	1669	3.06	0.00
Licensed premises	3317	7.90	0.08
Public recreational buildings	2581	1.86	0.05
Shops	5671	5.01	0.06
Hotels	1021	11.36	0.24
Hostels	1338	4.48	0.04
Hospitals	3063	3.69	0.11
Care homes	1616	8.04	0.28
Offices	1988	11.02	0.02
Factories	5299	5.40	0.08

APPENDIX B FIRE BEHAVIOUR

FIRE GROWTH RATE

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

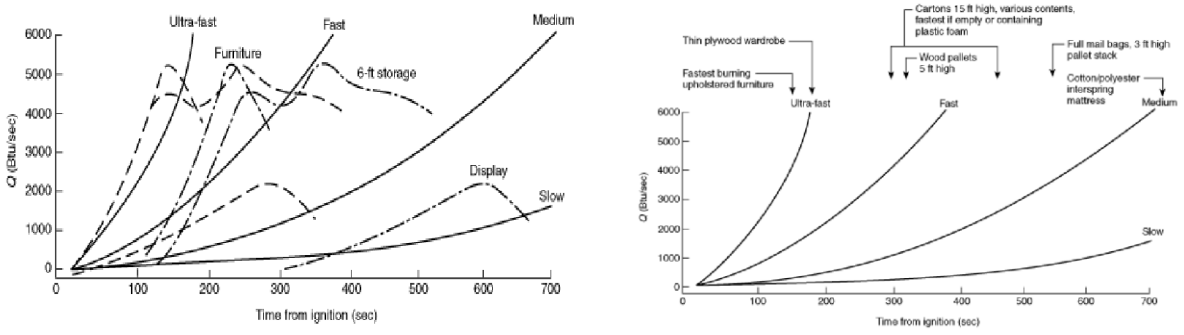
The rate of fire growth is generally expressed in terms of an energy release rate. The most commonly used relationship is what is commonly referred to as a quadratic t-squared fire. In such a fire, the rate of heat release is given by the expression:

$$Q = \left(\frac{t}{k}\right)^2$$

Where; t is time from ignition of the fire (seconds) and k is the growth time (seconds) for the fire to reach a heat output of 1.055 MW.

The continued growth of a fire defined by the above equation relies on both a sufficient source of fuel and air and assumes that flashover has not been reached. The rate of fire growth can be estimated from the results of a number of fire tests that have been performed on various fuel commodities.

National Fire Protection Association Standard NFPA 92B, provides information on the relevance of t-squared approximation to real fire as depicted in Figure 7-1.



(a) t-squared fire, rates of energy release (b) Relation of t-squared fires to some fire tests

Figure 7-1: NFPA 92B design fires and heat release rates

A slow fire growth is not considered to be the most challenging in terms of fire and life safety or fire brigade intervention. The continued growth of a fire defined by the above equation relies on both a

sufficient source of fuel and air and assumes that flashover has not been reached. The rate of fire growth can be estimated from data published in CIBSE Guide E [12] and BS9999:2008 are listed below:

- Assembly hall seating : Medium-Fast
- Dwelling : Medium
- Office : Medium
- Hotel bedroom : Medium
- Hotel reception : Medium
- Meeting room : Medium
- Picture Gallery : Slow
- Reception area : Slow
- Restaurant/Canteen : Medium
- Shop : Fast
- Teaching laboratories : Fast
- Warehouse : Medium/Fast/Ultra-fast
- Waiting Room : Slow

From the above list, it can be concluded that the likely fire scenarios in the building may be approximated by the standard Ultra-fast time-squared fire growth rate curve.

APPENDIX C FIRE LOADS

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 IFEG has published further fire load densities for broad occupancy groupings (extracted from CIB 1983) as provided in the table below. The CIB compilation emphasises that at least the 95% fractile should be selected for design purposes. The following fire loads have been extracted from the IFEG and are considered applicable to the subject building:

Table 7-3: Fuel load densities for different occupancy groups

Densities in mega-joules per square metre				
Occupancy	Mean	Percent fractile		
	(MJ/m^2)	80	90	95
Dwelling	780	870	920	970
Hospital	230	350	440	520
Hospital storage	2000	3000	3700	4400
Hotel bedroom	310	400	460	510
Offices	420	570	670	760
Shops	600	900	1100	1300
Manufacturing	300	470	590	720
Manufacturing and storage <150kg/m^2	1180	1800	2240	2690
Libraries	1500	2250	2550	-
Schools	285	360	410	450

WAREHOUSES (U.S.A.)

The following data has been extracted from the fire statistics data published by the NFPA for the years 2009-2013. The sum of each column of data may not equal totals due to rounding errors.

Table 7-4: Leading causes of structure fires in warehouse properties (2009-2013 annual averages)

Cause	Fires	Civilian Injuries
Intentional	220 (18%)	4 (21%)
Electrical distribution and lighting equipment	220 (18%)	8 (38%)
Heating equipment	90 (8%)	0 (0%)
Exposure fire	90 (7%)	0 (0%)

Cause	Fires	Civilian Injuries
Smoking materials	60 (5%)	0 (0%)
Cooking equipment	50 (4%)	0 (0%)
Lightning	20 (2%)	0 (0%)

Based on the table above, it can be noted that the leading cause is generally equipment used by the building occupants. Electrical distribution and lighting equipment is the leading cause of fires and civilian injuries, accounting for over a third of civilian injuries (38%). The following table indicates the majority of deaths and injuries occur in storage and loading bays of warehouse buildings.

Table 7-5: Structure fires in warehouse properties by area of origin (2009-2013 annual averages)

Cause	Fires	Civilian Injuries
Unclassified storage area	140 (11%)	4 (19%)
Shipping receiving or loading area	120 (10%)	2 (10%)
Storage room, area, tank or bin	80 (7%)	1 (4%)
Vacant structural area	60 (5%)	0 (0%)
Unclassified outside area	50 (4%)	1 (3%)
Storage of supplies or tools or dead storage	50 (4%)	0 (0%)
Exterior roof surface	50 (4%)	0 (0%)
Trash or rubbish chute, area or container	40 (4%)	0 (0%)
Unclassified equipment or service area	40 (4%)	0 (2%)
Processing or manufacturing area, or workroom	40 (3%)	1 (5%)
Unclassified area of origin	40 (3%)	1 (5%)
Office	40 (3%)	1 (7%)
Exterior wall surface	40 (3%)	0 (0%)
Maintenance or paint shop area	30 (3%)	1 (5%)

Cause	Fires	Civilian Injuries
Unclassified structural area	30 (2%)	0 (0%)
Garage or vehicle storage area	30 (2%)	1 (6%)
Kitchen or cooking area	20 (2%)	0 (0%)
Wall assembly or concealed space	20 (2%)	0 (0%)
Machinery room or area or elevator machinery room	20 (2%)	0 (0%)
Other known area of origin	280 (23%)	6 (27%)

The following table lists the extent of fire spread in warehouse properties and the corresponding number of civilian injuries.

Table 7-6: Structure fires in warehouse properties by extent of flame (2009-2013 annual averages)

Extent Of Fire Spread	Fires	Civilian Injuries
Confined fire identified by incident type	280 (23%)	0 (0%)
Confined to object of origin	170 (14%)	6 (32%)
Confined to room of origin	260 (21%)	4 (19%)
Confined to floor of origin	70 (6%)	1 (6%)
Confined to building of origin	370 (31%)	7 (38%)
Beyond building of origin	60 (5%)	1 (5%)