BUSHFIRE PRONE PLANNING

OTR Neerabup

Bushfire Risk Assessment & Management Report

Produced to meet the relevant requirements of STATE PLANNING POLICY 3.7 Planning in Bushfire Prone Areas & Guidelines

Lot 1001 (11) Greenwich Parade, Neerabup

City of Wanneroo

14 November 2022

Job Reference No: 180353

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Limitations: *The protection measures contained in this Bushfire Risk – Assessment and Management Report, are considered to be minimum requirements and they do not guarantee that buildings or infrastructure will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating. This is substantially due to the unpredictable nature and behaviour of fire and fire weather conditions. Additionally, the correct implementation of the recommended protection measures will depend upon, among other things, the ongoing actions of the landowners and/or operators over which Bushfire Prone Planning has no control.*

All surveys, forecasts, projections and recommendations made in this report associated with the proposed development are made in good faith based on information available to Bushfire Prone Planning at the time. All maps included herein are indicative in nature and are not to be used for accurate calculations.

Notwithstanding anything contained therein, Bushfire Prone Planning will not, except as the law may require, be liable for any loss or other consequences whether or not due to the negligence of their consultants, their servants or agents, arising out of the services provided by their consultants.

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1 CONSULTANT STATEMENT - KEY OBSERVATIONS

The statement provides a subjective overall opinion to the persons tasked with reading this report and making decisions

The intent is to further assist or clarify the reported outcome. Importantly, the statement draws on the relevant qualifications and practical experience associated with bushfire and bushfire events and their management, of the bushfire practitioner compiling or approving this report.

In the absence of the required set of risk factor criteria, risk level matrix and risk tolerability scale being established by the regulatory authorities to enable the derivation of a 'determined' risk level - this statement will necessarily be framed around the applied assessment process that derives an 'indicative risk' level (refer to section 2.3.4 and Appendix 2).

The following statement is based on:

1. My opinions as an accredited bushfire practitioner with relevant experience and qualification; and
2. Supporting information derived from the assessments detailed in this report.

Summary Statement

The *Guidelines for Planning in Bushfire Prone Areas (WAPC 2017 v1.4)* (Guidelines), support the application of SPP 3.7.

SPP 3.7 establishes the single source of risk to be considered (i.e. 'any flammable onsite hazards') while Section 5.6 of the Guidelines effectively expands on the sources of risk to be considered by establishing the consequences that are to be considered. The consequences established are:

- Ignition of a bushfire;
- Prolonging a bushfire's duration;
- Increasing the intensity of a bushfire; and
- Exposing persons and the environment to dangerous and uncontrolled substances during a bushfire event.

From this guidance, it is determined that the risk management report required by SPP 3.7 for a high risk land use, is not required to consider sources of risk that are either not associated with bushfire or are planning assessments required to be dealt with by in the Bushfire Management Plan. Therefore, these are excluded from the scope of this risk management plan. This includes any risk management requirements for planning and operational purposes that are established by other legislation and/or regulations (e.g. Dangerous Goods Safety Act 2004).

The treatments stated in this Risk Assessment Report with respect to threat, exposure and vulnerability are recommended to be applied and maintained, and where relevant included in the site emergency plan and site procedures and guidelines. The recommended/required treatment measures to be applied are outlined in Section 1.1.

Key Factors Contributing to the Opinion

- The bushfire hazard, associated threat levels and the ability to apply protection measures
- The exposure of elements at risk and the ability to apply protection measures
- The vulnerability of elements at risk and the ability to apply protection measures

1.1 RECOMMENDED BUSHFIRE PROTECTION MEASURES

The treatments outlined below have been determined through the analysis in the Bushfe Risk Assessment Report. Further detail is available in the body of this document.

Application of Measure	Protection Measures to be implemented
Design and Construction	Construction of the Control Building (retail use) to AS3959 standards is an additional protection measure required in the Bushfire Management Plan for this site. The site layout must include positioning any installed/stored gas cylinders >6m from stored combustible liquids, bowsers, or other flammable material (such as the Refuse Enclosure) and comply with AS1596. Ember screening is recommended to be applied to any penetrations within the bowser canopy (where practical). At the detailed design stage, it is recommended that designs are investigated for: • Roof/building complexities which may trap debris or collect embers • Cabling/piping contacting the ground or any arrangement of associated structures creating a 'pocket' for accumulation of debris. These complexities are recommended to be removed, enclosed, or filled with non-combustible material where practical. Consideration should be given to making the arrangement self-cleaning through wind action to the greatest extent possible. Functionally this means preventing details which may accumulate leaf litter which will not naturally be cleared by wind.
Asset Protection Zones	It is recommended that the City of Wanneroo Firebreak Notice on neighbouring properties, to reduce the bushfire hazard to developed lots within local cleared (grassed) area. It is recommended that any fencing or other potential fuel loads be constructed using non-combustible material. Landscaping (gardens) which may be included within the APZ should avoid use of constructed heavy fuels (e.g. timber sleepers as garden edges, plastic or timber lattice). Feature columns may be composed of timbers with a density >750kg/m3 at 12% moisture content (see AS3959 Table E1).
Details or Requirements for Future Operational Documents	Measures including preparation, responses, and training (including designation of roles) for bushfire events are required to be included in the future site Emergency Management Plan (document title pending). Staff induction and training are recommended to include basic bushfire awareness training and review of the site Emergency Management Plan (document title pending). Staff are recommended to be trained in the use of fire extinguishers to combat consequential fires. Operating and maintenance procedures are to be developed to ensure regular maintenance of firefighting equipment and clearing of accumulated debris and other consequential fire hazards. Operating procedures and/or the site Emergency Management Plan (document title pending) are required to include a trigger for site evacuation due to bushfire. It is recommended that any stored combustible items are removed from the profile of buildings. This may be ongoing or be actioned as a response to a bushfire event (e.g. moving furniture away from a building).

2 INTRODUCTION

2.1 THE PROPOSED DEVELOPMENT/USE

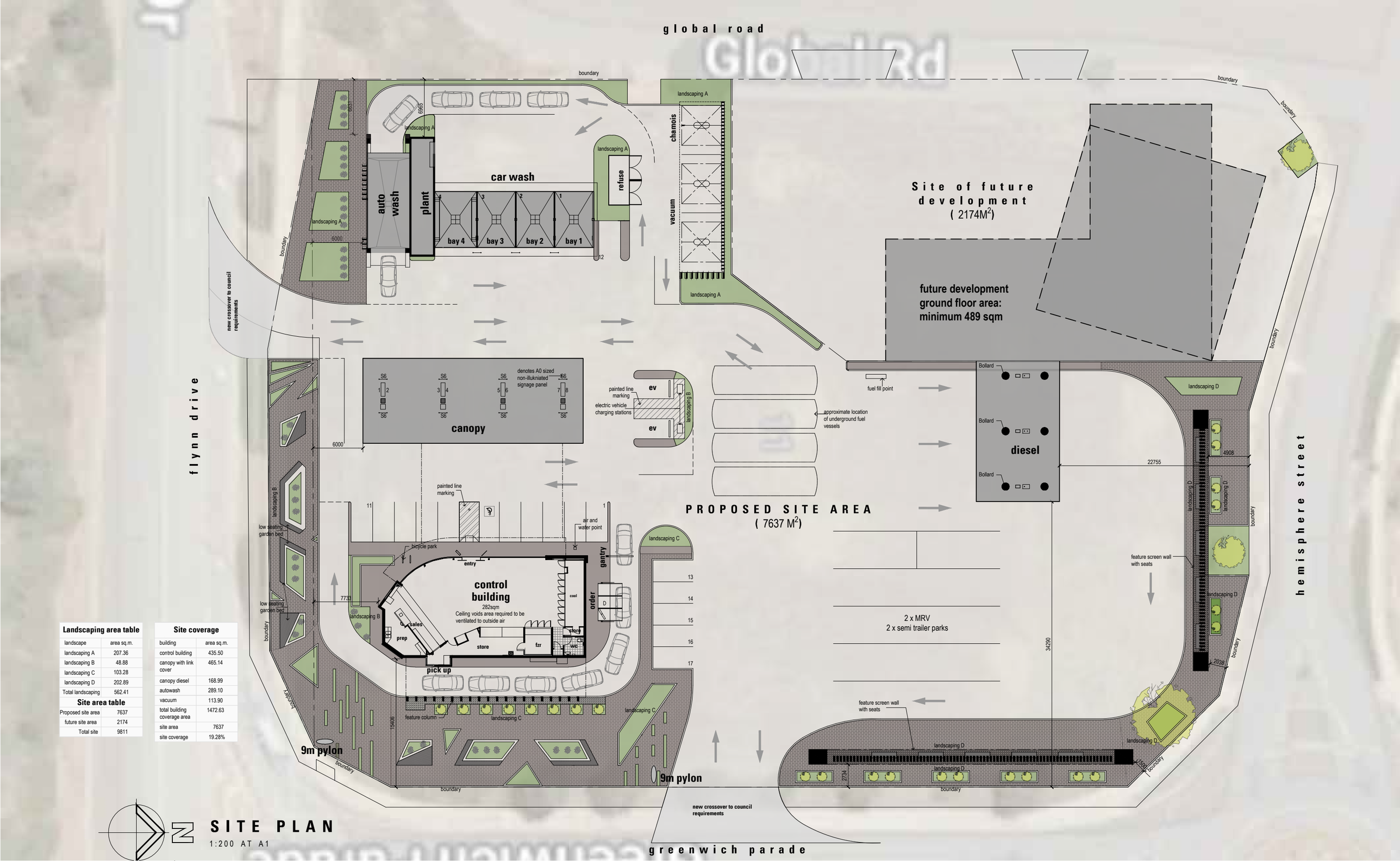
This Bushfire Risk Assessment and Management Report has been developed to accompany the development application for a proposed service station located at Lot 1001 (11) Greenwich Parade, Neerabup, in the City of Wanneroo.

The key components of the proposal include:

- Fuel dispensing forecourt, tanks, pumps and canopy (passenger vehicle and high-flow diesel separate);
- Electric Vehicle charging stations;
- Control building (including food service drive through);
- Car vacuum/wash bays, auto wash, and associated plant room.

This development is considered a high-risk land use, being a service station with combustible (flammable) materials, including hazardous materials stored onsite and business operations that are a potential source of ignition for onsite or offsite flammable/combustible materials.

The bowsers and refilling point(s) of the underground fuel tanks are considered the high-risk components of the facility. Other structures are not high risk but may pose a hazard in terms of structure-to-structure or consequential fire hazard.



Landscaping area table	
landscape	area sq.m.
landscaping A	207.36
landscaping B	48.88
landscaping C	103.28
landscaping D	202.89
Total landscaping	562.41

Site area table	
Proposed site area	7637
future site area	2174
Total site	9811

Site coverage	
building	area sq.m.
control building	435.50
canopy with link cover	465.14
canopy diesel	168.99
autowash	289.10
vacuum	113.90
total building coverage area	1472.63
site area	7637
site coverage	19.28%

N

SITE PLAN

1:200 AT A1

NEW SERVICE STATION COMPLEX

11 GREENWICH PARADE, NEERABUP WA

0 1 2 5 10m

Scale 1:100 at A1

12.10.22

Neerabup sk00d

design

2.2 THE RISK ASSESSMENT OBJECTIVES

Establishing the objectives directs the way the assessment process is conducted, and the type of information reported. Relevant objectives are typically determined by the applicability of one or more of the following three key factors:

1. The type of proposed or existing development. This can include:
    a) Construction or modification of buildings, structures and infrastructure assets; or
    b) Subdivision of land.
2. The type of proposed or ongoing land use. This can include:
    a) Those defined as industrial, commercial or residential; and
    b) Including those that have a planning classification of 'high risk' or 'vulnerable' - including tourism and event uses.
3. The relevant stage of planning. This can include but is not limited to:
    a) An existing development and/or use for which an assessment of the necessity for and the potential to improve bushfire resilience is conducted and the consequent lowering of the associated risks identified.
    b) At the strategic planning stage of new development/use when final details of the proposed development/use are not fully known and therefore relevant protection measures can potentially be identified and incorporated into design.
    c) At the final planning stage that requires approval or a 'decision to proceed'. All relevant details of the proposed development/use are known. The requirement at this stage is to inform decision makers by providing an assessment of the residual bushfire risk.

The primary objectives for the subject development and/or use are collated as a summary in Table 2.1.

Table 2.1: Identifying the risk assessment objectives for the subject development/use.

RISK ASSESSMENT OBJECTIVES - INFORMATION TO BE DERIVED
Identify: The types of bushfire prone vegetation (considering factors that include components, arrangement and fuel loads), that exist onsite and offsite. Initially this may be limited to a desktop assessment with ground truthing to follow at a later date.
Determine: The relative threat levels each bushfire hazard attack mechanism (direct and indirect) presents. Determine if the broader physical landscape surrounding the subject development/use has the potential to increase or decrease the levels of those threats.
Identify: All at risk physical elements that are exposed to the potential threats of the bushfire hazard.
Identify: Assets that owners/operators are prepared to lose from consequential fire resulting from a bushfire event, rather than apply sufficient protection measures i.e., the asset loss risk is to be retained. This may be due to cost or practicability. Consideration the consequent risk from asset abandonment and the availability of person risk mitigation measures.
Identify: All at risk human elements that are exposed to the potential threats of the bushfire hazard.
Identify: Bushfire protection measures that have or can be applied to reduce bushfire hazard threat levels to the greatest extent allowable and practicable.
Identify: Bushfire protection measures that have or can be applied to reduce the exposure and vulnerability of buildings/structures, infrastructure and other physical assets, to the potential threats of the bushfire hazard. The intent being to increase asset resilience to the threats to the greatest extent practicable.

RISK ASSESSMENT OBJECTIVES - INFORMATION TO BE DERIVED
Identify: Bushfire protection measures that have or can be applied to reduce the exposure and vulnerability of persons to the potential threats of the bushfire hazard to the greatest extent practicable.
Identify: Bushfire protection measures that have or can be applied to reduce the exposure and vulnerability of the bushfire prone vegetation to site activities which may pose an ignition hazard.
Applicable to New Development and/or Use: Inform relevant persons (planners / designers / operators / owners), at the appropriate planning stage, of available bushfire protection measures to be incorporated into siting, design, construction, education and management, to optimise bushfire performance. Identify site specific protection measures, from the defined sets of bushfire protection measure principles, that have the potential to be applied as a package of protection measures. The intent is to achieve at least a tolerable level of risk to persons and property by ensuring that: • Buildings, structures and other physical assets are resilient against bushfire hazard threats, to the greatest extent practicable. • Persons have their exposure and vulnerability to bushfire hazard threats reduced, to the greatest extent practicable. Provide implementation advice as necessary.
Assess: The indicative residual risk levels to inform planners / designers / operators / owners and/or relevant decision makers. This is to be achieved through the application of the following information that has been established by the bushfire consultant: • The process for determining relative threat, exposure and vulnerability levels; • the indicative risk matrix; and • the risk tolerance scale. (Refer to Section 2.3.4, Appendix 2 and the glossary for additional information).

2.3 THE APPLIED RISK ASSESSMENT PROCESS

2.3.1 THE DEFINITION OF RISK

For the applied risk assessment process, the relevant risks are the potential for loss of life, injury, or destroyed or damaged assets which results in personal loss and economic loss due to disruption of services and/or repair or replacement of buildings and infrastructure. The source of the risk is the bushfire as a natural hazard.

2.3.2 THE ASSESSMENT PROCESS (FRAMEWORK)

To conduct and report the risk assessment process, Bushfire Prone Planning has adapted the understanding of disaster risk as described by the United Nations Office for Disaster Risk Reduction (UNDRR) and shown in Figure 2.2.

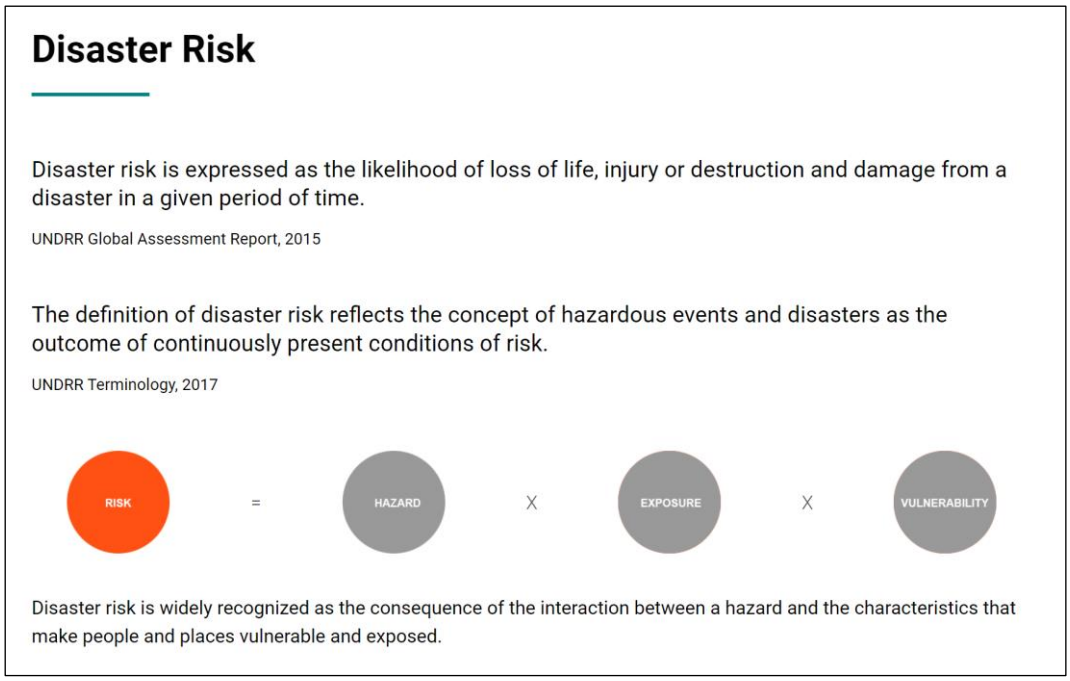


Figure 2.2: Understanding disaster risk (Source: United Nations Office for Disaster Risk Reduction [46]).

Although the UNDRR approach is designed to addresses disaster risk at large scale strategic levels, it can justifiably be applied to all scales of planning because it is focused on natural hazards and establishes a concept that can be readily adapted. The rationale for adopting this approach, rather than the methodology established by the National Emergency Risk Assessment Guidelines (AIDR 2020, NERAG), is provided in Appendix 1.

Also utilised within this assessment approach are relevant principles and measures to be applied in the development of bushfire risk mitigation strategies that are detailed in the Bushfire Verification Method Handbook [14].

PROCESS OVERVIEW

The risk presented by a natural hazard (such as a bushfire) is a consequence of the interaction between the potential threats associated with the hazard and the exposure and vulnerability of any elements at risk from those threats (the 'exposed elements').

The application of available protection measures will lower the risk by:

1. Reducing the number and/or level of the hazard threats; and/or
2. Reducing the level of exposure and/or vulnerability of the elements at risk.

Figure 2.3 illustrates the framework of the adapted risk assessment process (refer to the glossary for terminology information and Appendix 2 provides greater detail of the risk analysis component of the assessment process).

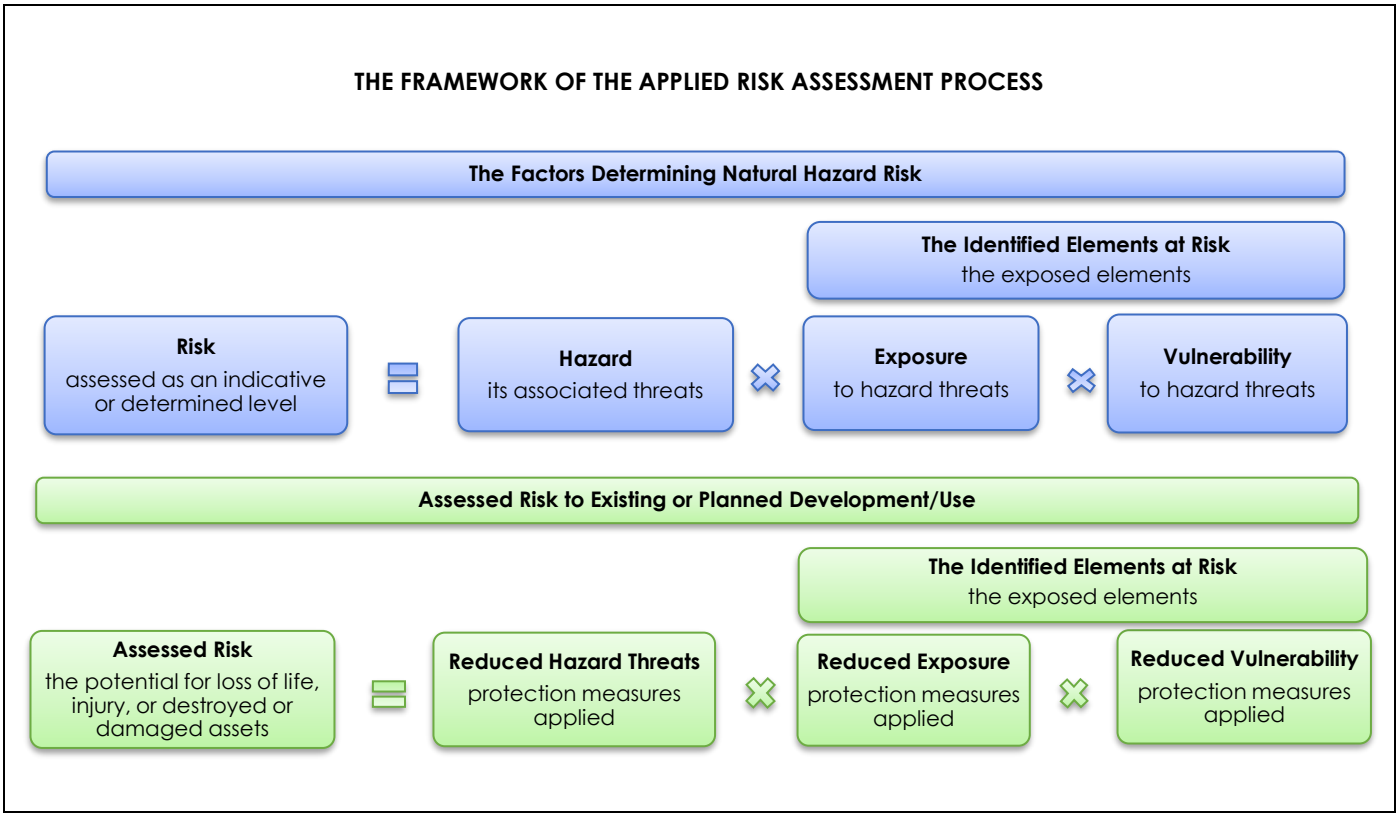


Figure 2.3: Framework of the applied risk assessment process.

2.3.3 RISK LEVEL ANALYSIS

(Refer to Appendix 2 and 3 and the Glossary for additional information.)

When the derivation of risk levels is a stated assessment objective, the risk analysis will derive a risk level as a summary outcome. The required risk level analysis can be conducted for either each exposed element separately and/or the proposed or existing development/use overall.

The risk level can be reported as either indicative or determined:

- **Indicative Risk Level**: This is derived based on a comparison of the numbers of protection measures able to be applied with the number of possible measures in the protection measure 'universe'. Appropriate weighting is given to the level of effectiveness of each of the measures. The intent is to provide a qualitative understanding of the level of risk that exists, to assist with making the required decisions.
- **Determined Risk Level**: This is derived using defined sets of risk factor criteria that correspond to each hazard threat level, exposure level and vulnerability level, for the elements at risk. Subsequently, how these defined levels are then applied to establish a determined risk level and its tolerability, is defined by an accepted risk level matrix and risk tolerance scale.

  The risk factor criteria must reflect societies preparedness to tolerate risk and should be determined by regulatory authorities exercising their responsibilities. The criteria will vary dependent on development/use type and scale.

  Consequently, the risk factor criteria (and potentially the risk level matrix and risk tolerance scale) need to be defined by the regulatory authorities before they can be applied in assessing a determined risk level.

Dependent on the stage of development/use, or to meet differing assessment objectives, the risk level can also be reported as:

- **Inherent Risk:** As the current risk when the assessment has only accounted for the bushfire protection measures that are either already in place (for existing development/use), or are planned to be incorporated into the proposed development/use; or
- **Residual Risk:** As the remaining risk when the assessment has also accounted for the application of any additional protection measures recommended by this report. If there are none, the residual risk is the same as the inherent risk.

2.3.4 USING THE ASSESSMENT PROCESS TO MEET THE STATED OBJECTIVES

The reporting objectives (established in Section 2.2) will vary for different types and stages of proposed (or existing) development/use. However, the same base framework is able to be utilised and the process can be adapted to achieve the required outcomes.

Figure 2.4 provides further detail of the adopted assessment process, based on the framework shown in Figure 2.3.

2.3.5 BUSHFIRE PROTECTION MEASURE EFFECTIVENESS RATINGS

The following effectiveness ratings are applied to the applicable bushfire protection measures, as part of the risk assessment process, and as a factor applied in deriving 'relative' threat, exposure and vulnerability levels.

The more effective a bushfire protection measure is, the greater its value in increasing bushfire resilience (buildings/structures), and/or increasing the safety of persons and in decreasing the level of risk associated with bushfire.

The effectiveness ratings incorporate the qualities of:

1. **Independence:** As a qualitative assessment, the extent to which the protection measure has the capacity to reduce threat, exposure and vulnerability levels as either independent of other protection measures (i.e., standalone) or requiring the cumulative capacity of a package of interdependent measures; and
2. **Passiveness:** The capacity of the protection measure to function without the active involvement of persons.

The greater the independence and passiveness of a protection measure, the greater its effectiveness.

Table 2.2: Bushfire protection measure effectiveness ratings.

THE APPLIED BUSHFIRE PROTECTION MEASURE EFFECTIVENESS RATINGS	
Rating / Descriptor	Protective Characteristics and Capability
Very High (Independent and Passive)	Very significant risk reduction as an independent (standalone) measure. Impact on risk reduction is immediate and persistent in all scenarios. Operates passively with no or minimal requirement for ongoing implementation, management and maintenance. A priority measure to be implemented wherever possible.
High (Independent and Passive)	Material risk reduction as an independent (standalone)measure; Operates passively with none or minimal requirement for ongoing implementation, management and maintenance.
Effective (Independent and Active)	Material risk reduction as an independent (standalone) measure; Effectiveness relies on active implementation, management, maintenance and/or response.
Moderate (Combined and Passive or Active)	Alone the measure will have limited impact on risk reduction. It has additive value when combined with other protection measures to create a 'package' of bushfire protection measures. Effectiveness is achieved both passively and/or with active implementation, management, maintenance and/or response.
Not Relevant	The measure is not relevant to the type of development/use. (Note: this is different to not being able to be applied – it is just not relevant to any configuration of the subject development/use.

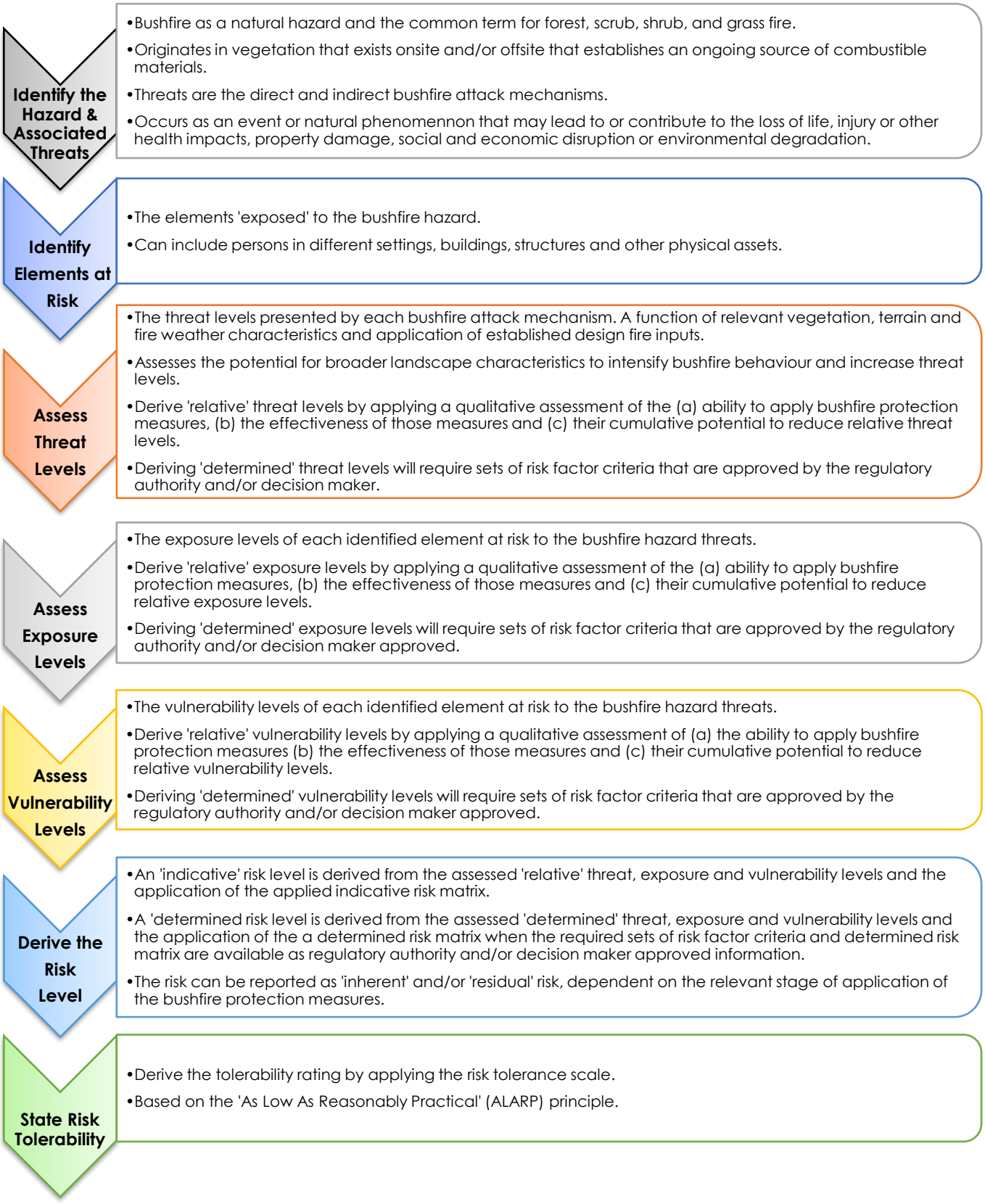


Figure 2.4: Outline of the adapted risk assessment process applied in this report.

2.4 THE BUSHFIRE HAZARD - BEHAVIOUR AND ATTACK MECHANISMS

Information regarding bushfire attack mechanisms and the potential influence of the broader landscape on the intensification of fire behaviour, is provided in Appendix 4 and 5. The content of these appendices is outlined below. Providing this information is intended to:

1. Assist those tasked with making design, construction, planning and management decisions (based on the information and assessments presented in this report), to have a better understanding of bushfire hazards where this may not be within their general field of expertise. This knowledge may also benefit development of innovative protection measures to increase the bushfire resilience of buildings/structures and/or improve persons safety and/or reduce bushfire threat levels; and
2. Assist readers understand why the assessment of the bushfire hazard threats and the presentation of the identified protection measures is organised the way it is in this report. It can also assist with guiding the search for additional information when necessary.

CONTENT OF APPENDIX 4

1. Factors Influencing Bushfire Behaviour
    - Vegetation and other fuels - key characteristics
    - Weather
    - Topography
2. Bushfire Direct Attack Mechanisms
    - Ember attack
    - Radiant heat attack
    - Bushfire flame attack
    - Surface fire attack
3. Bushfire Indirect Attack Mechanisms
    - Debris accumulation
    - Consequential fire
    - Fire driven wind
    - Tree strike and/or obstruction

CONTENT OF APPENDIX 5

1. Recent bushfire research
2. Dynamic Fire Behaviours
    - Spotting
    - Fire whirl/tornado
    - Junction fire
    - Crown fire
    - Eruptive fire
    - Fire channelling (vorticity-driven lateral spread)
    - Conflagrations
    - Downbursts
    - Pyroconvective events.
3. Drivers of deep flaming
4. Extreme bushfire events
5. Physical requirements of terrain, fuel load (and windspeed) for deep flaming.

3 ASSESSMENT SUMMARY

The assessment summary is presented in three parts. Section 3.1 states the derived bushfire threat levels, and the exposure and vulnerability levels of each element at risk – as the factors from which the risk levels are derived.

Section 3.2 two shows the type of risk level that is to be reported, states the derived risk levels and the tolerability of that risk - for each exposed element and each identified area of bushfire prone vegetation.

Section 3.3 in which the bushfire protection measures that can be applied are summarised and in which operational document they will need to be incorporated.

3.1 THE ASSESSED THREAT, EXPOSURE AND VULNERABILITY LEVELS ESTABLISHING THE RISK LEVEL

Table 3.1: The assessed threat levels of the bushfire hazard.

ASSESSED HAZARD THREAT LEVELS [1]		
Bushfire Prone Vegetation	Relative Threat Level [2]	
	Inherent	Residual
All bushfire prone vegetation within 150m of the proposed development. All vegetation within the Lot will be removed in the course of development.	Low	Low
All bushfire prone vegetation within the broader locality (2km radius) including along access routes.	Moderate	
[1] Refer to Section 6 for detailed assessment information. [2] Refer to Appendix 2 for explanatory information.		

Table 3.2: The assessed exposure and vulnerability levels for each exposed element to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE AND VULNERABILITY LEVELS OF IDENTIFIED ELEMENTS AT RISK [1]				
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.			
Elements At Risk[2]	Relative Exposure Level [3]		Relative Vulnerability Level [3]	
Description	Inherent	Residual	Inherent	Residual
Persons located onsite and temporarily offsite	Low		High	Moderate
Buildings/Structures - NCC Classes 1-10	High	Moderate	Low	Very Low
[1] Refer to Sections 7 and 8 for detailed assessment information. [2] Refer to their identification in Section 5. [3] Refer to Appendix 2 for explanatory information.				
Vegetation Area / Location	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.			
Elements At Risk[2]	Relative Exposure Level [3]		Relative Vulnerability Level [3]	
Description	Inherent	Residual	Inherent	Residual
Persons on access/egress routes (in vehicles) or pathways	Moderate		Low	
[1] Refer to Sections 7 and 8 for detailed assessment information. [2] Refer to their identification in Section 5. [3] Refer to Appendix 2 for explanatory information.				

3.2 THE ASSESSED BUSHFIRE RISK LEVEL AND ITS TOLERABILITY

Table 3.3: Identifying the 'type' of risk level being assessed and reported in this report.

THE TYPE OF RISK LEVEL DERIVED FROM THE ASSESSMENT [1]			
Indicative Risk		Determined Risk	
Inherent	Residual	Inherent	Residual
✓	✓	☐	☐
[1] Refer to Section 2, Appendix 2 and the glossary for explanatory information (inherent/residual corresponds to the level that available protection measures have been considered in the assessment with 'residual' including recommended measures).			

Table 3.4: The tolerability of the assessed risk levels for each exposed element and corresponding to the identified areas of bushfire prone vegetation.

THE ASSESSED BUSHFIRE RISK LEVEL AND TOLERABILITY [2]					
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.				
Elements At Risk [1]	Indicative Risk Level [2]		Inherent Risk Tolerability (ALARP) [3]	Residual Risk Tolerability (ALARP) [3]	Adjusted Residual Risk Tolerability (ALARP) [4]
Description	Inherent	Residual			
Persons located onsite and temporarily offsite	**L6**	**L5**	Tolerable but NOT ALARP	Acceptable	N/A
Buildings/Structures - NCC Classes 1-10	**L6**	**L4**	Tolerable but NOT ALARP	Acceptable	N/A
Vegetation Area / Location	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.				
Elements At Risk [1]	Indicative Risk Level [2]		Inherent Risk Tolerability (ALARP) [3]	Residual Risk Tolerability (ALARP) [3]	Adjusted Residual Risk Tolerability (ALARP) [4]
Description	Inherent	Residual			
Persons on access/egress routes in vehicles	**L6**	**L6**	Acceptable	Acceptable	N/A
Supporting Comments: An inherent risk tolerability is considered to be TOLERABLE because it has an indicative risk level of LOW or VERY LOW, but is assessed as being 'reasonably practical' for the inherent risk level to be lowered further with the application of the assessed available and recommended bushfire protection measures. The residual risk tolerability is considered to be ACCEPTABLE because it is assessed as not being 'reasonably practical' for the residual risk level of 'LOW' to be further lowered by the application any additional bushfire protection measures.					
[1] Refer to their identification in Section 5. [2] Refer to Section 2, Appendix 2 and the glossary for explanatory information (inherent/residual corresponds to the level that available protection measures have been considered in the assessment with 'residual' including recommended measures). [3] Refer to Appendix 3 for information supporting the application of the tolerance scale. [4] Refer to Section 3.2.1 for adjustment justification when applicable.					

3.2.1 ADJUSTMENT OF RESIDUAL RISK TOLERABILITY

Development/use scenarios can exist where - for certain elements at risk - high and extreme levels of residual risk might be considered to be a tolerable or acceptable level of risk.

Such a situation may exist when the exposed element is not persons and the economic cost due to the loss or damage of assets and/or disruption of services, is a risk that is retained by the owners as an informed decision.

The knock-on risk implications to persons who might be associated with these elements will need to be part of the tolerability adjustment assessment.

Table 3.5: Identification of relevant exposed elements and justification for adjustment of risk tolerability.

ELEMENTS AT RISK SUBJECT TO ADJUSTMENT OF RISK TOLERANCE	
Elements At Risk Description	Justification For Risk Tolerance Adjustment
Buildings/Structures - NCC Classes 1-10: Car Wash facilities	The Car Wash facilities including Auto Wash, Plant Room, Car Wash, and Vacuum Bays, are not habitable structures. They have no staffing or occupancy, only transient use. These structures are not enclosed and are thus unable to comply with AS 3959 or NASH. They will be largely constructed from non-combustible materials and have a >6m setback from other structures, limiting structure-to-structure fire. The Car Wash facilities are not high-risk uses and are not considered as part of this risk assessment.
Fixed (hard) infrastructure assets: Refuse Enclosure	The Refuse Enclosure contains waste materials only. Potential ignition of stored waste is considered as a hazard, however the Enclosure itself is considered a tolerable loss in a bushfire. It has not been considered an asset for the purposes of this Risk Assessment (the tolerability is not adjusted).

3.3 BUSHFIRE PROTECTION MEASURE APPLICATION & IMPLEMENTATION SUMMARY

ENSURING THE PROTECTION MEASURES ARE APPLIED THROUGH RELEVANT OPERATIONAL DOCUMENTS

The assessed 'base' hazard threat level and the ability to apply bushfire protection measures, are the key determinants of the risk to persons and property associated with the subject development/use.

Existing, planned and recommended protection measures have been accounted for in the derivation of the inherent and residual risk levels for each identified element at risk.

Consequently, it is crucial that these applied protection measures are incorporated into the relevant operational documents to ensure their actual implementation - if proceeding with the development/use is approved.

The required operational documents can be one or more of the following:

- **The Bushfire Management Plan (BMP)** – in which a limited number of bushfire protection measures are being addressed as the bushfire protection criteria to be met. The BMP also has scope to recommend additional protection measures as required and justifiable;
- **The Bushfire Emergency Plan (BEP)** - which addresses a particular set of bushfire protection measures associated with the preparation for, response to, recovery from and the review of a bushfire emergency event, including the movement of persons to safer locations;
- **A Site Emergency Plan** – which typically is prepared for uses associated with higher risk operations that involve flammable/hazardous materials or may present a source of ignition for bushfire prone vegetation. For these uses, there is a regulatory requirement for an appropriate site emergency plan to establish how a range of relevant emergency events is to be prepared for and responded to. A bushfire event is an additional emergency that must be incorporated into that plan; or
- **Project Design Documents** – which are in the development phase and require specific information about the protection measures that can be incorporated to mitigate risk associated with a bushfire event.
- **A Bushfire Resilience Works Program** – for an existing or planned development/use (operation) the works program document will detail additional works and procedures (i.e. protection measures) that need to be conducted to improve the bushfire resilience of persons and property – as a once off or annually. It also identifies the priority level for individual works so that potentially limited funds can be allocated in the most effective way.

  The relevant information is derived from the results of this Bushfire Risk – Assessment and Management Report which essentially is utilised as a bushfire threat and resilience audit for the existing operation.

The check to ensure the incorporation of bushfire protection measures into the relevant operational document is established within the tables below. It is aligned with each individual bushfire protection measure that is presented as a summary description grouped by element at risk and the protection principle being employed.

The detailed protection measure information is contained within Sections 6, 7 and 8 of this report.

Table 3.6 summarises the bushfire protection measures that currently exist and/or are recommended to be implemented and that are to be maintained into the future.

The detail of these measures is set out in the Hazard Threat Level, Exposure and Vulnerability assessment tables.

The checklist identifies the operational documents that are recommended to be updated and/or created to incorporate the requirements and responsibilities into the documents.

3.3.1 THREAT (BUSHFIRE HAZARD) REDUCING PROTECTION MEASURES

Table 3.6: Summarised application of threat reducing protection measures (refer to section 6.1 for details).

Threat Reducing Protection Measure			Application Status Subject Development/Use		Checklist - Incorporation of Protection Measures into Operational Documents				
Protection principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Prevent fire ignition and/or severity by controlling the fuel	1.1	Remove offsite bushfire fuel	Not applied to proposed development						
	1.2	Reduce offsite bushfire fuel - hazard reduction burning	Not applied to proposed development						
	1.3	Reduce offsite bushfire fuel- mechanical	Not applied to proposed development						
	1.4	Remove onsite bushfire fuel	✓	□	✓	□	□	✓	✓
	1.5	Reduce onsite bushfire fuel - hazard reduction burning	Not applied to proposed development						
	1.6	Reduce onsite bushfire fuel - mechanical	Not applied to proposed development						
	1.7	Reduce onsite consequential fire fine fuels	✓	□	✓	□	□	□	✓
	1.8	Reduce road verge fuel	Not applied to proposed development						
	1.9	Greater enforcement applied to compliance with the local government's fire break and fuel load notice	□	✓	✓	□	□	□	□
Prevent fire ignition by controlling heat energy sources	1.10	Operational procedures – fire safe site procedures	✓	□	□	□	✓	✓	□
	1.11	Operational procedures – hazard reduction burning	Not applied to proposed development						
	1.12	Equipment design – limit potential for spark production	✓	□	□	□	□	✓	□
	1.13	Legal enforcement – of total fire bans	Not applied to proposed development						
	1.14	Legal enforcement – methods to reduce arson	✓	□	✓	□	□	□	□
	1.15	Education of persons	Not applied to proposed development						
Prevent fire ignition by controlling heat energy source and fuel interactions	1.16	Shielding of ignition sources from bushfire fuels	Not applied to proposed development						
	1.17	Separation of ignition sources from bushfire fuels	Not applied to proposed development						
	1.18	Equipment design – control energy transfer to fuels	✓	□	□	□	□	✓	□

3.3.2 EXPOSURE REDUCING PROTECTION MEASURES - PERSONS

Table 3.7: Summarised application of exposure reducing protection measures for persons (refer to sections 7.1.1 for details).

Exposure Reducing Protection Measure - Persons			Application Status Subject Development/Use		Checklist – Incorporate into Stated Operational Documents				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Separation from All Bushfire Threats	Persons Located Onsite and Temporarily Offsite								
	2.1	Stay away from the subject site	Not applied to proposed development						
	2.2	Stay within the subject site – remote offsite hazard	Not applied to proposed development						
	2.3	Relocate away from remote offsite hazard - safer offsite location available	Not applied to proposed development						
	2.4	Evacuate from the subject site - safer offsite location(s) available	✓	☐	☐	☐	☐	☐	☐
	2.5	Relocate within the subject site - safer onsite area	Not applied to proposed development						
	2.6	Relocate within the subject site – pathway to safer onsite area/building	Not applied to proposed development						
	2.7	Pre-emptively relocate away from the subject site	Not applied to proposed development						
	Persons on Access / Egress Routes in Vehicles								
	3.1	Locating route away from adjacent hazards	Not applied to proposed development						
	3.2	Egress routes located to ensure driving away from hazard	✓	☐	☐	☐	☐	☐	☐
	3.3	Greater road width	✓	☐	☐	☐	☐	☐	☐
	3.4	Reduce and maintain road verge fuel to low threat state	Not applied to proposed development						
Shielding from All Bushfire Threats	Persons Located Onsite and Temporarily Offsite								
	2.8	On-site shelter building – community bushfire refuge standard	Not applied to proposed development						
	2.9	On-site shelter building – accommodation not part of site use	Not applied to proposed development						
	2.10	On-site shelter building – appropriate threat resilience	Not applied to proposed development						
	2.11	On-site shelter structure – Class 10c	Not applied to proposed development						
	2.12	Constructed barrier – shield persons in the open	Not applied to proposed development						
	2.13	Natural barrier - shield persons in the open	Not applied to proposed development						
	2.14	Constructed/natural barrier – shielding for persons on pathways to safer onsite area/building:	Not applied to proposed development						

	Persons on Access / Egress Routes in Vehicles		
	3.5	Vehicle type – protection level	Not applied to proposed development

3.3.3 VULNERABILITY REDUCING PROTECTION MEASURES - PERSONS

Table 3.8: Summarised application of vulnerability reducing protection measures for persons (refer to sections 8.1.1 for details).

Vulnerability Reducing Protection Measure - Persons			Application Status Subject Development/Use		Checklist – Incorporate into Stated Operational Documents				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Transport and Multiple Evacuation Destinations and Routes Available	Persons Located Onsite and Temporarily Offsite								
	7.1	Sufficient evacuation transport available	✓	□	□	□	□	□	□
	7.2	Multiple safer offsite locations available	✓	□	□	□	□	□	□
Provision of Bushfire Emergency Information and Education	7.3	Bushfire emergency plan	□	✓	✓	□	✓	□	□
	7.4	Bushfire emergency poster	Not applied to proposed development						
	7.5	Bushfire protection measures to be implemented are published in the relevant operational documents	□	✓	✓	□	✓	□	□
	7.6	Prominent display of information stating safe early evacuation is the primary procedure	Not applied to proposed development						
	7.7	Egress pathway signage	Not applied to proposed development						
	7.8	Trained personnel onsite	□	✓	□	□	✓	□	✓
	7.9	Build community resilience through education	Not applied to proposed development						
	7.10	Encourage 'property bushfire resilience assessments'	Not applied to proposed development						
A Bushfire Emergency Firefighting Capability Exists (Response)	7.11	Personnel onsite can manage bushfire emergency procedures	□	✓	□	□	✓	□	□
	7.12	Personnel onsite can operate firefighting equipment	□	✓	□	□	✓	□	□
	7.13	Locations of vulnerable persons are registered	Not applied to proposed development						
	7.14	External emergency services available	✓	□	□	□	□	□	□
Apply Best (Safer) Road Design and Construction (Materials)	Persons on Access / Egress Routes in Vehicles								
	8.1	Road width	✓	□	□	□	□	□	□
	8.2	Road gradient	✓	□	□	□	□	□	□
	8.3	Road Clearance	✓	□	□	□	□	□	□
	8.4	Road Surface Materials	✓	□	□	□	□	□	□
	8.5	Driver road ahead visibility and signage	✓	□	□	□	□	□	□

	8.6	Road length	✓	☐	☐	☐	☐	☐	☐
	8.7	Interconnected roads	✓	☐	☐	☐	☐	☐	☐
Evacuees Self-Sufficient (Local Awareness and Transport)	8.8	Persons onsite have local awareness	Not applied to proposed development						
	8.9	Persons onsite have own transport	✓	☐	☐	☐	☐	☐	☐

3.3.4 EXPOSURE REDUCING PROTECTION MEASURES – BUILDINGS

Table 3.9: Summarised application of exposure reducing protection measures for buildings (refer to sections 7.2.1 for details).

Exposure Reducing Protection Measure - Buildings / Other Structures/ Infrastructure			Application Status Subject Development/Use		Operational Documents Protection Measure Incorporation Checklist				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Separation from All Bushfire Threats	4.1	Asset protection zone (APZ)	✓	□	✓	□	□	✓	✓
	4.2	Siting of buildings/structures - wind	Not applied to proposed development						
	4.3	Use of non-vegetated areas and/or public open space	✓	□	✓	□	□	✓	✓
	4.4	Landscaping - tree location	✓	□	□	□	□	✓	□
	4.5	Separation of stored flammable products - gas in cylinders	✓	□	□	□	□	✓	□
	4.6	Separation from stored flammable products – fuels / other hazardous materials	□	✓	□	□	✓	✓	✓
	4.7	Separation from stored and constructed combustible items	✓	✓	□	□	✓	✓	□
Shielding from All Bushfire Threats	4.8	Constructed Barrier – bushfire fuels	Not applied to proposed development						
	4.9	Constructed Barrier – consequential fire fuels	Not applied to proposed development						
	4.10	Natural Barrier - landforms	Not applied to proposed development						
	4.11	Planted Barrier - vegetation	Not applied to proposed development						
	4.12	Shield non-structural essential elements	□	✓	□	□	□	✓	□

3.3.5 VULNERABILITY REDUCING PROTECTION MEASURES – BUILDINGS

Table 3.10: Summarised application of vulnerability reducing protection measures for buildings / other structures / infrastructure (refer to sections 8.2.1 for detail).

Vulnerability Reducing Protection Measure - Buildings / Other Structures/ Infrastructure			Application Status Subject Development/Use		Operational Documents Protection Measure Incorporation Checklist				
Protection Principle	Ref. No.	Brief Description	Exists or Planned (fully/partly)	Additionally Recommended	Bushfire Management Plan	Bushfire Emergency Plan	Site Emergency Plan	Project Design	Works Program
Design and Construction (Materials)	9.1	Construction to a standard - AS 3959:2018	□	✓	✓	□	□	✓	□
	9.2	Construction to a standard – NASH Standard	Not applied to proposed development. Can be applied in place of AS3959:2018						
	9.3	Construction materials – external and internal cavity building elements	✓	□	□	□	□	✓	□
	9.4	Construction materials – consequential fire fuels	□	✓	□	□	□	✓	□
	9.5	Construction – resistant to high wind	Not applied to proposed development						
	9.6	Construction – gas supply	□	✓	□	□	✓	✓	□
	9.7	Construction - electricity supply or Construction non-structural essential elements	□	✓	□	□	□	✓	□
	9.8	Minimise debris and ember accumulation – re-entrant detail	□	✓	□	□	□	✓	□
	9.9	Minimise debris and ember accumulation – trapping surfaces	□	✓	□	□	□	✓	□
	9.10	Minimise debris and ember accumulation – roof plumbing	□	□	□	□	□	□	□
	9.11	Minimise debris and ember accumulation – construction cavities	□	✓	□	□	□	✓	□
	9.12	Minimise flame/radiant heat/ember/debris entry - external openings	Not applied to proposed development.						
	9.13	Screening and sealing - gaps and penetrations	□	✓	□	□	□	✓	□
	9.14	Screening - external doors and windows	Not applied to proposed development						
	9.15	Shutters - external doors and windows	Not applied to proposed development						

	9.16	Landscaping construction - fences and walls	□	✓	□	□	□	✓	□
Firefighting Capability	9.17	Firefighting water supply	✓	□	□	□	□	□	□
	9.18	Firefighting equipment – active operation	Not applied to proposed development						
	9.19	Firefighting equipment – passive operation	Not applied to proposed development						
	9.20	Firefighting equipment – maintain operability	✓	□	□	□	✓	□	✓
	9.21	Firebreaks for access	✓	□	✓	□	□	✓	□
Management And Maintaining Effectiveness Of Applied Protection Measures	9.22	Formal management / maintenance plan – actions and responsibilities	□	✓	□	□	✓	□	□

4 IDENTIFICATION OF THE ELEMENTS AT RISK

Elements at risk are those exposed to the bushfire hazard threats identified in Section 5. This section establishes the generic list of possible elements at risk and identifies the exposed elements of the subject development/use.

Table 4.1: Identification of the elements at risk for which this risk assessment and management report is produced.

THE ELEMENTS AT RISK (THE EXPOSED ELEMENTS)	
Type Description	Identification of Relevant Elements
Persons located onsite: as part of site operations or visitors) and **Persons temporarily offsite as part of site operations**: (e.g. tourism day trips)	✓
Persons on Access/Egress Routes (in Vehicles): i.e., roads, driveways, access ways	✓
Buildings - NCC Class 1 & 2: residential - of a domestic nature	
Buildings - NCC Class 3: residential – of long term or transient nature, for unrelated people	
Buildings - NCC Class 4: part of a Class 5-9 used as a residence – caretakers office	
Buildings – NCC Class 5: offices for professional or commercial purposes	
Buildings – NCC Class 6: shops selling retail goods or services to the public	✓
Buildings – NCC Class 7: warehouses & carparks - storage – wholesale goods / vehicles	
Buildings – NCC Class 8: factory / workshop / laboratory - in which a process is carried out	
Buildings – NCC Class 9: health care / residential care / assembly	
Buildings or Structures – NCC Class 10: non-habitable – shed / carport / garage / fence / retaining wall etc.	✓
Non-Building Accommodation: caravans / camper trailers / tents etc	
Fixed (Hard) Infrastructure Assets: telecommunications / power generation / transport / water supply / waste management	
Livestock/Animals: as part of commercial or private operations (saleyards / events / wildlife sanctuaries).	

Table 4.2: Description of the elements at risk that are subject to assessment for the proposed/existing development and/or use.

ELEMENT AT RISK DETAIL FOR THE SUBJECT DEVELOPMENT/USE	
Elements At Risk	Element Description
Persons located onsite and temporarily offsite	The site is for public retail purposes and will be occupied by a variable number of persons. There will be <5 staff onsite at any time. A limited number of visitors may use the facility at one time (refuelling, using car wash bays etc), and any additional persons will remain in their vehicles while waiting for use. Persons within vehicles can immediately self-evacuate if required. The number of persons onsite and not waiting within vehicles is unlikely to exceed 30 in peak periods. Visitors may include some persons who are less able to respond in a bushfire, however the site use is not Vulnerable. • Each vehicle must include persons able to drive/clean/refuel (self-sufficient),

	• Children/elderly will be accompanied, • Physically disabled persons will necessarily have access to suitable transport, • Non-English speakers do not require direction as they are required only to drive away. Some foot traffic can be expected. Foot traffic is possible in any public development and such persons must be considered self-sufficient. Any foot traffic will most likely be from either the industrial developments to the north or residences to the south and are expected to return to these locations.
Persons on access/egress routes in vehicles	Staff, visitors, and/or emergency services accessing to / egressing from the facility.
Buildings/Structures - NCC Classes 1-10	The facility as a whole is designated a Class 6 building under the NCC. The site includes multiple potential designations including the Control Building (Class 6), Car Wash Bays (Class 10a), and EV Charging Bays and Bowsers (Class 10b).

5 IDENTIFICATION OF THE BUSHFIRE HAZARD

SEPARATE IDENTIFICATION OF ONSITE AND OFFSITE VEGETATION

The approach adopted in this report is to separately identify onsite and offsite bushfire prone vegetation when the distinction exists, and it is necessary. There are two reasons for this:

1. The required assessment of the broader landscape's influence on bushfire hazard threat levels will most likely be considering vegetation and terrain that is external to the subject development/use site and therefore needs to be separately identified; and
2. Owners and operators of a site will be more likely to have the authority to make and maintain any required changes to the extent and the composition of bushfire prone vegetation onsite. The only constraint will be any environmental conditions established by relevant authorities.

   This contrasts with the situation that exists for offsite vegetation. In these cases, the owner/operator does not normally have any authority to modify or manage offsite vegetation to reduce threats and maintain that reduction in perpetuity. Rather, the authority for management of offsite vegetation resides with a third party such as another landowner or a government authority.

   Consequently, management of offsite vegetation requires the establishment of enforceable vegetation management agreements if any reduction in threat level is to be achieved and accounted for in the threat level assessment. These can be problematic to establish.

5.1 ONSITE BUSHFIRE PRONE VEGETATION

Onsite vegetation is currently tussock grassland. All existing onsite vegetation is to be removed as part of the development. The subject lot is to be managed and maintained to a low bushfire threat state in perpetuity, as per the Bushfire Management Plan produced for this project. This report considers the effects of offsite bushfire prone vegetation only.

5.2 OFFSITE BUSHFIRE PRONE VEGETATION

Map I.D. Area No. / Location	Refer to Figure 4.1		
Classification or Exclusion Clause	Class A Forest	Class D Scrub	Class G Grassland
Types Identified	Open forest A-03	Closed scrub D-13	Open tussock G-23
Description & Classification Justification	Forest: Eucalypt dominant area, with scrub and shrub mid-storey, grass understorey. Scrub: Unmanaged shrub averaging greater than 2 metres in height, grass understorey. Grassland: Tussock grasses, partial management in some areas.		

Example Photo Forest

Example Photo Forest

Example Photo Scrub

Example Photo Scrub

Example Photo Grassland

Example Photo Grassland

Figure 3.1b

Classified Vegetation & Topography Map - (Post Development)

Lot 1001 on Plan / Diagram: P061212
11 Greenwich Parade
Neerabup
City of Wanneroo

------ LEGEND ------

- Photos
- Hydrants
- Elevation (m)
- Subject Site

Proposal

- Control Building
- Fuel Bowser Canopy 1
- Fuel Bowser Canopy 2
- Car Wash
- Vacuum Bays
- Under Ground Fuel Vessels

Assessment Area

- 150m Buffer

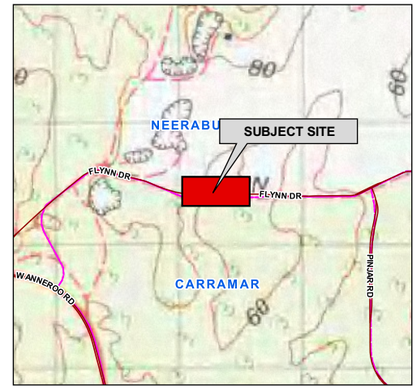
Classified Vegetation

- Class A - Forest
- Class D - Scrub
- Class G - Grassland
- Exclusion 2.2.3.2

0 10 20 30 40 50

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: Sarina Gorman 25-10-2022
SCALE (A3): 1 : 1550

BUSHFIRE PRONE PLANNING

5.3 REGIONAL BUSHFIRE PRONE VEGETATION

Map I.D. / Area No. / Location	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.		
Classification or Exclusion Clause	Class A Forest Class D Scrub Class G Grassland	Effective Slope (deg)	Upslope or flat 0 Downslope >0-5
Types Identified	Open forest A-03	Woodland B-05	Sown pasture G-26
Description & Classification Justification	The 'region' considered is limited to 2km, as beyond this is the built-out Perth Metropolitan Area. In the broader context: • Around the subject lot and to the north is entirely cleared and partially developed, with some grass regrowth present. • South is a low-density residential area with high proportion of remnant forests. • West beyond the cleared industrial area (300m) is a continuous tract of remnant forest, continuing to the north and south. • East is a previously developed industrial area, with remnant vegetation >800m beyond. The landscape-scale bushfire hazard is from the west and south.		

5.4 THE BROADER LANDSCAPE/ENVIRONMENT AND ITS POTENTIAL TO INTENSIFY FIRE BEHAVIOUR

More recent research into bushfire propagation has highlighted the role of environmental factors that are responsible for dynamic bushfire propagation and subsequent extreme fire development. Dynamic fire propagation arises from complex interactions between the terrain, the atmosphere and the fire. The intensified fire behaviour of an extreme bushfire event will significantly increase the threat levels generated by the bushfire attack mechanisms. Refer to Appendix 5 for an explanation of dynamic fire behaviours (DFBs) and their involvement in extreme bushfire events.

Consequently, in assessing the bushfire hazard threat levels to which the at risk elements of a proposed development/use could be exposed, the potential for dynamic bushfire propagation and subsequent development of extreme bushfire events within the broader landscape surrounding a subject site, must be assessed. The results of this assessment are incorporated into the assessed bushfire hazard threat levels for each attack mechanism is Section 4.5.

Table 5.1: Broader landscape assessment – the potential for extreme fire events to increase threat levels.

ASSESSING THE POTENTIAL FOR AN EXTREME BUSHFIRE EVENT TO DEVELOP AND INCREASE THE LEVEL OF THREATS IMPACTING THE SUBJECT SITE			
Relevant Physical Factors [1]	Factor Existence in Surrounding Landscape	Potential to Increase Bushfire Threat Levels	Assessment Comments
Physical factors more typically associated with conflagrations that are more likely to exist as large surface based bushfire events			
Large continuous areas of bushfire prone vegetation	Partially Exists	Moderate	The subject site is within an ongoing commercial development. Fragmented sections of grassland are within the local cleared area. A continuous tract of forest begins approximately 300m west of the site. To the south is a low-density residential area which includes a high proportion of forest and scrub.
Heavier fuel loads	Partially Exists		Heavier fuel loads exist within the forests to the west and south of the site. A fuel load of 15-20t/ha is assumed.
Fuel types (bark) that produce significant quantities of embers / firebrands (spotting);	Insignificant / Unlikely to Occur		The local forests are dominated by corymbia, eucalypts, and banksia, which do not generate significant embers at the distance from the proposed development (~300m).
Sufficient area of land and vegetation to support multiple fires of scale	Partially Exists		A continuous fire run and multiple such fires could occur simultaneously, though this is unlikely due to the availability of emergency services.
Terrain that can facilitate development of topographically modified winds (e.g. scarp or foehn-like)	Does Not Exist		The topography is almost entirely flat, with some gentle slopes and would not facilitate topographically modified winds.
Strong synoptic winds (i.e., not fire driven)	Possible to Occur		Strong synoptic winds do occur in this area.

ASSESSING THE POTENTIAL FOR AN EXTREME BUSHFIRE EVENT TO DEVELOP AND INCREASE THE LEVEL OF THREATS IMPACTING THE SUBJECT SITE			
Relevant Physical Factors [1]	Factor Existence in Surrounding Landscape	Potential to Increase Bushfire Threat Levels	Assessment Comments
Physical factors with identified links to deep flaming and the development of pyroconvective, coupled atmosphere, bushfire events			
Terrain slopes of approximately 24^0 or greater - or some degrees lower with greater wind speeds (associated with eruptive fire)	Does Not Exist	Low	The landscape is flat to gently undulating.
Rugged terrain with local relief in the order of at least 300m (associated with eruptive fire)	Does Not Exist		
Terrain with leeward slopes >20-25 degrees (associated with vorticity-driven lateral spread)	Does Not Exist		
Wind direction within $30\text{-}40^0$ of topographic aspect (associated with vorticity-driven lateral spread)	Does Not Exist		
Wind speed in excess of approximately 20 km/hr (associated with vorticity-driven lateral spread)	Substantially Exists		Wind speeds exceed 20km/h with >50% frequency.
Heavy forest fuel types with loads in excess of 15-20 t/ha (associated with vorticity-driven lateral spread)	Partially Exists		Heavier fuel loads exist within the forests to the west and south of the site. A fuel load of 15-20t/ha is assumed.
Fuel moisture content around 5% or less (associated with vorticity-driven lateral spread)	Partially Exists		The potential must be considered.
Sufficiently sized areas (scale) of bushfire prone vegetation to potentially support deep flaming and supply the required quasi-instantaneous energy release.	Does Not Exist		Bushfire prone vegetation is of sufficient extent to support deep flaming. The vegetation types and scale, fuel loads, and topography do not support the atmospheric/localised effects of deep flaming *within 200m of the subject site*.
Atmospheric instability to create opportunity for atmospheric coupling and violent pyroconvection.	Possible to Occur		It will be assumed, as a minimum, that at most locations, the potential for vertical movement of air without any resistance to that movement (e.g. temperature inversions) can always exist. That is, it is not sufficiently risk averse to assume that atmospheric instability will never exist – different temperature air masses can always interact as a consequence of the passage of different weather systems at any location.
[1] These are physical terrain / environment factors that are either required for certain dynamic fire behaviours or will enhance the potential for and the development of an extreme bushfire event.			

5.5 ASSESSMENT OF VEGETATION CHARACTERISTICS DRIVING BUSHFIRE ATTACK MECHANISM THREAT LEVELS

This qualitative assessment derives the **base threat levels** of identified areas of bushfire prone vegetation by accounting for:

1. Fuel types, arrangement and quantities; and
2. The existence of relevant characteristics within the broader landscape that have the potential to intensify bushfire behaviour and increase threat levels.

Note: This assessment does not account for the existence or potential application of threat reducing protection measures or the level of exposure and vulnerability of elements at risk. These are accounted for in subsequent steps of the risk assessment process that results in the derivation of inherent and/or residual risk levels.

Table 5.2: The assessed potential for bushfire attack mechanisms originating from Vegetation Areas 1 to 7 to adversely impact exposed elements.

CHARACTERISTICS ASSESSMENT OF THE BUSHFIRE PRONE VEGETATION AND ITS POTENTIAL TO IMPACT [1] ELEMENTS AT RISK – THE BASE THREAT LEVEL		
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.	
Identified Characteristics that will Contribute to the Severity of the Attack Mechanism and Consequent Base Threat Level to All Elements at Risk		Base Threat Level (the relative potential for adverse impact on exposed elements)
Direct Bushfire Attack Mechanisms		
Ember Attack: This threat level is strongly correlated with the existence of bark fuels. The varied typical rates of spread and residence time for flame fronts in different vegetation types is also incorporated into the threat level assessment (these impact on time available to make decisions and time exposed to threats).	Ember Attack can result from both immediate and regional vegetation. Other attack mechanisms below do not consider vegetation >150m from the site. The grass type fuels are finer fuels and will produce very little, short distance small embers with short lives. The majority of these embers will be consumed as part of the flame front which will have a residence time (the flaming phase at a point on the ground) typically less than 10 seconds. Consequently, embers from grassland presents a limited threat. There is potential for short distance ember attack from the forest/scrub vegetation to the south. The plant demographics in the forests >300m from the site and the topography make it unlikely that embers of a sufficient lifespan will be carried aloft and impact the site.	Moderate

CHARACTERISTICS ASSESSMENT OF THE BUSHFIRE PRONE VEGETATION AND ITS POTENTIAL TO IMPACT [1] ELEMENTS AT RISK – THE BASE THREAT LEVEL		
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.	
Radiant Heat Attack: This threat level is a function of fuel characteristics (size, shape, quantity, type, arrangement and moisture content) and the landscape and weather factors that can intensify fire behaviour. Larger flame sizes and higher temperatures produce higher levels of heat. The varied typical rates of spread and residence time for flame fronts in different vegetation types is also incorporated into the threat level assessment (these impact on time available to make decisions and time exposed to threats).	Fine fuel loads for the grassland (pasture) vegetation ranges from 2-4 t/ha and a calculated flame length of 7m. The potential impact of the radiant heat transfer is going to be moderated by the short residence time (the flaming phase at a point on the ground) for the flame front. For much of the identified grassland vegetation types, the residence time will typically be less than 10 seconds. The residual radiant heat after the passage of the fire front will be low. The remnant forest to the south poses a greater threat of sustained radiant heat attack. The setback from this vegetation is 40m for the Control Building and 37m for the southern bowsers (canopy excluded). These setbacks equate to BAL-19 (a relatively moderate heat flux), which will have a longer residence period (30-60 seconds) and residual heat due to the coarser fuel loads available. Given the setback and scale of the vegetation, the residual heat flux is likely to be relatively low.	Moderate
Bushfire Flame Attack: This threat level is a function of potential flame lengths which are significantly influenced by fine fuel loads and the slope of the land on which the fire is burning. The varied typical rates of spread and residence time for flame fronts in different vegetation types is also incorporated into the threat level assessment (these impact on time available to make decisions and time exposed to threats).	The modelled solid portion flame lengths for the identified grassland vegetation type on flat land are up to 7m. The modelled flame lengths for forest on flat land are 19.8m The primary high-risk use are the fuel bowsers and vents, with the canopy as a secondary consideration. These components will not receive direct flame contact from a bushfire.	Very Low
Surface Fire Attack: This threat level is a function of the existence of intermittent surface fuels surrounding and leading up to exposed elements.	Bushfire prone vegetation will be entirely cleared from the subject site during development, which will primarily be sealed hardstand or structures. The surface fire vector is via offsite grassland, which cannot impact structures directly due to setbacks to be installed. The only potential source of a surface fire attack is due to onsite and offsite landscaping (gardens and mulch). Such a surface fire attack is a minimal threat to the facility but may cause a consequential fire.	Low
Indirect Bushfire Attack Mechanisms		
Debris Accumulation – threat level is a function of having a source of vegetative debris, its extent and proximity to exposed elements.	Grassland vegetation produces very little wind-blown debris which can accumulate onsite. Forest vegetation is at a sufficient setback that the hazard of debris accumulation is very limited.	Low

CHARACTERISTICS ASSESSMENT OF THE BUSHFIRE PRONE VEGETATION AND ITS POTENTIAL TO IMPACT [1] ELEMENTS AT RISK – THE BASE THREAT LEVEL		
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.	
Consequential Fire – threat level is a function of the existence of accumulated debris (fine fuels) and stored or constructed combustible / flammable items that exist either as part of the site use or operations or are adjoining/adjacent buildings/structures (heavy fuels).	The potential for debris accumulation has been assessed. Fuel bowsers and vents and EV charging stations pose a potential consequential fire hazard, to be addressed by engineering design and appropriate management measures. The Refuse Enclosure contains waste which may ignite in a bushfire. All structures onsite will be constructed largely or entirely from non-combustible materials.	High
Fire Driven Wind – threat level is correlated with the potential for development of extreme bushfire events (refer to Appendix 5).	The potential for an extreme bushfire event to occur near the subject site is limited (but possible), due to the relatively flat topography and fragmented distribution and setbacks of bushfire prone vegetation.	Low
Tree Strike and Obstruction – threat level is a function of the existence of trees and their proximity to exposed elements.	There will be no trees on the subject site and very few within 30m of all proposed structures. An element may be considered at risk where the setback from the tree is <1.5x the mature height of that tree.	Low
[1] Refer to glossary.		

5.6 BUSHFIRE ATTACK LEVELS (BAL) AND CORRESPONDING SEPARATION DISTANCES

In assessing risk, knowing the separation distances away from each identified area of classified vegetation that correspond to a BAL rating, assists with evaluating threat levels from that bushfire hazard and the exposure levels of elements at risk. BAL ratings indicate the level of radiant heat that an exposed element will be subject to. They also indicate the potential for flame contact (refer to Appendix 7 for additional information).

Table 5.3: Summary of applied calculation input variables applied in deriving the BAL rating for the identified exposed element (the relevant building/structure).

DATA APPLIED TO THE DERIVATION OF THE BUSHFIRE ATTACK LEVELS (BAL) [1]							
BAL Determination Method	METHOD 1 - AS 3959:2018 CLAUSE 2.2 - SIMPLIFIED PROCEDURE				Applied Fire Danger Index		FDI 80
The Receiver of Radiant Heat Relevant Building(s) / Structure(s) and Their Location	Vegetation Classification		Effective Slope		Separation Distance		Bushfire Attack Level (AS 3959:2018 Table 2.5)
			Measured	Applied Range	Minimum Allowed Building Setback from Lot Boundary [2]	Total	
	Area	Class	degrees	degree range	metres		
Control Building – (the sole habitable building on the lot)	1	(G) Grassland	flat 0	Upslope or flat 0	-	77	BAL-LOW
	2	(G) Grassland	flat 0	Upslope or flat 0	-	45	BAL-12.5
	3	(D) Scrub	flat 0	Upslope or flat 0	-	87	BAL-12.5
	4	(A) Forest	flat 0	Upslope or flat 0	-	41	BAL-19
	5	(A) Forest	d/slope 3.8	Downslope >0-5	-	>100	BAL-LOW
	6	(D) Scrub	d/slope 3.2	Downslope >0-5	-	91	BAL-12.5
	7	Excluded cl 2.2.3.2(f)	N/A	N/A	-	N/A	BAL-LOW
	8	Excluded cl 2.2.3.2(e & f)	N/A	N/A	-	N/A	BAL-LOW
						Indicative Bushfire Attack Level	BAL-19
Fuel Bowser Canopy 1	1	(G) Grassland	flat 0	Upslope or flat 0	-	53	BAL-LOW
	2	(G) Grassland	flat 0	Upslope or flat 0	-	71	BAL-LOW

	3	(D) Scrub	flat 0	Upslope or flat 0	-	>100	BAL-LOW
	4	(A) Forest	flat 0	Upslope or flat 0	-	35	BAL-19
	5	(A) Forest	d/slope 3.8	Downslope >0-5	-	>100	BAL-LOW
	6	(D) Scrub	d/slope 3.2	Downslope >0-5	-	66	BAL-12.5
	7	Excluded cl 2.2.3.2(f)	N/A	N/A	-	N/A	BAL-LOW
	8	Excluded cl 2.2.3.2(e & f)	N/A	N/A	-	N/A	BAL-LOW
	Indicative Bushfire Attack Level						BAL-19
Fuel Bowser Canopy 2	1	(G) Grassland	flat 0	Upslope or flat 0	-	54	BAL-LOW
	2	(G) Grassland	flat 0	Upslope or flat 0	-	42	BAL-12.5
	3	(D) Scrub	flat 0	Upslope or flat 0	-	>100	BAL-LOW
	4	(A) Forest	flat 0	Upslope or flat 0	-	>100	BAL-LOW
	5	(A) Forest	d/slope 3.8	Downslope >0-5	-	>100	BAL-LOW
	6	(D) Scrub	d/slope 3.2	Downslope >0-5	-	>100	BAL-LOW
	7	Excluded cl 2.2.3.2(f)	N/A	N/A	-	N/A	BAL-LOW
	8	Excluded cl 2.2.3.2(e & f)	N/A	N/A	-	N/A	BAL-LOW
	Indicative Bushfire Attack Level						BAL-12.5
Car Wash	1	(G) Grassland	flat 0	Upslope or flat 0	-	32	BAL-12.5
	2	(G) Grassland	flat 0	Upslope or flat 0	-	94	BAL-LOW
	3	(D) Scrub	flat 0	Upslope or flat 0	-	>100	BAL-LOW
	4	(A) Forest	flat 0	Upslope or flat 0	-	35	BAL-19
	5	(A) Forest	d/slope 3.8	Downslope >0-5	-	>100	BAL-LOW
	6	(D) Scrub	d/slope 3.2	Downslope >0-5	-	47	Select.

	7	Excluded cl 2.2.3.2(f)	N/A	N/A	-	N/A	BAL-LOW
	8	Excluded cl 2.2.3.2(e & f)	N/A	N/A	-	N/A	BAL-LOW
	Indicative Bushfire Attack Level						BAL-19
Vacuum Bays	1	(G) Grassland	flat 0	Upslope or flat 0	-	23	BAL-12.5
	2	(G) Grassland	flat 0	Upslope or flat 0	-	91	BAL-LOW
	3	(D) Scrub	flat 0	Upslope or flat 0	-	>100	BAL-LOW
	4	(A) Forest	flat 0	Upslope or flat 0	-	73	BAL-12.5
	5	(A) Forest	d/slope 3.8	Downslope >0-5	-	>100	BAL-LOW
	6	(D) Scrub	d/slope 3.2	Downslope >0-5	-	80	BAL-12.5
	7	Excluded cl 2.2.3.2(f)	N/A	N/A	-	N/A	BAL-LOW
	8	Excluded cl 2.2.3.2(e & f)	N/A	N/A	-	N/A	BAL-LOW
	Indicative Bushfire Attack Level						BAL-12.5

[1] All data and information supporting the determination of the classifications and values stated in this table and any associated justification, is presented in Appendix A.

[2] This is the minimum building setback (i.e., the distance from a proposed building to the lot boundary) that is established by either the applicable R-code setback or another mechanism (e.g., restricted covenant), that is to apply to the proposed building/structure on the relevant lot. It is identified as a fixed component of the total separation distance from vegetation when its application is important to be identified because it establishes the closest distance to the lot boundary that a building/structure can legally exist. In other words, it identifies the part of the lot on which development cannot occur. When it is not critical for this distance to be identified, just the total separation distance is stated.

6 ASSESSING BUSHFIRE HAZARD THREAT LEVELS

SUMMARY OF THE QUALITATIVE ASSESSMENT PROCESS

1. Identify all protection measures (grouped by protection principle) that are available to reduce threat levels and rate their effectiveness;
2. Produce a numerical summary of all potential threat reducing protection measures that are available and determine their application status;
3. Assess the potential threat reducing impact of the package of protection measures that is able to be applied. The effectiveness rating weights the potential impact of an individual measure; and
4. Derive the threat level, for each identified area of bushfire prone vegetation, by accounting for:
    - The relevant characteristics of the vegetation as they influence the bushfire attack mechanisms and establish the base threat level;
    - The potential threat increasing influence of the broader landscape; and
    - The impact of the applied package of protection measures in reducing threat levels (refer to Section 2.3.3 and Appendix 2 for additional risk assessment process information).

6.1 PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS – IDENTIFICATION AND APPLICATION

Table 6.1: For the stated area of vegetation, all available bushfire protection measures for preventing or reducing the potential for fire ignition and eliminating or reducing its threat levels.

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					
PROTECTION PRINCIPLE - PREVENT FIRE IGNITION AND/OR SEVERITY BY CONTROLLING THE FUEL: Eliminate or reduce vegetation fuel loads, modify their properties (vegetation types and the arrangement of the fuels). Maintain the measures over time to eliminate bushfire or lower the severity of fire behaviours and the consequent threat levels. The measures may conflict with desired / regulated environmental conservation outcomes and this remains a potential limitation.						
1.1	**Remove Offsite Bushfire Fuel:** Remove fuel permanently by clearing bushfire prone vegetation when an authority exists.	Not Relevant	N/A	N/A	N/A	N/A
1.2	**Reduce Offsite Bushfire Fuel:** Programmed hazard reduction burning when an authority exists to conduct and maintain (refer to Appendix 6 for additional information).	Not Relevant	N/A	N/A	N/A	N/A

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					
1.3	**Reduce Offsite Bushfire Fuel:** Mechanical fuel reduction to modify composition of vegetation types and/or the arrangement of fuels and maintain the modification over time e.g. reduce canopy, limit higher threat bark types, minimise 'ladder' fuels' - when an authority exists to conduct and maintain.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *The neighbouring lots are currently cleared and host grassland only. The developer/proponent has no control over offsite vegetation.*						
1.4	**Remove Onsite Bushfire Fuel:** Remove fuel permanently by clearing bushfire prone vegetation when approved.	Very High	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: *All onsite bushfire prone vegetation is to be removed per requirement of the Bushfire Management Plan.*						
1.5	**Reduce Onsite Bushfire Fuel:** Programmed hazard reduction burning (refer to Appendix 6 for additional information).	Not Relevant	N/A	N/A	N/A	N/A
1.6	**Reduce Onsite Bushfire Fuel:** Mechanical fuel reduction to modify composition of vegetation types and/or the arrangement of fuels and maintain the modification over time e.g. reduce canopy, limit higher threat bark types, minimise 'ladder' fuels' - when approved.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment*: N/A. See 1.4 above.*						
1.7	**Reduce Onsite Consequential Fire Fine Fuels:** Apply the specifications for an Asset Protection Zone (APZ) surrounding the exposed element(s) to ensure this area contains minimal consequential fire fuels and is maintained in a low threat state. The specifications are established in the Guidelines [22] within the *Explanatory Notes for Element 2 of the Bushfire Protection Criteria and Schedule 1: Standards for Asset Protection Zones.*	Effective	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment*: The whole of the subject lot is to be managed to APZ standards as per the Bushfire Management Plan.*						
1.8	**Reduce Road Verge Fuel:** Road verges of designated evacuation routes are subject to fuel load reduction, tree management and ongoing maintenance when an authority exists to conduct and maintain.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *The measure is not under the control of the landowner/developer.*						
1.9	**Greater Enforcement Applied to Compliance with the Local Government's Fire Break and Fuel Load Notice:** Inform the relevant landowners of the high level of enforcement that will be applied under the authority conferred through Section 33 of the Bush Fires Act 1954.	Effective	Yes	No	No	Yes

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					
Informative and/or Site Specific Comment/Assessment: *The level of enforcement is determined by the Local Government. The site will be entirely cleared and thus compliant with the City of Wanneroo Firebreak Notice to the maximum possible extent. It is recommended that the City of Wanneroo enforce the Notice on neighbouring properties, to reduce the bushfire hazard to developed lots.*						
PROTECTION PRINCIPLE – PREVENT FIRE IGNITION BY CONTROLLING HEAT ENERGY SOURCES: Fire prevention focussed on potential ignition sources from human actions and/or faulty or poorly designed equipment. Natural causes of ignition (lightning) cannot be controlled and are a limitation.						
1.10	**Operational Procedures:** Apply fire safe principles to site operation procedures including: • Eliminating or reducing the potential for open air creation of fire, embers or sparks; and • Closing identified high risk operations when a bushfire event exists. Ensure safe practices are carried out via appropriate guidelines, protocols, signage and education.	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *The operating procedures of the development have not yet been finalised. Additional measures to reduce the risk of bushfire ignition are not applicable, as these measures are assumed to be implemented in reducing the risk of igniting onsite hazards.*						
1.11	**Operational Procedures:** Ensure proper management of hazard reduction burning as an unintended ignition source.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *N/A. Hazard reduction burning will not be a requirement of the Plan.*						
1.12	**Equipment Design:** Apply fire safe design principles to equipment, vehicles, and energy transmission etc. Design to control rate of energy release and eliminate/reduce potential for open air creation of fire, embers or sparks.	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: To be included in equipment design at purchase stage. All equipment must meet minimum national and state standards and guidelines, and this is considered adequate.						
1.13	**Legal Enforcement:** Impose restrictions on source of ignition operations by enforcing total fire bans.	Effective	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *Operation on days of total fire bans is considered an acceptable risk.*						
1.14	**Legal Enforcement:** Reduce arson events by monitoring / enforcement / penalties.	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *Legal penalties are in place and enforced by law.*						
1.15	**Education:** Educate persons to reduce the occurrence of accidental ignitions in vegetation by persons and/or vehicles, particularly with regard to road reserves.	Not Relevant	N/A	N/A	N/A	N/A

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					
Informative and/or Site Specific Comment/Assessment: *Cannot be applied to the public/retail use.*						
PROTECTION PRINCIPLE - PREVENT FIRE IGNITION BY CONTROLLING HEAT ENERGY SOURCE AND FUEL INTERACTIONS: Fire prevention focussed on limiting potential ignition sources by preventing a source and a fuel being able to interact.						
1.16	**Shielding of Ignition Sources:** Utilise physical barriers (shielding) between bushfire fuels and heat energy sources such as electricity generation / transmission, fuel supplies, stored flammable products etc. Examples include appropriate walls, enclosures, and underground transmission of electricity or liquid/gas fuels.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *Barriers are not practical as bowsers and vents must be accessible to both staff and customers.*						
1.17	**Separation of Ignition Sources:** Establish sufficient separation distance between bushfire fuels and heat energy sources such as electricity generation / transmission, fuel supplies, stored flammable products etc.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment*: The temperature of a fire within the available ignition sources is unknown, however a calculated BAL setback is based on an assumed bushfire flame temperature of 1090K. The inverse heat flux received by the classified vegetation is unknown. The ignition point of cured grass on temperature alone (no flame or ember contact) varies, but is at least 250 degrees Celsius (no calculation is available to translate to kW/m2 radiant heat flux). Small-scale fires are highly unlikely to ignite vegetation through heat flux alone. Large-scale fires are an extreme hazard with no appropriate setback. Increased separation distance is not possible within the lot boundary.*						
1.18	**Equipment Design:** Through design and materials, control heat energy transfer via conduction, convection and radiation of heat energy.	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *All equipment must meet minimum national and state standards and guidelines, and this is considered adequate. Controls applied are independent of bushfire requirements. Hot works are necessarily restricted for the site use.*						

[1] **Protection Measure Effectiveness Rating:** Refer to section 2.3.4 for explanation and defining.

[2] **Protection Measure Application Status:**

- **Possible:** Protection measures that can potentially be applied to the proposed development/use;
- **Exists**: Protection measures already implemented by existing components of the proposed development/use. These measures are accounted for in assessing 'inherent' risk levels (refer to Glossary);
- **Planned:** Protection measures that:
    - Are incorporated into the site plans;

PROTECTION MEASURES TO REDUCE BUSHFIRE THREAT LEVELS		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					

- Exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), alternative solutions and any additional recommended protection measures - for which a responsibility for their implementation has been created and approved; and/or
- Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), that can be met and for which a responsibility for their implementation can be created in the BMP.

These planned measures are accounted for in assessing 'inherent' risk levels (refer to Glossary).

- **Additionally Recommend:** Protection measures that:
  - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and comprise alternative solutions and/or additional recommended protection measures (that can and should be implemented in the opinion of the bushfire consultant), and for which a responsibility for their implementation can be created in the BMP; and/or
  - Are developed in the process of producing this risk assessment and management report and for which a responsibility for their implementation can be created in the BMP.

These additionally recommended measures, along with existing and planned measures, are accounted for in assessing 'residual' risk levels (refer to Glossary).

6.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 6.2: For the stated area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

BUSHFIRE THREAT REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					
The Protection Principle	Effectiveness Rating [1]	Numbers of Protection Measures				
		Total Available	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Prevent Fire Ignition and/or Severity by Controlling the Fuel	Very High	1	1	-	1	-
	High	-	-	-	-	-
	Effective	2	2	-	1	1
	Moderate	-	-	-	-	-
	Not Relevant	6	-	-	-	-
Prevent Fire Ignition by Controlling Heat Energy (Ignition) Sources	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	1	1	-	-	-
	Moderate	3	3	3	-	-
	Not Relevant	2	-	-	-	-
Prevent Fire Ignition by Controlling Heat Energy Source and Fuel Interactions	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	2	2	1	-	-
	Not Relevant	1	-	-	-	-
Total Numbers	**Very High**	**1**	**1**	**-**	**1**	**-**
	High	**-**	**-**	**-**	**-**	**-**
	Effective	**3**	**3**	**-**	**1**	**1**
	Moderate	**5**	**5**	**4**	**-**	**-**
	Not Relevant	**9**	**-**	**-**	**-**	**-**
	Totals	**18**	**9**	**4**	**2**	**1**

[1] Protection Measure Effectiveness Rating: Refer to section 2.3.4 for explanation and defining.

[2] Protection Measure Application Status: Refer to table footnotes on previous page.

6.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (THREAT REDUCTION)

Table 6.3: The potential impact of the applied protection measures in reducing threat levels in the stated area of bushfire prone vegetation.

ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (THREAT REDUCTION)								
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.							
Threat Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Minimal	Medium	Medium	Significant	Significant	Significant	Minimal	Significant
	Significant				Medium			
Existing, Planned and Recommended (applied to residual risk)	Minimal	Significant	Significant	Significant	Very Significant	Significant	Minimal	Significant
	Significant				Significant			
[1] Corresponds to the stage at which the risk level is to be reported i.e. inherent or residual (refer to Section 2.3.3) [2] Refer to Appendix 4 for explanatory information.								

Assessment Comments: All classified vegetation will be removed from the subject lot, and other measures are either impractical or not under the control of the landowner/developer. The enforcement of the Firebreak Notice to neighbouring lots, will measurably reduce the hazard posed.

6.4 ASSESSED HAZARD THREAT LEVELS

Assessed as a function of the base threat levels of the bushfire hazard (refer to Section 4.5) and the number and effectiveness of protection measures that will be applied and their ability to reduce the base levels of threat from the identified areas of bushfire prone vegetation (Note: This assessment is independent of the exposure level and vulnerability level assessments).

Table 6.4: The assessed threat levels corresponding to the stated area of bushfire prone vegetation.

ASSESSED HAZARD THREAT LEVELS								
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.							
Threat Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Low	Moderate	Moderate	Low	Very Low	Moderate	Low	Very Low
	Low							
Existing, Planned and Recommended (applied to residual risk)	Low	Moderate	Low	Very Low	Very Low	Moderate	Low	Very Low
	Low							
[1] Corresponds to the stage at which the risk level is to be reported i.e. inherent or residual (refer to Section 2.3.3). [2] Refer to Appendix 2 for explanatory information.								

Assessment Comments: One additional measure has been identified, which reduces the direct hazard posed but has a lesser impact on overall hazard levels.

7 ASSESSING THE EXPOSURE LEVELS OF ELEMENTS AT RISK

SUMMARY OF THE QUALITATIVE ASSESSMENT PROCESS

5. Identify all protection measures (grouped by protection principle) that are available to reduce exposure levels and rate their effectiveness;
6. Produce a numerical summary of all potential exposure reducing protection measures that are available and determine their application status;
7. Assess the potential exposure reducing impact of the package of protection measures that is able to be applied. The effectiveness rating weights the potential impact of an individual measure; and
8. Derive the exposure level of the identified element at risk, to the threats presented by each identified area of bushfire prone vegetation (refer to Section 2.3.3 and Appendix 2 for additional risk assessment process information).

7.1 PERSONS ONSITE OR TEMPORARILY OFFSITE (ELEMENT AT RISK CATEGORY 1)

7.1.1 PROTECTION MEASURES AVAILABLE TO REDUCE EXPOSURE LEVELS AND THEIR APPLICATION STATUS

Table 7.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
PROTECTION PRINCIPLE – SEPARATION FROM THE HAZARD: To ensure that the persons are located or re-located at a sufficient distance from the bushfire hazard to ensure the level of exposure to the threats, and the associated risk of persons death or injury, is contained within acceptable parameters.						
2.1	**Stay Away from the Subject Site:** In response to a pre-determined fire danger rating and/or total fire ban or set months of the year (bushfire season), prevent access to, occupancy or operation of the subject site (i.e. closure of use). The relevant conditions and the requirement to stay away will be established through a Bushfire Emergency Plan.	Very High	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *Persons onsite will have evacuation transport available and effective egress routes. Daily site activities do not include hot works or open flame. It is not practical to close the business on predetermined days.*						
2.2	**Stay Within the Subject Site – Remote Hazard:** For offsite tourism operations, all associated persons (staff, guests, visitors), in response to a pre-determined fire danger rating and/or total fire ban, will remain on-site as better communication and sheltering options exist on-site. The relevant conditions and the requirement to stay will be established through a Bushfire Emergency Plan.	Not Relevant	N/A	N/A	N/A	N/A

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
Informative and/or Site Specific Comment/Assessment: *Not applicable to this site.*						
2.3	**Relocate Away from Remote Hazard - Safer Offsite Location Available:** For offsite tourism operations (where persons are to be moved offsite as part of operations e.g., tourism day trips), a suitable offsite alternative safer location(s) is identified as a destination should the subject site and/or the route back to the subject site, be impacted by a bushfire event. That is, two safer locations will exist.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Not applicable to this site.*						
2.4	**Evacuate from the Subject Site: Safer Offsite Location(s) Available:** A building/area is accessible from the subject site as an evacuation destination. The offsite location exists at a sufficient distance away ensuring that the destination and the subject site are very unlikely to be simultaneously impacted by a bushfire event.	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *The subject site is on Flynn Drive, which can be used to quickly travel to low threat built-out areas via Pinjar Road. Wanneroo may also be used but travels through bushfire prone vegetation for a greater distance.*						
2.5	**Relocate Within the Subject Site - Safer Onsite Area:** Provide an accessible area located in the open (i.e. not in an enclosed building), within the subject site and on which persons can assemble and that will not be subject to radiant heat flux in excess of 2 kW/m^2 (determined using a flame temperature of 1200 K). Consideration must also be given to potential exposure to embers, adverse weather, availability of water / facilities and the relative importance of these to the specific use proposal.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Cannot achieve 2kWm2 in open space within the site.*						
2.6	**Relocate Within the Subject Site – Pathway to Safer Onsite Area/Building:** To facilitate the lower risk movement, on foot, of persons and firefighters on the site, heavy fuels are excluded from areas adjacent to pathways used to access designated safer locations onsite. The required minimum separation distances are: • At least 4m from stored heavy fuels (refer to Appendix 4). • At least 6m from stored and constructed large heavy fuels (refer to Appendix 4). • At least 12m from constructed large heavy fuels that are buildings/structures other than the one being evacuated. Additionally: • The pathway/route is constructed of non-combustible materials;	Not Relevant	N/A	N/A	N/A	N/A

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	• No gas bottles are venting towards the pathway/route; and • Shrubs are separated from the pathway/route corresponding to a distance to minimise the threats to persons on foot with consideration of their flammability and height.					
Informative and/or Site Specific Comment/Assessment: *Sheltering onsite is not recommended as an emergency procedure.*						
2.7	**Pre-Emptively Relocate Away from the Subject Site:** In response to a pre-determined fire danger rating and/or total fire ban or other established conditions, all persons onsite will pre-emptively relocate offsite for the duration of the existence of the conditions. The relevant conditions and the requirement to pre-emptively relocate will be established through a Bushfire Emergency Plan.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Due to the nature of the business (service station), pre-emptive closure is not considered.*						
PROTECTION PRINCIPLE – SHIELDING FROM THE HAZARD: To utilise constructed or natural shielding to reduce the exposure of persons to the flame, radiant heat, and ember attack from bushfire and consequential fire.						
2.8	**On-site Shelter Building – Community Refuge:** For a 'vulnerable land use' (defined by SPP 3.7 [43]), provide a building which is constructed in accordance with the NCC and the ABCB Design and Construction of Community Bushfire Refuges – Information Handbook [20]. Note: preferred floor area per person is an increase from 0.75 m^2 to 1.0 m^2 (Guidelines v1.4) [22].	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Not applicable to this site.*						
2.9	**On-site Shelter Building – No Accommodation in the Site Use:** For a 'vulnerable land use' (defined by SPP 3.7 [43]), and for which accommodation is not part of the site use, provide a building that will not be subject to radiant heat flux in excess of 10 kW/m^2 (determined using AS 3959 BAL determination methodology [4] and applying a flame temperature of 1200 K) and constructed to the bushfire standard corresponding to the BAL-29 rating (to provide greater resistance to consequential fire).	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Not applicable to this site.*						
2.10	**On-site Shelter Building – Appropriate Threat Resilience:** For other than a 'vulnerable land use' (defined by SPP 3.7 [43]), provide a building that incorporates sufficient design and construction protection measures to reduce the building vulnerability to bushfire and consequential fire threats to an appropriate level (refer to the section of this report that identifies bushfire protection measures to reduce the vulnerability of buildings/structures).	Not Relevant	N/A	N/A	N/A	N/A

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	Alternatively, provide a building that will not be subject to radiant heat flux in excess of 10 kW/m^2 (determined using AS 3959 BAL determination methodology [4] and applying a flame temperature of 1200 K) and constructed to the bushfire standard corresponding to the BAL-29 rating (to provide greater resistance to consequential fire).					
Informative and/or Site Specific Comment/Assessment: *No proposed buildings are subject to <10kW/m2 radiant heat flux.*						
2.11	**On-site Shelter Structure – Class 10c:** Provide a private bushfire shelter (Class 10c building) constructed in accordance with the NCC and the *Performance Standard – The design and construction of private bushfire shelter (ABCB 2014)*. This is not a standalone measure but an additional measure as a last resort.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *The proposed development is not considered a vulnerable land use.*						
2.12	**Constructed Barrier – Shield Persons in the Open:** Construct walls / fences / landforms as shielding structures that are not buildings, applying appropriate fire resistant / non-combustible construction materials (e.g. masonry, steel, earthworks). These are to withstand the impact of direct bushfire attack mechanisms for the required period of time and provide the required reduction in threat levels to persons in the open. Construction requirements will correspond, as a minimum, to the BAL-FZ requirements for walls as established by AS 3959:2018 [4] and/or the NASH Standard [33] and additionally informed by the research report 'Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires' [29].	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Sheltering onsite is not recommended as an emergency procedure and no area is subject to <2kW/m2 radiant heat flux. Persons can evacuate effectively.*						
2.13	**Natural Barrier – Shield Persons in the Open:** Utilise natural landforms that have the potential to shield persons from the bushfire and consequential fire threats.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Cannot achieve 2kWm2 in open space within the site. Therefore sheltering in the open is not an option for this development.*						
2.14	**Constructed/Natural Barrier – Shielding for Persons on Pathways to Safer Onsite Area/Building:** Where possible, alongside pathways to an on-site shelter building/area, utilise walls / fences / landforms as shielding structures constructed using fire resistant / non-combustible construction materials (e.g. masonry, steel, earthworks). These are to withstand the impact of direct bushfire attack mechanisms for the required period of time and provide the required reduction in threat levels to persons (including firefighters) traversing the pathway.	Not Relevant	N/A	N/A	N/A	N/A

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
		Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)					
Construction can be informed by the BAL-FZ requirements for walls as established by AS 3959:2018 [4] and/or the NASH Standard [33] and additionally informed by the research report 'Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires' [29].					
Informative and/or Site Specific Comment/Assessment: *No such landforms exist.*					

[1] **Protection Measure Effectiveness Rating:** Refer to section 2.3.4 for explanation and defining.

[2] **Protection Measure Application Status:**

- **Possible:** Protection measures that can potentially be applied to the proposed development/use;
- **Exists**: Protection measures already implemented by existing components of the proposed development/use. These measures are accounted for in assessing 'inherent' risk levels (refer to Glossary);
- **Planned:** Protection measures that:
    - Are incorporated into the site plans;
    - Exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), alternative solutions and any additional recommended protection measures - for which a responsibility for their implementation has been created and approved; and/or
    - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), that can be met and for which a responsibility for their implementation can be created in the BMP.

These planned measures are accounted for in assessing 'inherent' risk levels (refer to Glossary).

- **Additionally Recommend:** Protection measures that:
    - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and comprise alternative solutions and/or additional recommended protection measures (that can and should be implemented in the opinion of the bushfire consultant), and for which a responsibility for their implementation can be created in the BMP; and/or
    - Are developed in the process of producing this risk assessment and management report and for which a responsibility for their implementation can be created in the BMP.

These additionally recommended measures, along with existing and planned measures, are accounted for in assessing 'residual' risk levels (refer to Glossary).

7.1.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 7.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

EXPOSURE REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Persons located onsite and temporarily offsite (Category 1)					
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					
The Protection Principle	Effectiveness Rating [1]	Numbers of Protection Measures				
		Total Available	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Separation from the Hazard	Very High	1	1	-	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	1	1	1	-	-
	Not Relevant	5	-	-	-	-
Shielding from the Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	-	-	-	-	-
	Not Relevant	7	-	-	-	-
Total Numbers	**Very High**	**1**	**1**	**-**	**-**	**-**
	High	**-**	**-**	**-**	**-**	**-**
	Effective	**-**	**-**	**-**	**-**	**-**
	Moderate	**1**	**1**	**1**	**-**	**-**
	Not Relevant	**12**	**-**	**-**	**-**	**-**
	Totals	**14**	**2**	**1**	**-**	**-**

[1] Protection Measure Effectiveness Rating: Refer to section 2.3.4 for explanation and defining.

[2] Protection Measure Application Status: Refer to table footnotes on previous page.

7.1.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (EXPOSURE REDUCTION)

Table 7.3: For the stated element at risk, the potential impact of the applied protection measures in reducing exposure levels to the stated area of bushfire prone vegetation.

ASSESSED IMPACT OF APPLIED MEASURES (EXPOSURE REDUCTION)								
Element at Risk	Persons located onsite and temporarily offsite							
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.							
Exposure Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accum.	Conseq. Fire	Fire Driven Wind	Tree Strike / Obstruct
Existing and Planned (applied to inherent risk)	Minimal	Significant	Significant	Very Significant	Very Significant	Significant	Significant	Significant
	Medium				Significant			
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 4 for explanatory information.								

7.1.4 ASSESSED EXPOSURE LEVELS

Assessed as a function of the capacity to apply sufficient exposure reducing protection measures, their individual effectiveness and their combined impact in reducing the exposure of the identified element at risk (Note: This assessment is independent of the threat level and vulnerability level assessments).

Table 7.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE LEVELS	
Element at Risk	Persons located onsite and temporarily offsite
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.
Exposure Reducing Protection Measures Applied to Assessment [1]	Relative Exposure Level [2]
Existing and Planned	Low
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 2 for explanatory information.	

Assessment Comments: The only protection measure existing/planned is the availability of offsite safer location(s), as staff and visitors are able to self-evacuate. Appropriate shelter-in-place options have not been identified. No recommendations are applied. All persons can quickly move to low threat built-out areas and thus the relative exposure is Low.

7.2 PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES

7.2.1 PROTECTION MEASURES AVAILABLE TO REDUCE EXPOSURE LEVELS AND THEIR APPLICATION STATUS

Table 7.5: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES						
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.					
PROTECTION PRINCIPLE - SEPARATION FROM ALL BUSHFIRE THREATS: To utilise distance away from all relevant bushfire hazard threats (direct and indirect attack mechanisms) while traversing an access/egress route in a vehicle to lower the exposure of persons to the threats for the expected time on the route.						
3.1	**Locating Routes Away from Adjacent Hazards:** Existing or to be installed vehicular access/egress route components (roads, access ways, and driveways) are positioned to maximise the distance away from any adjacent bushfire prone vegetation where possible.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *All routes travel through bushfire prone vegetation (forest of scrub) for >1.5km before reaching a low threat area. Note that the subject site is part of an ongoing commercial development and the area to the north is expected to become low threat in its entirety.*						
3.2	**Egress Routes Located to Ensure Driving Away from Hazard:** Existing or to be installed vehicular access/egress route components (roads, access ways, and driveways) are positioned so that the direction of egress is away from the hazard into lower threat areas.	Very High	No	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *Evacuees can quickly choose to egress east or west along Flynn Drive, or south on Tranquil Drive. Flynn Drive east travels away from the primary bushfire hazard(s), thus evacuees can rapidly leave the immediate area (and bushfire hazard).*						
3.3	**Greater Road Width:** Wider roads will allow for a greater separation distance between traversing vehicles and the bushfire hazard. The incorporation of non-vegetated and trafficable road verges/shoulders and adjacent footpaths can also safely increase effective separation for slower moving vehicles.	Moderate	No	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *The measure is not under the control of the developer. Flynn Drive is a local main road and is a minimum 8m wide (including shoulders) at its narrowest point.*						

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
3.4	**Reduce and Maintain Road Verge Fuel to Low Threat State:** Road verges, or part of, have vegetation removed or reduced to a minimal fuel, low threat state annually to increase the separation distance from the bushfire hazard. This is practical when an authority exists to conduct the management and will have greater impact as a protection measure if there is certainty it will be carried out.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *The measure is not under the control of the developer. The routes are bounded by either forest or scrub for most of their length before reaching low threat areas. The routes very rapidly leave the local area (and bushfire hazard).*						
PROTECTION PRINCIPLE - SHIELDING FROM ALL BUSHFIRE THREATS: To utilise constructed or natural shielding to reduce the exposure of persons traversing the access/egress routes to the direct attack mechanisms of bushfire. To assist with ensuring the level of exposure to the threats is survivable for the expected time on the route while travelling in a vehicle.						
3.5	**Vehicle Type – Protection Level:** People can only tolerate low levels of radiant heat without some protection. Vehicles provide some protection from low intensity fires (if they stay on cleared area and remain in the vehicle) but they will not protect people in moderate to intense grass fires or in any location where scrub or forest adjoin the road. Protection provided by vehicles with predominantly metal bodies (including roof) and able to be enclosed (glass window), while limited is also still significant. It is particularly significant when compared to other potentially available modes of transport on roads (e.g. open top/backed vehicles, motorbikes, bicycles and being on foot). The availability such vehicles of required capacity can contribute to reduced exposure to the bushfire threats for persons on access/egress routes.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Most evacuees vehicles will have an enclosed cabin, but it is unreasonable for this to be assumed, expected, or required for public (retail) uses.*						

[1] **Protection Measure Effectiveness Rating:** Refer to section 2.3.5 for explanation and defining.

[2] **Protection Measure Application Status:**

- **Possible:** Protection measures that can potentially be applied to the proposed development/use;
- **Exists**: Protection measures already implemented by existing components of the proposed development/use. These measures are accounted for in assessing 'inherent' risk levels (refer to Glossary);
- **Planned:** Protection measures that:
  - Are incorporated into the site plans;
  - Exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), alternative solutions and any additional recommended protection measures - for which a responsibility for their implementation has been created and approved; and/or

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
		Possible	Exists	Planned	Additionally Recommend
• Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), that can be met and for which a responsibility for their implementation can be created in the BMP. These planned measures are accounted for in assessing 'inherent' risk levels (refer to Glossary). • **Additionally Recommend:** Protection measures that: • Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and comprise alternative solutions and/or additional recommended protection measures (that can and should be implemented in the opinion of the bushfire consultant), and for which a responsibility for their implementation can be created in the BMP; and/or • Are developed in the process of producing this risk assessment and management report and for which a responsibility for their implementation can be created in the BMP. These additionally recommended measures, along with existing and planned measures, are accounted for in assessing 'residual' risk levels (refer to Glossary).					

7.2.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 7.6: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

EXPOSURE REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Persons on access/egress routes in vehicles					
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.					
The Protection Principle	Effectiveness Rating [1]	Numbers of Protection Measures				
		Total Available	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Separation from the Bushfire Hazard	Very High	1	-	1	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	1	-	1	-	-
	Not Relevant	2	-	-	-	-
Shielding from the Bushfire Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	-	-	-	-	-
	Not Relevant	1	-	-	-	-
Total Numbers	**Very High**	**1**	**-**	**1**	**-**	**-**
	High	**-**	**-**	**-**	**-**	**-**
	Effective	**-**	**-**	**-**	**-**	**-**
	Moderate	**1**	**-**	**1**	**-**	**-**
	Not Relevant	**3**	**-**	**-**	**-**	**-**
	Totals	**5**	**-**	**2**	**-**	**-**

[1] Protection Measure Effectiveness Rating: Refer to section 2.3.5 for explanation and defining.

[2] Protection Measure Application Status: Refer to table footnotes on previous page.

7.2.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (EXPOSURE REDUCTION)

Table 7.7: For the stated element at risk, The potential impact of the applied protection measures in reducing exposure levels to the stated area of bushfire prone vegetation.

ASSESSED IMPACT OF APPLIED MEASURES (EXPOSURE REDUCTION)								
Element at Risk	Persons on access/egress routes in vehicles							
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.							
Exposure Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Minimal	Minimal	Medium	Significant	N/A	N/A	Medium	Medium
	Minimal				Medium			
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 4 for explanatory information.								

7.2.4 ASSESSED EXPOSURE LEVELS

Assessed as a function of the capacity to apply sufficient exposure reducing protection measures, their individual effectiveness and their combined impact in reducing the exposure of the identified element at risk (Note: This assessment is independent of the threat level and vulnerability level assessments).

Table 7.8: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE LEVELS	
Element at Risk	Persons on access/egress routes in vehicles
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.
Exposure Reducing Protection Measures Applied to Assessment [1]	Relative Exposure Level [2]
Existing and Planned (applied to inherent risk)	Moderate
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 2 for explanatory information.	

Assessment Comments: The local and regional road network and its proximity to bushfire prone vegetation is not under the control of the landowner. The evacuation routes available are highly effective at allowing for rapid egress from the local area. However, all routes are bounded by forest or scrub (Bushfire Hazard Level of Extreme) for most of the route to a low threat area. The mitigating factors are that the nearest low threat area (on Pinjar Road) can be reached in 2 minutes of travel (1.5km), and there is little preparation time for occupants to evacuate. No recommendations are available to be applied.

7.3 BUILDINGS AND STRUCTURES NCC CLASSES 1-10 (ELEMENT AT RISK CATEGORIES 3-10)

7.3.1 PROTECTION MEASURES AVAILABLE TO REDUCE EXPOSURE LEVELS AND THEIR APPLICATION STATUS

Table 7.9: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

	EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
PROTECTION PRINCIPLE – SEPARATION FROM ALL BUSHFIRE THREATS (SITING): To locate (site) the buildings and attached/adjacent structures at distances away from the direct and indirect attack mechanisms of bushfire (the hazard threats) to reduce their exposure. The required distances will be dependent on the relative threat levels and the degree of bushfire resilience that is or is planned to be incorporated into the exposed elements through design and construction.						
4.1	**Asset Protection Zone (APZ):** Ensure an APZ can be established surrounding the exposed element(s) to create the required separation distance from the bushfire hazard and its threats (the direct and indirect attack mechanisms). This is to be an area containing minimal fire fuels and maintained in a low threat state. The *Explanatory Notes for Element 2 of the Bushfire Protection Criteria and Schedule 1: Standards for Asset Protection Zones* established in the Guidelines [22] provides the key requirements for establishing and maintaining an APZ. Additional requirements may exist within a relevant local governments firebreak notice, or the responsibilities established by an applicable Bushfire Management Plan (BMP). The required dimensions of the APZ will correspond to the maximum level of radiant heat the exposed element is to be exposed to – or a greater distance if it is stipulated by a different authority (e.g. firebreak notice or BMP). As a minimum avoid dimensions (separation distances) that correspond to BAL-FZ and BAL-40 ratings for any given site/vegetation combination of relevant the parameters (Note: this will also apply to BAL-29 separation distances if flame length modelling indicates potential contact due to specific site and effective slope configurations). The APZ should be contained solely within the boundaries of each lot, except in instances where the neighbouring lot(s) or adjacent public land will be managed in a low-fuel state on an ongoing basis, in perpetuity. ***Note that the APZ does not provide separation from the consequential fire attack mechanism. Separation from consequential fire fuels requires additional assessment and management.***	Effective	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: *Bushfire prone vegetation will be removed from the entirety of the subject lot. Any landscaped vegetation (gardens) will be managed to APZ standards.*						
4.2	**Siting of Buildings/Structures - Wind:** Site the buildings and attached/adjacent structures in locations that have lower wind exposure. Avoid the top and sides of ridges which are especially vulnerable to fire driven winds as well as	Not Relevant	N/A	N/A	N/A	N/A

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
	topographically influenced winds. Winds can directly or indirectly (carrying materials/debris) cause damage to the external building envelope potentially allowing flame, radiant heat and ember entry.					
Informative and/or Site Specific Comment/Assessment: *The limited size and flat topography of the lot precludes strategic positioning of buildings to reduce the effects of high winds.*						
4.3	**Use of Non-Vegetated Areas and/or Public Open Space:** Reduce exposure by increasing separation from APZ landscaping vegetation and/or the bushfire hazard by incorporating these lowest threat areas adjacent to buildings/structures and/or adjacent to the bushfire hazard. These lowest threat components of the APZ include non-vegetated areas (e.g. footpaths, paved areas, roads, parking, drainage, swimming pools), formally managed areas of vegetation (public open space and other recreation areas) and services installed in a common section of non-vegetated land. These elements create robust and easier managed asset protection zones.	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *The entirety of the subject lot will be cleared of bushfire prone vegetation, and either developed, sealed to a trafficable hardstand, or landscaped as maintained gardens. Some landscaping is proposed around structures but is very limited. There is no landscaping proposed around the high-risk components of the facility.*						
4.4	**Landscaping - Tree Location:** Use separation to minimise the potential for debris accumulation and tree strike damage to the building envelop potentially allowing flame, radiant heat and ember entry to internal spaces. • The buildings/structures are separated from trees (or trees from buildings) by a distance of at least 1.5 times the height of the tallest tree. • Trees that produce significant quantities of debris (fine fuels) during the bushfire season should be located a sufficient distance away from vulnerable exposed elements to ensure debris cannot Drop and accumulate within at least 4m of buildings/structures or be likely to be relocated by wind to closer than 4m to buildings / structures. • If the minimum distance cannot be achieved with an existing tree either remove the tree or at least ensure tree branches are sufficiently separated from buildings and attached/adjacent structures (at a minimum to not overhang) to ensure branches cannot fall onto or be blown onto the buildings/structures.	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *There are few trees within 30m (assumed 1.5 x 20m height) of the proposed structures. Some trees may included in future landscaping around the site perimeter. The 10-30 second residence period of a grassland fire is insufficient to compromise a living tree. A tree may burn through with residual fire, but this would be significantly after the passage of the fire front.*						

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
4.5	**Separation of Stored Flammable Products - Gas in Cylinders:** To reduce the potential for gas flaring or explosion (consequential fire), installation of LPG cylinders is to apply as a minimum, the principles and requirements established in AS 1596 and LP Gas cylinder safety in bushfire prone areas (Energy Safety – Govt. of WA). Otherwise, the required separation distance is 6m from any combustible materials. Heat from bushfire or consequential fire can be sufficient to cause cylinder pressure to reach critical levels and the pressure relief valve release large quantities of gas (flare). If the cylinder falls over the pressure relief valve may not function correctly, and the cylinder may rupture (explosion).	Moderate	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *Any gas cylinders installed and/or stored onsite will be positioned >6m from stored combustible liquids and comply with AS1596.*						
4.6	**Separation from Stored Flammable Products – Fuels / Other Hazardous Materials:** Establish sufficient separation distance between the consequential fire fuels and buildings/structures. The required separation distance will be dependent on the fuel and storage type.	Moderate	Yes	No	Unknown	Yes
Informative and/or Site Specific Comment/Assessment: *Onsite hazardous materials are controlled under legislative requirements for service stations. Management of other fuels that may contribute to consequential fires will be included in site procedures and guidelines and specified separation distances applied.*						
4.7	**Separation from Stored and Constructed Combustible Items:** These consequential fire fuels include: • Stored Combustible Items - Heavy Fuels e.g. building materials, packaging materials, firewood, sporting/playground equipment, outdoor furniture, rubbish bins etc: • Stored Combustible Items – Large Heavy Fuels e.g. vehicles, caravans, boats and large quantities of dead vegetation materials stored as part of site use. • Constructed Combustible Items – Heavy Fuels e.g. landscaping structures including fences, screens, walls, plastic water tanks. • Constructed Combustible Items – Large Heavy Fuels e.g. adjacent buildings/structures including houses, sheds, garages, carports. (Note: If the adjacent structure is constructed to BAL-29 requirements or greater and can implement a significant number of additional bushfire protection measures associated with reducing exposure and vulnerability, these minimum separation distances could be reduced by 30%) [31].	Moderate	Yes	Yes	No	Yes

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
	Apply the rule of thumb [13] "assume flames produced from a consequential fire source will be twice as high as the object itself … where the consequential fire source is a structure, then the maximum eave height is a reasonable measure of maximum height". Apply the following separation distances from the subject building/structure as a multiple of the height of the consequential fire source and dependent on the construction standard applied to the building/structure [13 and 31]: • At least six times the height when the building/structure construction incorporates design and materials that is only intended to resist low levels of radiant heat up to 12.5 kW/m^2) and no flame contact; • Between 4 and 6 six times the height when the building/structure construction incorporates design and materials intended to resist radiant heat up to 29 kW/m^2 and no flame contact. • Between 2 and 4 times the height when the building/structure construction incorporates design and materials intended to resist up to 40kW/m^2 and potential flame contact. • Less than 2 times the height when the building/structure construction incorporates design and materials intended to resist extreme levels of radiant heat and flame contact. • Zero separation distance is required if the building/structure is separated by a non-combustible FRL 60/60/60 rated wall or the potential consequential fire source is fully enclosed by the building/structure.					
Informative and/or Site Specific Comment/Assessment: *The measure is applicable to the Refuse Enclosure which contains stored combustible items. Skip bins are generally no more than 2m in height and the enclosure is approximately 1m from the car wash bays and 3m from the vacuum bays. These are not habitable structures which can comply with AS 3959 but will be constructed entirely from non-combustible material, and thus resistant to extreme radiant heat and flame contact. The structures are not enclosed (masonry walls are <2m high as a movement barrier) and there are no cavities to seal. All other structures are >11m from the refuse enclosure.* *It is recommended that any stored combustible items are removed from the profile of buildings. This may be actioned as a response to a bushfire event (e.g. moving furniture away from a building).*						
PROTECTION PRINCIPLE – SHIELDING FROM ALL BUSHFIRE THREATS: To shield buildings and attached/adjacent structures (or other consequential fire fuels) from the direct bushfire attack mechanisms of flame, radiant heat, surface fire and surface migration of embers. To also reduce exposure to the indirect attack mechanism of debris accumulation against buildings/structures and other consequential fire fuels and wind attack.						
4.8	**Constructed Barrier – Bushfire Fuels:** Walls, fences and/or landforms to shield the subject building/structure from direct and indirect bushfire attack mechanisms and reduce the potential impact of these threats to vulnerable exposed elements.	Not Relevant	N/A	N/A	N/A	N/A

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
	Must be constructed using appropriate fire resistant / non-combustible construction materials (e.g. masonry, steel, earthworks). These are to withstand the impact of direct bushfire attack mechanisms for the required period of time. Apply the bushfire construction standards for external walls subject to the assessed level of radiant heat or flame contact to which the barrier will be exposed (or otherwise to BAL-FZ requirements). These are established by AS 3959:2018 [4] and/or the NASH Standard [33] and additionally informed by the research report 'Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires.' [29]					
Informative and/or Site Specific Comment/Assessment: *The area between structures must be trafficable for use and thus internal constructed barriers cannot be installed. The primary bushfire hazard is on the opposite verge of Flynn Drive, but a constructed barrier is impractical to install as this will be a primary road access to the site and visibility is required for advertising.*						
4.9	**Constructed Barrier – Consequential Fire Fuels:** Applicable to all consequential fire fuel sources. Install a non-combustible barrier (including complete enclosure when appropriate), of required robustness, that can perform the following as relevant: • Reduce the exposure of the subject building/structure to the threats of consequential fire; and/or • Reduce the exposure of the consequential fire fuels to the bushfire hazard.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *The Refuse Enclosure is intended to be metal slatted. The barrier would need to be >4m tall to be functional in limiting exposure of nearby structures to consequential fire, and complete enclosure would be required to reduce the exposure of stored waste to ember attack. The measure is possible but impractical for a minor reduction in risk.* *The bowsers and fuel vents cannot have a barrier installed, as they must necessarily be accessible to the public.*						
4.10	**Natural Barrier - Landforms:** Use existing natural landforms to reduce buildings/structures exposure to radiant heat, and lower wind speeds (prevailing synoptic and/or fire driven).	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Not applicable to this site.*						
4.11	**Planted Barrier - Vegetation Barrier:** Use appropriate hedges and trees strategically to reduce (to varying extents) buildings/structures exposure to radiant heat, to filter/trap embers and firebrands, and to lower wind speeds (prevailing synoptic and/or fire driven).	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *This conflicts with the requirements of the APZ (including tree setbacks) due to the size of the lot and setbacks of structures from the lot boundary.*						

EXPOSURE REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
4.12	**Shield Non-Structural Essential Elements:** These are elements essential to the continued operation of the building/structure which are potentially exposed to fire attack mechanisms of both bushfire and consequential fire. They include cabling and plumbing associated with power / data transmission and water / fuel transport. When the use of fire rated materials to the degree necessary is not possible or practical, the application of non-combustible shielding can be applied to reduce exposure to the bushfire threats. Shielding includes underground installation.	Moderate	Yes	No	Unknown	Yes
Informative and/or Site Specific Comment/Assessment: *The facility should be investigated at detailed design stage, with shielding applied as necessary.*						

[1] **Protection Measure Effectiveness Rating:** Refer to section 2.3.4 for explanation and defining.

[2] **Protection Measure Application Status:**

- **Possible:** Protection measures that can potentially be applied to the proposed development/use;
- **Exists**: Protection measures already implemented by existing components of the proposed development/use. These measures are accounted for in assessing 'inherent' risk levels (refer to Glossary);
- **Planned:** Protection measures that:
  - Are incorporated into the site plans;
  - Exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), alternative solutions and any additional recommended protection measures - for which a responsibility for their implementation has been created and approved; and/or
  - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), that can be met and for which a responsibility for their implementation can be created in the BMP.

These planned measures are accounted for in assessing 'inherent' risk levels (refer to Glossary).

- **Additionally Recommend:** Protection measures that:
  - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and comprise alternative solutions and/or additional recommended protection measures (that can and should be implemented in the opinion of the bushfire consultant), and for which a responsibility for their implementation can be created in the BMP; and/or
  - Are developed in the process of producing this risk assessment and management report and for which a responsibility for their implementation can be created in the BMP.

These additionally recommended measures, along with existing and planned measures, are accounted for in assessing 'residual' risk levels (refer to Glossary).

7.3.2 NUMBER ANALYSIS OF AVAILABLITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 7.10: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

EXPOSURE REDUCING PROTECTION MEASURES – SUMMARY NUMBERS						
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Category 6)					
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.					
The Protection Principle	Effectiveness Rating [1]	Numbers of Protection Measures				
		Total Available	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
Separation from the Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	1	1	-	1	-
	Moderate	5	5	4	-	2
	Not Relevant	1	-	-	-	-
Shielding from the Hazard	Very High	-	-	-	-	-
	High	-	-	-	-	-
	Effective	-	-	-	-	-
	Moderate	3	3	-	-	1
	Not Relevant	2	-	-	-	-
Total Numbers	**Very High**	**-**	**-**	**-**	**-**	**-**
	High	**-**	**-**	**-**	**-**	**-**
	Effective	**1**	**1**	**-**	**1**	**-**
	Moderate	**8**	**8**	**4**	**-**	**3**
	Not Relevant	**3**	**-**	**-**	**-**	**-**
	Totals	**12**	**9**	**4**	**1**	**3**

[1] Protection Measure Effectiveness Rating: Refer to section 2.3.4 for explanation and defining.

[2] Protection Measure Application Status: Refer to table footnotes on previous page.

7.3.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (EXPOSURE REDUCTION)

Table 7.11: For the stated element at risk, The potential impact of the applied protection measures in reducing exposure levels to the stated area of bushfire prone vegetation.

ASSESSED IMPACT OF APPLIED MEASURES (EXPOSURE REDUCTION)								
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Category 6)							
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.							
Exposure Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accum.	Conseq. Fire	Fire Driven Wind	Tree Strike / Obstruct
Existing and Planned (applied to inherent risk)	Minimal	Medium	Significant	Significant	Significant	Minimal	Medium	Significant
	Medium				Medium			
Existing, Planned and Recommended (applied to residual risk)	Medium	Significant	Significant	Significant	Significant	Significant	Medium	Significant
	Significant				Significant			
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 4 for explanatory information.								

7.3.4 ASSESSED EXPOSURE LEVELS

Assessed as a function of the capacity to apply sufficient exposure reducing protection measures, their individual effectiveness and their combined impact in reducing the exposure of the identified element at risk (Note: This assessment is independent of the threat level and vulnerability level assessments).

Table 7.12: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED EXPOSURE LEVELS	
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Category 6)
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.
Exposure Reducing Protection Measures Applied to Assessment [1]	Relative Exposure Level [2]
Existing and Planned (applied to inherent risk)	High
Existing, Planned and Recommended (applied to residual risk)	Moderate
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 2 for explanatory information.	

Assessment Comments: The primary additional measure recommended is the separation of combustible hazards from structures where practical, and the inclusion of this procedure in future site operating procedures.

8 ASSESSING THE VULNERABILITY LEVELS OF ELEMENTS AT RISK

SUMMARY OF THE QUALITATIVE ASSESSMENT PROCESS

1. Identify all protection measures (grouped by protection principle) that are available to reduce vulnerability levels and rate their effectiveness;
2. Produce a numerical summary of all potential vulnerability reducing protection measures that are available and determine their application status;
3. Assess the potential vulnerability reducing impact of the package of protection measures that is able to be applied. The effectiveness rating weights the potential impact of an individual measure; and
4. Derive the vulnerability level of the identified element at risk, to the threats presented by each identified area of bushfire prone vegetation (refer to Section 2.3.3 and Appendix 2 for additional risk assessment process information).

8.1 PERSONS ONSITE OR TEMPORARILY OFFSITE (ELEMENT AT RISK CATEGORY 1)

8.1.1 PROTECTION MEASURES AVAILABLE TO REDUCE VULNERABILITY LEVELS AND THEIR APPLICATION STATUS

Table 8.1: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
PROTECTION PRINCIPLE – TRANSPORT AND MULTIPLE EVACUATION DESTINATIONS AND ROUTES AVAILABLE						
7.1	**Sufficient Evacuation Transport Available:** Ensure that all persons likely to be on site have access to transport. This can be through own vehicles, facility vehicles, a formal arrangement with an external provider or a combination of these.	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *Visitors to the site (customers) will most likely have their own transport, given the primary purpose of the facility is a fuel station. It is possible some staff or foot traffic visitors do not have transportation, however any such persons can evacuate in the ample vehicles associated with the use.*						
7.2	**Multiple Safer Offsite Locations Available:** Increasing the route and destination options decreases vulnerability of persons as the exposed element. Multiple buildings/areas are accessible from the subject site as evacuation destinations. The offsite locations exist at a sufficient distance from the subject site ensuring that the destination and the subject site are very unlikely to be simultaneously impacted by a bushfire event.	Very High	Yes	Yes	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	For the most robust scenario: • Multiple access/egress route are available to the safer locations from the subject site; • The entirety of at least two routes is unlikely to be simultaneously impacted by a bushfire event; and • The availability of water and amenities corresponding to person numbers increases the effectiveness of the measure.					
Informative and/or Site Specific Comment/Assessment: *Two-way access will be available immediately on leaving the site. Flynn Drive provides rapid egress to multiple destinations.*						
PROTECTION PRINCIPLE – PROVISION OF BUSHFIRE EMERGENCY INFORMATION AND EDUCATION						
7.3	**Bushfire Emergency Plan:** Is produced and appropriately located within the site of the subject development/use. It is an operational document that details site specific preparation, response, recovery and review procedures. It is produced for use by the site owners, managers, operators and occupants (as relevant).	Effective	Yes	Unknown	No	Yes
Informative and/or Site Specific Comment/Assessment: *The relevant information is to be included in the site Emergency Management Plan (document title pending), to include preparation and responses to bushfire emergencies.*						
7.4	**Bushfire Emergency Poster:** A poster is prominently displayed, for the attention of all persons onsite. It presents the key emergency contacts, information sources and response procedures in the event of a bushfire event. It has increased value attached to its display when there are no bushfire emergency trained persons onsite or no persons that are familiar with the site and local area.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *Persons onsite will have immediate access to personal vehicles, multiple routes available, and no attachment to the site. They will immediately self-evacuate without consulting a Bushfire Emergency Poster.*						
7.5	**Bushfire Protection Measures to be Implemented are Published in the Relevant Operational Documents:** The relevant documents can include the Bushfire Management Plan (BMP), the Bushfire Emergency Plan (BEP), the Site Emergency Plan (as required to be developed by the operators of 'high risk' land uses), and any relevant documents associated with a projects design phase. The purpose of this measure is to ensure the application of relevant protection measures, that have been identified in this Bushfire Risk Assessment and Management Report, will be acted upon through responsibilities created by the operational documents.	Effective	Yes	Unknown	No	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
Informative and/or Site Specific Comment/Assessment: *The relevant information is to be included in the site Emergency Management Plan (document title pending), to include preparation and responses to bushfire emergencies.* Operating procedures and/or the site Emergency Management Plan (document title pending) are required to include a trigger for complete site evacuation due to bushfire.						
7.6	**Prominent Display of Information Stating Safe Early Evacuation is the Primary Procedure:** For the subject development/use evacuation in the event of a bushfire within the locality has or is likely to be determined as the primary response procedure and that it must be conducted early. This option is available. The emphasis on early rather than a late evacuation is important. Analysis of past events identify that most people who die in bushfires are caught in the open, either in vehicles or on foot, because they have left their property too late. For evacuation to provide the safest response for occupants, it must be conducted early. Being on roads when a bushfire is close is a high risk action. Otherwise, sheltering-in-place is likely to provide greater protection to persons – particularly when a suitable onsite shelter place is identified.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *Persons onsite will have immediate access to personal vehicles, multiple routes available, and no attachment to the site. They will immediately self-evacuate without consulting Bushfire Emergency Information.*						
7.7	**Egress Pathway Signage:** Where pathways exist onsite for occupants to relocate to an identified safer onsite location, appropriate signage to guide unfamiliar persons can reduce their vulnerability.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Not applicable to this site.*						
7.8	**Trained Personnel Onsite:** Operational persons (staff) are provided with bushfire emergency management training, aligned with the subject site's prepared Site Emergency Plan The intent also includes identifying the specific roles and persons to fill any required responsibilities that have determined through the SEP construction process.	Moderate	Yes	No	Unknown	Yes
Informative and/or Site Specific Comment/Assessment: *It is recommended that staff receive basic bushfire awareness training and review of the site Emergency Management Plan (document title pending), as a component of employment induction.*						
7.9	**Build Community Resilience Through Education:** When relevant to the type and scale of proposed development/use, the delivery of effective education programs can result in lowering the vulnerability of the community to a bushfire event, once the information has been acted upon and packages of protection measures put in place. Local government develops an ongoing program of innovative and leading edge community and landowner education that builds on the information presented within this Bushfire Risk Assessment and Management Report.	Not Relevant	N/A	N/A	N/A	N/A

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
	Subsequent implementation of recommended/required protection measures can be encouraged through legislation, education, audits, enforcement and penalties as appropriate. Examples of such community education programs exist in various jurisdictions. The CSIRO (2020) Climate and Disaster Resilience Overview Report in 'Recommendation No. 5' [18] encourages collaboration with research agencies on the issue of building community resilience.					
7.10	**Encourage 'Property Bushfire Resilience Assessments'**: Local government to promote (and potentially incentivise) the conducting of these assessments and the implementation of any recommendations. These assessments address bushfire hazard threat levels and the level of exposure and vulnerability of buildings and persons. It identifies appropriate protection measures to increase bushfire resilience.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Not applicable to this site.*						
PROTECTION PRINCIPLE – A BUSHFIRE EMERGENCY FIREFIGHTING CAPABILITY EXISTS (RESPONSE)						
7.11	**Personnel Onsite Can Manage Bushfire Emergency Procedures:** Different categories of persons can perform this role in different scenarios, with potentially varying levels of expertise and effectiveness. These include: • Appropriately trained person(s) will be onsite at all times, or able to be onsite at short notice. They are trained in bushfire emergency procedures in general and have specific knowledge of site preparation, response and recovery procedures from the required Bushfire Emergency Plan), and the environment in which the development/use exists. This person(s) may have the official title of fire warden. • An untrained person familiar with the local area will be onsite at all times. They have knowledge and instruction gained from the required Site Emergency Plan for the subject development/use and will ensure the preparation, response and recovery procedures established by the required Site Emergency Plan are conducted appropriately and provide emergency event guidance to any other persons onsite.	Effective	Yes	No	No	Yes
7.12	**Personnel Onsite Can Operate Firefighting Equipment:** Such person(s) is suitably capable of maintaining and operating any installed firefighting water supply and associated pumps, hoses/nozzles and sprinklers.	Moderate	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: *The primary response procedure for site staff, is to enforce evacuation of all persons onsite.* *Staff are intended to evacuate rather than directly defend the site. Staff are recommended to be trained in the use of fire extinguishers to combat consequential fires.*						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)						
7.13	**Locations of Vulnerable Persons are Registered:** Relevant department of local government and their emergency services maintains a register of the location of land uses that are likely to result in a number of 'vulnerable' persons residing onsite, so that their needs can be addressed as a priority in a bushfire emergency. The subject development/use would exist on that register.	Not Relevant	N/A	N/A	N/A	N/A
Informative and/or Site Specific Comment/Assessment: *Not applicable for this site.*						
7.14	**External Emergency Services Available:** An emergency service with a bushfire response capability is located within a realistic operational distance of the subject development/use. Bushfire services include volunteer bushfire brigades, volunteer fire and emergency services, DFES career fire and Rescue Service or Parks and Wildlife. Even if an emergency service response capability exists, effectiveness will be limited by number of resources and their availability likelihood at the crucial time. *Bushfire Verification Method – Handbook s6.6 [14] states "During significant bushfires, there will be conflicting demands on fire brigade resources and reliance should not be placed on fire brigade intervention to protect a specific property.* *Prior to the 2009 Black Saturday fires, an early evacuation or stay and defend policy was in place and data from major fires indicated that the presence of occupants significantly increased the probability of house survival (refer Table 7.1). However, in response to the subsequent Royal Commission findings there is now a greater emphasis on early evacuation. Whilst this is expected to reduce fatalities by reducing the numbers of people at risk, a negative consequence will be an increase in property losses for buildings constructed to similar standards. It should therefore be assumed that there will be no fire brigade or occupant intervention with respect to protecting a specific property."*	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *Joondalup Career Fire and Rescue Service is within 6.2km of the site (5-10 minute travel).*						

[1] **Protection Measure Effectiveness Rating:** Refer to section 2.3.4 for explanation and defining.

[2] **Protection Measure Application Status:**

- **Possible:** Protection measures that can potentially be applied to the proposed development/use;
- **Exists**: Protection measures already implemented by existing components of the proposed development/use. These measures are accounted for in assessing 'inherent' risk levels (refer to Glossary);
- **Planned:** Protection measures that:
    - Are incorporated into the site plans;

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
		Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: PERSONS LOCATED ONSITE AND TEMPORARILY OFFSITE (CATEGORY 1)					

- Exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), alternative solutions and any additional recommended protection measures - for which a responsibility for their implementation has been created and approved; and/or
- Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), that can be met and for which a responsibility for their implementation can be created in the BMP.

These planned measures are accounted for in assessing 'inherent' risk levels (refer to Glossary).

- **Additionally Recommend:** Protection measures that:
  - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and comprise alternative solutions and/or additional recommended protection measures (that can and should be implemented in the opinion of the bushfire consultant), and for which a responsibility for their implementation can be created in the BMP; and/or
  - Are developed in the process of producing this risk assessment and management report and for which a responsibility for their implementation can be created in the BMP.

These additionally recommended measures, along with existing and planned measures, are accounted for in assessing 'residual' risk levels (refer to Glossary).

8.1.2 NUMBER ANALYSIS OF AVAILABLITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 8.2: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

VULNERABILITY REDUCING PROTECTION MEASURES – SUMMARY NUMBERS							
Element at Risk	Persons located onsite and temporarily offsite (Category 1)						
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.						
The Protection Principle	Effectiveness Rating [1]	Numbers of Protection Measures					
		Total Available	Application Status [2]				
			Possible	Exists	Planned	Additionally Recommend	
Transport and Multiple evacuation destinations and routes available	Very High	1	1	1	-	-	
	High	-	-	-	-	-	
	Effective	1	1	1	-	-	
	Moderate	-	-	-	-	-	
	Not Relevant	-	-	-	-	-	
Provision of bushfire emergency information and education	Very High	-	-	-	-	-	
	High	-	-	-	-	-	
	Effective	2	2	-	-	2	
	Moderate	3	3	-	-	1	
	Not Relevant	3	-	-	-	-	
A bushfire emergency firefighting capability exists (response)	Very High	-	-	-	-	-	
	High	-	-	-	-	-	
	Effective	2	2	1	-	1	
	Moderate	1	1	-	-	1	
	Not Relevant	1	-	-	-	-	
Total Numbers	**Very High**	**1**	**1**	**1**	**-**	**-**	
	High	**-**	**-**	**-**	**-**	**-**	
	Effective	**5**	**4**	**1**	**-**	**3**	
	Moderate	**4**	**4**	**-**	**-**	**2**	
	Not Relevant	**4**	**-**	**-**	**-**	**-**	
	Totals	**14**	**9**	**2**	**-**	**5**	

[1] Protection Measure Effectiveness Rating: Refer to section 2.3.4 for explanation and defining.

[2] Protection Measure Application Status: Refer to table footnotes on previous page.

8.1.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (VULNERABILITY REDUCTION)

Table 8.3: For the stated element at risk, The potential impact of the applied protection measures in reducing vulnerability levels to the stated area of bushfire prone vegetation.

ASSESSED IMPACT OF APPLIED MEASURES (VULNERABILITY REDUCTION)								
Element at Risk	Persons located onsite and temporarily offsite (Category 1)							
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.							
Vulnerability Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	N/A	Medium	Very Significant	N/A	Medium	Medium	N/A	N/A
	Significant				Medium			
Existing, Planned and Recommended (applied to residual risk)	N/A	Significant	Very Significant	N/A	Medium	Significant	N/A	N/A
	Very Significant				Significant			
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 4 for explanatory information.								

Assessment Comments: Existing measures include the availability of personal vehicles and access routes, and Emergency Services. Persons are not vulnerable to direct ember attack or surface fire impacts, or fire driven wind or tree obstruction (addressed as Persons on Access/Egress Routes). Recommendations are for the inclusion of preparation, responses and training for bushfire events to be included in the future site Emergency Management Plan (document title pending). This must include a trigger for complete site evacuation due to bushfire. Training in direct firefighting response by staff is not necessary, except use of fire extinguishers to combat consequential fires.

8.1.4 ASSESSED VULNERABILITY LEVELS

Assessed as a function of the capacity to apply sufficient vulnerability reducing protection measures, their individual effectiveness and their combined impact in reducing the vulnerability of the identified element at risk (Note: This assessment is independent of the threat level and exposure level assessments).

Table 8.4: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED VULNERABILITY LEVELS	
Element at Risk	Persons located onsite and temporarily offsite (Category 1)
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.
Vulnerability Reducing Protection Measures Applied to Assessment [1]	Relative Vulnerability Level [2]
Existing and Planned (applied to inherent risk)	High
Existing, Planned and Recommended (applied to residual risk)	Moderate
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 2 for explanatory information.	

Assessment Comments: There are limited measures available to reduce the vulnerability of persons onsite, given the brief, high-volume turnover of customers associated with a service station. Such customers cannot be familiar with emergency procedures. The primary measure is to ensure all persons are quickly evacuated to low threat areas.

8.2 PERSONS ON ACCESS/EGRESS ROUTES (IN VEHICLES) OR PATHWAYS

8.2.1 PROTECTION MEASURES AVAILABLE TO REDUCE VULNERABILITY LEVELS AND THEIR APPLICATION STATUS

Table 8.5: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

	VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK:	**PERSONS ON ACCESS/EGRESS ROUTES IN VEHICLES**					
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.					
PROTECTION PRINCIPLE – APPLY BEST (SAFER) ROAD DESIGN AND CONSTRUCTION (MATERIALS): The application of as many of the following protection measures as possible ensures a greater level of safety for users and lowers the associated risk when roads need to be used to evacuate to a safer offsite location in potentially high stress situations within a threatening environment. Safety for persons using the route is increased through reducing the likelihood of vehicle/terrain or vehicle/vehicle accidents and the ability to maintain travelling speed.						
8.1	**Road Width:** Ensure appropriate width roads are installed. Wider roads allow safer passing of the anticipated traffic that can be travelling in both directions (e.g. emergency services travelling towards the emergency event). The effectiveness of road width to reduce vulnerability is also a function of the required carriage capacity - which may be increased by the proposed development/use when it will increase traffic intensity. The incorporation of non-vegetated and trafficable road verges/shoulders and adjacent footpaths can also be considered to increase effective width for slower moving vehicles (providing additional separation from the hazard and passing opportunities).	High	No	Yes	No	No
8.2	**Road Gradient:** Ensure appropriate road gradients are available. Lower gradients ensure traction and speed can be maintained and can also be associated with driver visibility. Appropriate gradients will depend on the constructed surface materials and the weights and tractive capability of expected vehicle types.	High	No	Yes	No	No
8.3	**Road Clearance:** Ensure appropriate clearance can exist and is established. Sufficient horizontal and vertical clearances from obstructions ensure unhindered movement of all possible vehicle types;	High	No	Yes	No	No
8.4	**Road Surface Materials:** Ensure that roads are constructed of materials that will provide the necessary traction (also a function of gradient), can support the weight of all expected vehicle types and remain operational in all weather. The required supportive capacity also applies to associated structures such as bridges.	High	No	Yes	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
8.5	**Driver Visibility and Road Ahead Signage:** Ensure that road design provides high levels of visibility ahead (at least in the absence of smoke and embers) and informative signage indicating relevant 'up ahead' route information (includes information stating distance to turnaround area for narrow roads in more remote locations). Good visibility is associated with the avoidance 'blind' corners and crests to the greatest extent possible.	High	No	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *The measure is not under the control of the landowner/developer. Flynn Drive is a local main road. All roads have >8m trafficable width at their narrowest point, >8m horizontal and >6m vertical clearance, gentle gradient, excellent visibility, and surface grading sufficient for road trains and vehicle carriers.*						
8.6	**Road / Pathway Length:** Shorter distances to safer locations reduce the length of time persons remain vulnerable to bushfire threats.	Very High	No	Yes	No	No
8.7	**Interconnected Roads:** Ensuring that the design of the road network provides through roads and avoids dead-end roads, provides the choice of alternative routes for drivers to minimise close contact with a bushfire event. Otherwise vehicles and persons can be trapped.	High	No	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *Evacuees can quickly choose egress east or west on Flynn Drive, and quickly choose from Tranquil Drive, Pinjar Road, or Wanneroo Road to egress in any direction. All roads are through-roads.*						
PROTECTION PRINCIPLE – EVACUEES SELF-SUFFICIENT (LOCAL AWARENESS AND TRANSPORT): The 'type' of persons that will be present on the site of the proposed development/use influences their degree of vulnerability to both bushfire threats and to risk associated with vehicular accidents in a stressful environment. Persons that have local knowledge, are self-supportive, have their own transport and are physically and mentally capable present the lowest degree of vulnerability for this factor. This contrasts with persons who meet the SPP 3.7 definition of 'vulnerable' where the most vulnerable are likely to be less effective at making the required decisions and carrying out the required actions in the timeframe required. They are likely to be dependent on others for both information and transport and will not have any local knowledge.						
8.8	**Self Sufficient Persons with Local Awareness:** These are the type of persons that will be present on the site of the proposed development/use.	Effective	Yes	Partly	No	No
Informative and/or Site Specific Comment/Assessment: *Staff will have a level of local awareness. Most customers will likely have similar awareness, however this cannot be expected or assumed. Measures are not available to improve awareness of customers.*						
8.9	**Persons Onsite Have Own Transport:** There is no need to have arrangements in place for external provision of evacuation vehicles.	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *Visitors to the site (customers) will most likely have their own transport, given the primary purpose of the facility is a fuel station. It is possible some staff or foot traffic visitors do not have transportation; however any such persons can evacuate in the ample vehicles associated with the use.*						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
		Possible	Exists	Planned	Additionally Recommend

[1] **Protection Measure Effectiveness Rating:** Refer to section 2.3.5 for explanation and defining.

[2] **Protection Measure Application Status:**

- **Possible:** Protection measures that can potentially be applied to the proposed development/use;
- **Exists**: Protection measures already implemented by existing components of the proposed development/use. These measures are accounted for in assessing 'inherent' risk levels (refer to Glossary);
- **Planned:** Protection measures that:
    - Are incorporated into the site plans;
    - Exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), alternative solutions and any additional recommended protection measures - for which a responsibility for their implementation has been created and approved; and/or
    - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), that can be met and for which a responsibility for their implementation can be created in the BMP.

  These planned measures are accounted for in assessing 'inherent' risk levels (refer to Glossary).
- **Additionally Recommend:** Protection measures that:
    - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and comprise alternative solutions and/or additional recommended protection measures (that can and should be implemented in the opinion of the bushfire consultant), and for which a responsibility for their implementation can be created in the BMP; and/or
    - Are developed in the process of producing this risk assessment and management report and for which a responsibility for their implementation can be created in the BMP.

  These additionally recommended measures, along with existing and planned measures, are accounted for in assessing 'residual' risk levels (refer to Glossary).

8.2.2 NUMBER ANALYSIS OF AVAILABILITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 8.6: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

VULNERABILITY REDUCING PROTECTION MEASURES – SUMMARY NUMBERS							
Element at Risk	Persons on access/egress routes in vehicles						
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.						
The Protection Principle	Effectiveness Rating [1]	Numbers of Protection Measures					
		Total Available	Application Status [2]				
			Possible	Exists	Planned	Additionally Recommend	
Road Design and Construction (Materials)	Very High	1	-	1	-	-	
	High	6	-	6	-	-	
	Effective	-	-	-	-	-	
	Moderate	-	-	-	-	-	
	Not Relevant	-	-	-	-	-	
Evacuees Self-Sufficient in Transport and Local Knowledge	Very High	-	-	-	-	-	
	High	-	-	-	-	-	
	Effective	2	2	1	-	-	
	Moderate	-	-	-	-	-	
	Not Relevant	-	-	-	-	-	
Total Numbers	**Very High**	**1**	**-**	**1**	**-**	**-**	
	High	**6**	**-**	**6**	**-**	**-**	
	Effective	**2**	**2**	**1**	**-**	**-**	
	Moderate	**-**	**-**	**-**	**-**	**-**	
	Not Relevant	**-**	**-**	**-**	**-**	**-**	
	Totals	**9**	**2**	**8**	**-**	**-**	

[1] Protection Measure Effectiveness Rating: Refer to section 2.3.5 for explanation and defining.

[2] Protection Measure Application Status: Refer to table footnotes on previous page.

8.2.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (VULNERABILITY REDUCTION)

Table 8.7: For the stated element at risk, the assessed impact of the applied protection measures corresponding to the stated area of bushfire prone vegetation.

ASSESSED IMPACT OF APPLIED MEASURES (VULNERABILITY REDUCTION)								
Element at Risk	Persons on access/egress routes in vehicles							
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.							
Vulnerability Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Very Significant	Significant	Very Significant	Significant	N/A	N/A	Medium	Significant
	Very Significant				Significant			
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 4 for explanatory information.								

Assessment Comments: No recommendations are applicable. The inherent and residual risk are the same. Suitable transportation, and quality of egress route(s) are all available to the highest practical level. Local awareness cannot reasonably be improved for the use type.

8.2.4 ASSESSED VULNERABILITY LEVELS

Assessed as a function of the capacity to apply sufficient vulnerability reducing protection measures, their individual effectiveness and their combined impact in reducing the vulnerability of the identified element at risk (Note: This assessment is independent of the threat level and exposure level assessments).

Table 8.8: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED VULNERABILITY LEVELS	
Element at Risk	Persons on access/egress routes in vehicles
Access/Egress Route Bushfire Hazard:	All bushfire prone vegetation within the broader locality (2km radius) including along access routes.
Vulnerability Reducing Protection Measures Applied to Assessment [1]	Relative Vulnerability Level [2]
Existing and Planned (applied to inherent risk)	Low
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 2 for explanatory information.	

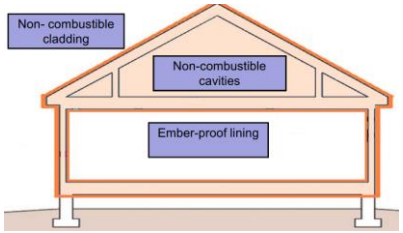
Assessment Comments: A relative vulnerability level of 'Very Low' is unlikely to be achieved for any use with high traffic of the general public (customers). The capacity for poor decision making will always exist.

8.3 BUILDINGS AND STRUCTURES NCC CLASSES 1-10 (ELEMENT AT RISK CATEGORIES 3-10)

8.3.1 PROTECTION MEASURES AVAILABLE TO REDUCE VULNERABILITY LEVELS AND THEIR APPLICATION STATUS

Table 8.9: All available protection measures to reduce exposure of the stated element at risk to bushfire hazard threats and their application to the subject development/use.

	VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
PROTECTION PRINCIPLE – DESIGN AND CONSTRUCTION (MATERIALS): Increase bushfire resilience through the application of beneficial design and construction, including using non-combustible materials and minimising the use of vulnerable materials, to the greatest extent possible. Practicality and cost will be key considerations in determining the viability of applying protection measures in differing scenarios, but this should be determined with due consideration of threat levels and the importance of the elements at risk. The constructed systems should utilise the following properties to the greatest extent possible: **reliability** (which requires their durability over time, low maintenance and being unlikely to change over time), **robustness** (which limits damage spread from minor sources, continue to protect when thermally loaded and protects vulnerable elements), **resilience** (which enables their return to a functional state following an overload) and **redundancy** (which ensures the fate of the subject building/structure is not reliant on the effective performance of a single element). Refer to the glossary for additional explanation. The principle is also applicable to constructed consequential fire fuels.					
9.1	**Construction to a Standard - AS 3959:2018 [4]:** Apply the specified requirements to construction. These are intended to reduce the risk of building ignition from bushfire direct attack mechanisms. Note that the indirect attack mechanisms and the threats presented by consequential fire fuels are not specifically considered. *"The standard is primarily concerned with improving the ability of buildings … to better withstand attack from bushfire thus giving a measure of protection to the building occupants (until the fire front passes), as well as to the building itself".* The AS 3959 approach adopts a strategy that relies on the integrity of the building's exterior envelope (i.e., the cladding of roof/wall/eaves, floor supporting structures/flooring and all penetrations) to resist all bushfire exposure conditions and environmental actions thereby protecting all structural construction elements behind it, including allowable combustible materials. It provides protection by: • Using specified materials that provide ignition resistance (tolerance of radiant heat and flames). Higher BAL ratings impose increased construction requirements for these exterior envelope materials; • Specifying precise gap control (applicable to all bushfire attack levels) for the exterior envelope of the building to prevent ember entry); and • Attached and adjacent structures (within 6m) must also comply with the Standard.	High	Yes	No	No	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
Informative and/or Site Specific Comment/Assessment: *Construction of the Control Building (retail use) to AS3959 standards is an additional protection measure required in the Bushfire Management Plan for this site.*						
9.2	**Construction to a Standard – NASH Standard [33]:** Apply the specified requirements to construction. The Standard: *"Sets out acceptable construction requirements for residential and low-rise buildings in bushfire prone areas to reduce the risk of ignition from bushfire attack involving embers, radiant heat and direct flame impingement using non-combustible materials. Buildings constructed in accordance with this Standard are intended to provide a sheltering envelope during the passage of a bushfire flame front. They do not constitute 'last resort' private bushfire shelters as defined in the NCC. The Standard is based on achieving ignition resistance through non-combustible construction using conventional building materials and a level of redundancy to provide a high level of performance in extreme bushfire events and an increased probability that unattended buildings will survive such events."* Key attributes of the Standard include: • Materials used anywhere on the building envelope (see shaded part of diagram below), must be non-combustible except for a small amount allowed externally that includes flooring, window frames, doors and external decorative trim. The building envelope is comprised of a framed roof/ceiling system, an external wall system and a floor system;  • The same construction requirements apply for all BAL ratings up to BAL-40 (except for external doors and windows which apply AS 3959 requirements). An additional benefit of this is the built in resistance to the direct attack mechanisms of consequential fire when lower BAL ratings apply. • It does not rely on eliminating ember entry to the roof space, wall cavities and floor system as these are non-combustible construction. Embers only need to be kept from entering the internal living/operating spaces. • It is ember tolerant without unrealistic workmanship, supervision and maintenance requirements;	Very High	Yes	No	No	No

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
	• The combination of a non-combustible cladding and cavities is a robust solution that enables the building to be configured so that failure or damage to one element does not lead to the inevitable failure of the building or a breach of the habitable envelope; and • Attached and adjacent structures (within 6m) must also comply with the Standard.					
Informative and/or Site Specific Comment/Assessment: *Building to NASH standards can be adopted instead of AS3959, if preferred by the developer.*						
9.3	**Construction Materials – External and Internal Cavity Building Elements:** Excluding internal living or operation spaces, to the degree necessary, utilise materials resistant to fire attack mechanisms of flame and radiant heat (preferably non-combustible) for all relevant building elements, including wall, roof, floor, supporting structures and framing systems.	Very High	Yes	No	Yes	No
Informative and/or Site Specific Comment/Assessment: *The control building, bowsers, and bowser canopy will have entirely non-combustible external components, primarily masonry, steel, aluminium and cement sheeting. They will be subject to a moderate radiant heat level (<BAL-19) and will not be subject to flame attack (unless by consequential fire). The AS3959 construction standard required for the Control Building will protect against the expected radiant heat flux level and ember attack for external building elements.*						
9.4	**Construction Materials – Consequential Fire Fuels:** For constructed large consequential fire fuels, construct using non-combustible materials to the fullest extent possible. These include: • Surrounding landscaping items - fences/screens, retaining walls, gazebos, plastic water tanks etc; • Attached structures - decks, verandahs, stairs, carports, garages, pergolas, patios, etc; • Adjacent structures - houses, sheds, garages, carports, etc. Structure to structure fire is a common cause of overall building loss in post bushfire event assessments [9].	Very High	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: *Non-structural features such as lattice, garden edging, fencing etc are recommended to be composed from non-combustible materials where practical. Feature columns may be composed of timbers with a density >750kg/m3 at 12% moisture content (see AS3959 Table E1).*						
9.5	**Construction – Resistant To High Wind:** Apply construction measures to prevent the type of building damage from wind that will open or create gaps (from the wind itself or carried projectiles) and allow the entry of embers, radiant heat and flames. This type of damage is typically superficial damage. Building codes relating to wind (e.g., cyclones) do not necessarily address this superficial type of impact. Additional fixings for building envelope claddings and protection of the most vulnerable elements, such as glazing, from debris impact, are key considerations. Consider applying the principles of the NASH Standard [33] design solution to construction.	Not Relevant	N/A	N/A	N/A	N/A

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
	"Potential wind effects directly associated with bushfire events have been considered in this Standard. Wind actions may affect houses subject to a bushfire attack in various ways including: • The intensity of flame front activity may produce locally high wind pressures on parts of the building; • In the post fire phase, some weakened components on the building envelope may be vulnerable to normal design pressures; and • Wind can drive embers into the building envelope." Most applicable when the physical requirements exist for the development of an extreme bushfire event within the surrounding broader landscape.					
Informative and/or Site Specific Comment/Assessment: *It is unlikely that fire-driven wind would be sufficient to compromise structural integrity due to the relatively flat topography and disjointed areas of vegetation, and primarily grassland vegetation type. No measures have been identified to apply.*						
9.6	**Construction – Gas Supply:** All gas cylinders are installed and maintained in accordance with AS 1596. This standard includes requirements for small portable cylinders and larger cylinders used for domestic house supply. These include: • Safety release valve shall be directed away from the building and persons access/egress routes; • Metal piping and fittings shall be used on all piping inside the building's cavities and enclosable occupied spaces and the high pressure side of any gas regulators; and • Tethers securing cylinders are to be non-combustible. The objective is to reduce the risk of local fire against a building and reduce the risk of death or injury, from gas flaring or explosion. The rationale is gas cylinders which have either flared or ruptured are commonly found in post bushfire surveys [9]. The heat from the bushfire or consequential local fire has been sufficient to cause their pressure to reach critical levels beyond which their pressure release valve releases large quantities of LP gas. If these gas cylinders fall over, this pressure release valve may no longer function correctly, meaning that the gas cylinder may continue to increase in pressure with continued heating until the cylinder ruptures. The resulting explosion includes a pressure wave and large ball of flame which can threaten nearby life and buildings.	Moderate	Yes	Unknown	Unknown	Yes
Informative and/or Site Specific Comment/Assessment: *Any cylinders are recommended to be positioned >6m from stored combustible liquids, bowsers, or other flammable material (such as the Refuse Enclosure) and comply with AS1596.*						
9.7	**Construction - Electricity Supply:** Cabling to be shielded (includes installing underground within subject property boundary) from applicable bushfire attack mechanisms.	Moderate	Yes	Unknown	Unknown	Yes

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
	The objective is to assist with continuity of supply for essential site operations and/or electrically driven firefighting pumps. It also reduces the risk of electrocution to any persons onsite and reduces potentially additional sources of fire ignition. It is common in bushfires for power infrastructure to burn and collapse or be impacted by falling trees or branches while power lines are still live. Removing this risk may be appropriate for some sites.					
Informative and/or Site Specific Comment/Assessment: *Exposed electrical cabling is recommended to be shielded from radiant heat and consequential fire by burying underground, enclosing within a structure, or shielding with non-combustible material where practical.*						
9.8	**Minimise Debris and Ember Accumulation – Re-Entrant Detail:** Avoid or minimise the accumulation of unburnt debris and embers by avoiding re-entrant details and/or adopting aerodynamic forms that will self-shed windblown debris and embers. For example: • Simple building/structure footprints that avoid re-entrant corners in access ways, at wall/floor, wall/ground, roof/wall junctions and around doors, vents, windows; and • Simple roof layouts that avoid valleys and minimise the number of ridges that need protection details (e.g. skillion roofs).	High	Yes	No	Partly	Yes
9.9	**Minimise Debris and Ember Accumulation – Trapping Surfaces:** Avoid or minimise the use of exposed combustible surfaces that can trap and accumulate embers. These can include: • Horizontal, or shallow angle surfaces e.g. exposed wall/roof framework, roofs, decking, verandahs, steps, windowsills; and • Vertical surfaces with rough textured cladding (e.g. sawn timber).	Moderate	Yes	No	Unknown	Yes
9.10	**Minimise Debris and Ember Accumulation – Roof Plumbing:** All roof plumbing (gutters, valleys) is protected from the accumulation of debris and embers that can result in direct fire attack mechanisms immediately adjacent to any combustible elements within the roof cavity.	Moderate	Yes	No	Unknown	Yes
9.11	**Minimise Debris and Ember Accumulation – Construction Cavities:** Apply designs that lower the potential for accumulation of embers and debris within cavity spaces of buildings/structures. Examples include concrete floor slab on the ground and solid masonry walls.	Moderate	Yes	No	Unknown	Yes
Informative and/or Site Specific Comment/Assessment: *It is recommended that future designs are investigated for complexities which may trap debris or collect embers, and remove or enclose these complexities where practical.* *Functionally this means preventing details which may accumulate debris and leaf litter which will not naturally be cleared by wind.*						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
9.12	**Minimise Flame/Radiant Heat/Ember/Debris Entry - External Openings:** Limit potential sites for entry through the external envelope to internal spaces and combustible materials within (as consequential fire fuels).	High	Yes	No	Unknown	No
Informative and/or Site Specific Comment/Assessment: *AS3959 or NASH construction standards applies the measure to the appropriate level.*						
9.13	**Screening and Sealing - Gaps and Penetrations:** Apply fire rated sealants and/or install metal screening (corrosion resistant steel, bronze, aluminium <2mm aperture). All external construction and penetration gaps with apertures greater than 2mm will allow ember entry (and potentially debris) to internal cavities and combustible materials within (as consequential fire fuels). This includes gaps in roofs, walls, doors, windows and their surrounding trims – including those associated with penetrations, vents, weepholes, poor workmanship and material deterioration and movement over time (maintenance). Internal fire is difficult to see and extinguish.	Moderate	Yes	No	Unknown	Yes
Informative and/or Site Specific Comment/Assessment: *AS3959 or NASH construction standards applies the measure to the appropriate level. It is recommended that ember screening is applied to any openings in the bowser canopy.*						
9.14	**Screening - External Doors and Windows**: Metal screens (corrosion resistant steel, bronze, aluminium <2mm aperture) installed over non-openable and/or openable parts of windows and doors to prevent ember entry to internal spaces containing combustible materials (consequential fire fuels) and reduce radiant heat load on vulnerable surfaces.	Moderate	Yes	No	Unknown	No
Informative and/or Site Specific Comment/Assessment: *AS3959 or NASH construction standards applies the measure to the appropriate level.*						
9.15	**Shutters - External Doors and Windows**: Fire rated shutters Installed to significantly increase bushfire resistance of the vulnerable building elements. Any requirement for onsite manual activation is a potential limitation to effectiveness.	Moderate	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *The measure is prohibitive in terms of practicality and cost for a minor impact on vulnerability.*						
9.16	**Landscaping Construction - Fences and Walls:** Non-combustible materials are used for fences, walls (including retaining walls), screens, garden edging, play equipment and other built structures - as potential consequential fire fuels. Where relevant, the capacity to resist high winds, to minimise potential for impact damage to subject building/structure, should also be incorporated.	Moderate	Yes	No	Unknown	Yes
Informative and/or Site Specific Comment/Assessment: Any security fences or other potential fuel loads should be constructed using non-combustible material. Landscaping (gardens) which may be included within the APZ should avoid use of constructed heavy fuels (e.g. timber sleepers as garden edges, plastic or timber lattice).						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
PROTECTION PRINCIPLE – FIREFIGHTING CAPABILITY: Provide sufficient, reliable and bushfire resilient water supply and delivery capability as is necessary for active and/or passive systems.						
9.17	**Firefighting Water Supply:** Have a dedicated static supply of firefighting water for the protection of buildings/structures before and after the passage of a bushfire front. Adequate water supply is critical for any firefighting operation, particularly where property protection is the intent. This is necessary when: • A water supply additional to a reticulated water supply is required to counter the loss of firefighting water as a protection measure, should the reticulated supply be interrupted; • It is the only source of firefighting water. All tanks shall be non-combustible. Aside from losing water, failure of combustible tank can provide an additional heat or load to a vulnerable building element. Metal piping and fittings shall be used for any above ground components. The limitation to the effectiveness of the measure is the requirement for persons to be present and have the minimum required operational knowledge and/or access to appropriate information.	Effective	Yes	Yes	No	No
Informative and/or Site Specific Comment/Assessment: *The site has a reticulated water supply and is within an expanding commercial development area. Loss of firefighting water is unlikely.*						
9.18	**Firefighting Equipment – Active Operation:** In addition to a dedicated water supply, appropriate firefighting equipment is installed (pumps, hoses, sprinklers etc). These will be resilient to bushfire impact, to the extent necessary, through the application of appropriate equipment materials and protection (shielding or separation from the hazard). The limitation to the effectiveness of the measure is the requirement for persons to be present and have the minimum required operational knowledge and/or access to appropriate information.	Effective	Yes	No	Unknown	No
Informative and/or Site Specific Comment/Assessment: *Additional hydrants and/or fire hose reels may be installed within the site and fire extinguishers will be available. Staff are not expected to actively defend the site against a bushfire, so these measures are considered additional to the requirements for bushfire.*						
9.19	**Firefighting Equipment – Passive Operation:** In addition to a dedicated water supply, appropriate water dispensing apparatus are installed (e.g. pumps, plumbing and sprinklers) that are automatically activated. These will be resilient to bushfire impact, to the extent necessary, through the application of appropriate equipment materials and protection (shielding or separation from the hazard).	High	Yes	No	No	No
Informative and/or Site Specific Comment/Assessment: *Passive operations are not intended for the facility. Where bowsers or fuel tanks ignite, sprinkler systems would likely be insufficient and direct (active) response required.*						

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES		Effectiveness Rating [1]	Application Status [2]			
			Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)						
9.20	**Firefighting Equipment – Maintain Operability:** Where water pumps, shutters or other active/passive protection measures rely on the continued supply of electricity, establish barriers (shielding) or separation from potential damaging factors (e.g. falling trees/branches, fire, or other impact sources). For example, bury transmission systems to the greatest extent possible.	Moderate	Yes	No	Partly	No
Informative and/or Site Specific Comment/Assessment: *Firefighting equipment (extinguishers, hose reels, onsite hydrants) are tested in accord with industry standards.*						
9.21	**Firebreaks For Access:** Installation and maintenance of firebreaks to remove vegetation, limit surface fire progression and facilitate firefighting access / backburning.	Moderate	Yes	Yes	Yes	No
Informative and/or Site Specific Comment/Assessment: *Firebreak notice will be complied with as a condition of the Bushfire Management Plan. Most of the site will be a trafficable sealed hardstand except for structures and gardens. Emergency services access will be unrestricted.*						
PROTECTION PRINCIPLE – MANAGEMENT AND MAINTAINING EFFECTIVENESS OF APPLIED PROTECTION MEASURES: To ensure the retention of the level of bushfire resilience that has been established through the implementation of appropriate bushfire protection measures, formal and enforceable responsibilities are created.						
9.22	**Formal Management/Maintenance Plan – Actions and Responsibilities:** Through a bushfire management plan, site operations emergency plan, bushfire emergency plan, operational annual works plan and/or a 'firebreak' notice, a mechanism is put in place to ensure that: • The required management and maintenance of applied bushfire protection measures is conducted on a regular basis – with the interval dependent on the necessary frequency that will maintain full effectiveness; and • The relevant protection measures are known and understood; and • Responsibilities are created The different documents will be able to satisfactorily perform this function to differing extents.	Effective	Yes	No	No	Yes
Informative and/or Site Specific Comment/Assessment: *Site emergency plan and site procedures to include management and maintenance of bushfire protection measures.*						

[1] **Protection Measure Effectiveness Rating:** Refer to section 2.3.4 for explanation and defining.

[2] **Protection Measure Application Status:**

- **Possible:** Protection measures that can potentially be applied to the proposed development/use;

VULNERABILITY REDUCING PROTECTION MEASURES – ALL AVAILABLE MEASURES	Effectiveness Rating [1]	Application Status [2]			
		Possible	Exists	Planned	Additionally Recommend
ELEMENT AT RISK: BUILDINGS/STRUCTURES - NCC CLASSES 1-10 (CATEGORY 6)					

- **Exists**: Protection measures already implemented by existing components of the proposed development/use. These measures are accounted for in assessing 'inherent' risk levels (refer to Glossary);
- **Planned:** Protection measures that:
    - Are incorporated into the site plans;
    - Exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), alternative solutions and any additional recommended protection measures - for which a responsibility for their implementation has been created and approved; and/or
    - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and are comprised of the applicable acceptable solutions (established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), that can be met and for which a responsibility for their implementation can be created in the BMP.

These planned measures are accounted for in assessing 'inherent' risk levels (refer to Glossary).

- **Additionally Recommend:** Protection measures that:
    - Exist in a yet to be submitted Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and comprise alternative solutions and/or additional recommended protection measures (that can and should be implemented in the opinion of the bushfire consultant), and for which a responsibility for their implementation can be created in the BMP; and/or
    - Are developed in the process of producing this risk assessment and management report and for which a responsibility for their implementation can be created in the BMP.

These additionally recommended measures, along with existing and planned measures, are accounted for in assessing 'residual' risk levels (refer to Glossary).

8.3.2 NUMBER ANALYSIS OF AVAILABLITY VERSUS APPLICATION OF PROTECTION MEASURES

Table 8.10: For the stated element at risk and area of bushfire prone vegetation, the summarised number of bushfire protection measures that can be applied (and their corresponding effectiveness rating), is compared to the number available.

VULNERABILITY REDUCING PROTECTION MEASURES – SUMMARY NUMBERS							
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Category 6)						
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.						
The Protection Principle	Effectiveness Rating [1]	Numbers of Protection Measures					
		Total Available	Application Status [2]				
			Possible	Exists	Planned	Additionally Recommend	
Design and Construction (Materials)	Very High	3	1	1	-	1	
	High	2	3	-	-	2	
	Effective	-	-	-	-	-	
	Moderate	7	9	-	-	7	
	Not Relevant	1	-	-	-	-	
Firefighting Capability	Very High	-	-	-	-	-	
	High	1	1	-	-	-	
	Effective	2	2	1	-	-	
	Moderate	2	2	1	1	-	
	Not Relevant	-	-	-	-	-	
Management and Maintaining Effectiveness of Applied Protection Measures	Very High	-	-	-	-	-	
	High	-	-	-	-	-	
	Effective	1	1	-	-	1	
	Moderate	-	-	-	-	-	
	Not Relevant	-	-	-	-	-	
Total Numbers	**Very High**	**3**	**1**	**1**	**-**	**1**	
	High	**4**	**4**	**-**	**-**	**2**	
	Effective	**3**	**3**	**1**	**-**	**1**	
	Moderate	**11**	**11**	**1**	**1**	**7**	
	Not Relevant	**1**	**-**	**-**	**-**	**-**	
	Totals	**22**	**19**	**3**	**1**	**11**	

[1] Protection Measure Effectiveness Rating: Refer to section 2.3.4 for explanation and defining.

[2] Protection Measure Application Status: Refer to table footnotes on previous page.

8.3.3 ASSESSED IMPACT OF APPLIED PROTECTION MEASURES (VULNERABILITY REDUCTION)

Table 8.11: For the stated element at risk, The potential impact of the applied protection measures in reducing vulnerability levels to the stated area of bushfire prone vegetation.

ASSESSED IMPACT OF APPLIED MEASURES (VULNERABILITY REDUCTION)								
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Category 6)							
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.							
Vulnerability Reducing Protection Measures Applied to Assessment [1]	The Bushfire Hazard Threats [2]							
	Direct Attack Mechanisms				Indirect Attack Mechanisms			
	Embers	Radiant Heat	Flame	Surface Fire	Debris Accumulation	Consequential Fire	Fire Driven Wind	Tree Strike / Obstruction
Existing and Planned (applied to inherent risk)	Medium	Significant	Significant	Medium	Minimal	Minimal	Medium	Minimal
	Medium				Minimal			
Existing, Planned and Recommended (applied to residual risk)	Significant	Significant	Very Significant	Significant	Significant	Significant	Medium	Minimal
	Significant				Medium			
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 4 for explanatory information.								

Assessment Comments: The protection measures concentrate on reducing the vulnerability of building(s) to ember attack, including ember screening, construction to AS 3959, and preventing leaf litter/debris accumulation. The structural components of the proposed structures are already resistant to bushfire impacts.

Potentially combustible non-structures, such as fences as garden edging, are recommended to be non-combustible wherever practical. Feature screens etc may use timber, where the timber is appropriate for BAL-29 (see AS 3959 Table E1).

8.3.4 ASSESSED VULNERABILITY LEVELS

Assessed as a function of the capacity to apply sufficient vulnerability reducing protection measures, their individual effectiveness and their combined impact in reducing the vulnerability of the identified element at risk (Note: This assessment is independent of the threat level and exposure level assessments).

Table 8.12: For the stated element at risk, the assessed exposure level corresponding to the stated area of bushfire prone vegetation.

ASSESSED VULNERABILITY LEVELS	
Element at Risk	Buildings/Structures - NCC Classes 1-10 (Category 6)
Vegetation Area / Location	All bushfire prone vegetation within 150m of the proposed development.
Vulnerability Reducing Protection Measures Applied to Assessment [1]	Relative Vulnerability Level [2]
Existing and Planned (applied to inherent risk)	Low
Existing, Planned and Recommended (applied to residual risk)	Very Low
[1] Corresponds to the stage of risk level being reported i.e. inherent or residual. Refer to Section 2.3.3 [2] Refer to Appendix 2 for explanatory information.	

Assessment Comments: Structures will be robust against bushfire impacts. The vulnerability of structures to fires within high-risk combustible material (independent of bushfire) is not assessed.

APPENDIX 1: RATIONALE FOR THE SELECTION OF THE APPLIED RISK ASSESSMENT PROCESS

The following information regarding the selection and adaptation of the risk assessment process applied in this report is presented to help inform persons (as necessary) tasked with understanding this report.

KEY DRIVERS

Bushfire Prone Planning has taken into account the following key drivers in determining the most appropriate risk assessment process to apply:

1. **The relevant hazard types.**

   Bushfire hazards are a natural hazard rather than a human-induced hazard (refer to glossary and see limitations of ISO 31000 in the next section). Natural processes and phenomena present particular types of threats.

   Consequently, the assessment process needs to be able to specifically deal with the unique characteristics of bushfire hazards in a way that derives meaningful risk-based information that can be readily interpreted and applied.

   A logical framework is needed around which the development of bushfire protection measures (risk treatments) can be constructed, assessed and understood by those tasked with making decisions based on the provided information.

2. **The relevant risks to be addressed.**

   These are the potential loss of life, injury, or destroyed or damaged assets as the risk exists in relation to the threats generated by natural bushfire hazards, rather than the range of additional or different risks that can originate from predominantly human activity and choices.

3. **The complexity and/or scale of proposed development/use.**

   For different development/use proposals, there are significant differences in the types of information required for the hazard assessments and the derivation of operationally useful information that is to be applied to mitigating the associated risks.

   For example, higher level, strategic planning proposals (e.g., LGA, State or National) or complex development, will require a completely different level of assessment and protection measure development compared to a single small development proposal.

   Also, different uses may be able to tolerate different levels of risk. For example the Guidelines v1.4 cl 5.5.2 establish that "different tourism land uses … may require different levels of risk management".

   Consequently, the applied risk management process will need to be able to accommodate these differences and remain both logical, useable and efficient to compile. It will need to be capable of being relatively easy to scaled up or down to provide a relevant and useful report.

LIMITATIONS OF ISO 31000:2018 AND NERAG

The approach adopted by Bushfire Prone Planning (BPP) contrasts with the typical approach historically used in various Australian jurisdictions. This historical approach conducts the risk management process by applying the *National Emergency Risk Assessment Guidelines (AIDR 2020, NERAG)*.

However, the considered view of BPP is that *NERAG* is unable to effectively provide the required outcomes for assessing risk associated with a natural hazard or evaluate the impact of specific bushfire protection measures at the finer grained level required (i.e. satisfy the key drivers discussed above).

It is not practical to fully justify the above statement here, but the following is noted:

The determination of pre and post treatment risk levels is a key objective of NERAG, and this is determined as the product of consequence and likelihood ratings. These ratings have the following inherent weaknesses in meeting the risk assessment requirements for a natural hazard:

1. Consequence levels are derived from a set of established qualitative and quantitative criteria - which are very broad based and have less relevance at smaller scales of development/use. No direct link between the application of a risk treatment(s) and how that can justifiably alter a consequence level is established; and

2. Likelihood levels (of both the emergency event and the consequences – which is difficult to separate) are derived from a set of established quantitative (probability) criteria. Varying the levels of this factor has limited applicability when the pragmatic requirement is to assume an emergency event will occur.

Also relevant is that the *NERAG* state they are "primarily focussed on assessing emergency risks" and that they are "structured to align broadly with relevant sections of *ISO 31000:2018 – Risk Management Guidelines*". *ISO 31000:2018* states that its intended use is "… to provide guidelines on managing risk faced by organisations".

The key point is that organisational risk is derived from a 'human-induced hazard' rather than a natural hazard (refer to the glossary) – but it is a natural hazard (bushfire) that is to be the source of risk addressed by the risk assessment requirement established by SPP 3.7 and the associated Guidelines.

Consequently, it is BPP's considered opinion that applying *ISO 31000:2018* and *NERAG* to assessing risk associated with a bushfire hazard has significant assessment, application and relevance limitations.

THE APPLIED ADAPTED RISK ASSESSMENT APPROACH

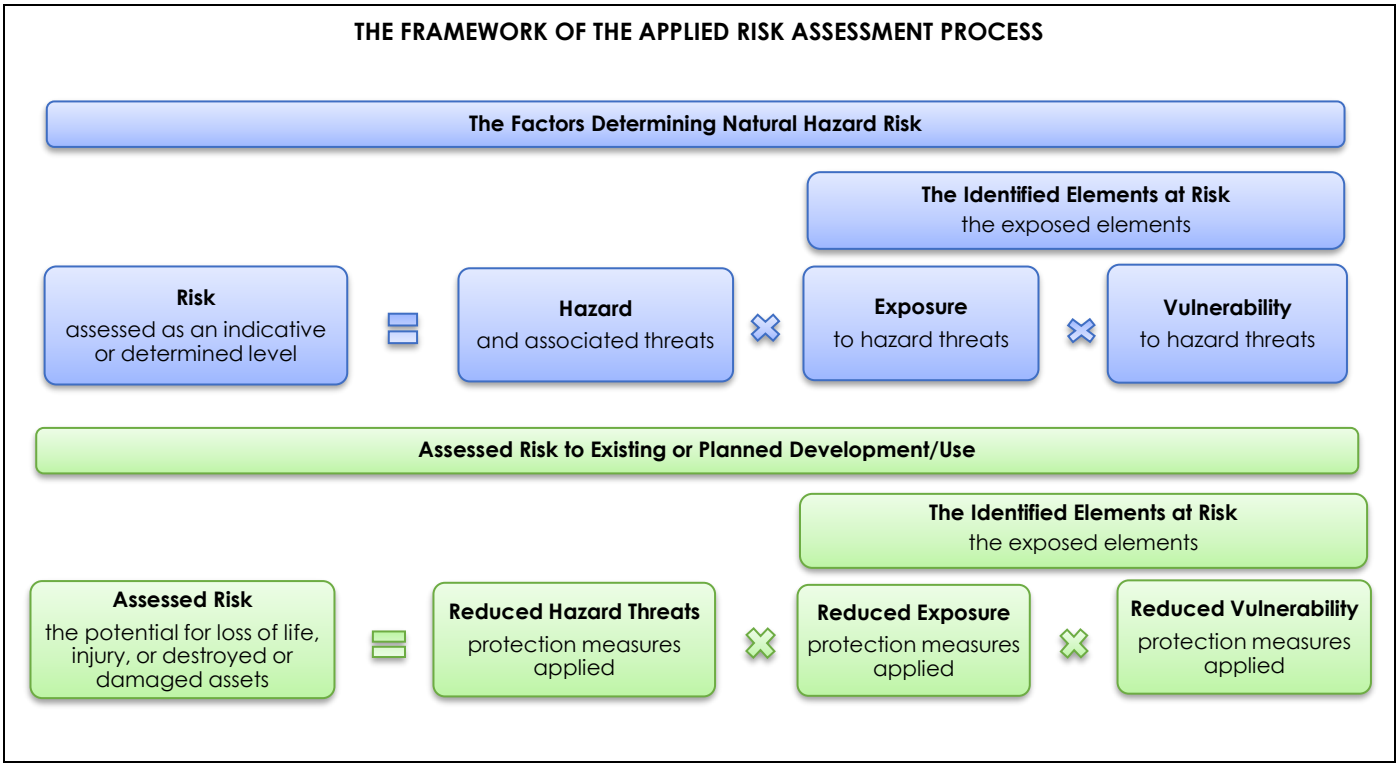
In acknowledging the key drivers, and the limitations of the risk management process developed by ISO 31000 and adapted by NERAG, Bushfire Prone Planning has adapted the understanding of disaster risk that is used by the United Nations Office for Disaster Risk Reduction (UNDRR).

Although the UNDRR approach is designed to addresses disaster risk at large scale strategic levels, it can justifiably be applied to all scales of planning because it is focused on natural hazards and establishes a concept that can be readily adapted.

The risk assessment report that is developed applying this process presents relevant, logical, comprehensive and practical facts, to appropriately inform those persons tasked with either:

- Planning the siting, design, construction and management of development/use to ensure an appropriate level of bushfire resilience is achieved and limiting associated risks to tolerable levels; or
- With making pragmatic planning approval decisions.

Figure 2.3 is reproduced below and illustrates the framework of the adapted risk assessment process.



Copy of Figure 2.3**:** Illustrated framework of the applied risk assessment process.

APPENDIX 2: RISK LEVEL ANALYSIS – ADDITIONAL EXPLANATION

INDICATIVE RISK LEVELS

Justification for reporting indicative risk levels is based on the following factors:

1. There is a finite 'universe' of bushfire protection measure principles that can be applied to reducing hazard threats and the exposure and vulnerability of at risk elements;
2. There will be a range of development/use specific protection measures associated with each protection measure principle. The number of available protection measures will vary dependent on the type and scale of development/use, but effectively there will also be a practical limit; and
3. Bushfire protection measures will vary in their standalone effectiveness at mitigating risk (refer to section 2.3.4);

Consequently, an indication of the level of risk – for a given development/use - can be gained by:

1. Assessing 'relative' threat levels.
2. Deriving 'relative' exposure and vulnerability levels by:
    a) Assessing how many protection measure principles and associated measures are applicable and can be applied;
    b) Assessing the relative effectiveness of each protection measure; and
    c) Comparing the numbers of applied protection measures with the number of possible measures in the protection measure 'universe'.
3. Making a qualitative assessment of the potential impact of the applied protection measures (including appropriate weighting given to their individual effectiveness) that can reduce the relative threat, exposure and vulnerability levels.
4. Derive the indicative risk level by applying the risk matrix shown as Table A2.1 and establish the tolerability of the risk by applying the risk tolerance scale of Table A3.2, Appendix 3.

Providing an indicative risk level establishes a qualitative understanding of the level of risk that potentially exists and is intended to inform and assist with making various planning decisions.

Deriving indicative risk levels is essentially a compilation and assessment of physical facts rather than determinations of what is to constitute different levels of threat, exposure and vulnerability and subsequently intolerable, tolerable and acceptable levels of risk for every development/use scenario.

An indicative risk level can be derived from an assessment of the site, the planned development/use and the knowledge and experience of the bushfire practitioner – such that an opinion can be provided regarding risk levels.

DETERMINED RISK LEVELS

Reporting determined risk levels will require reference information being available to the assessor so that 'determined' levels of threat, exposure and vulnerability can be established (this contrasts with the 'relative' levels required in deriving an indicative risk level).

The required reference information are the risk factor criteria, the risk level matrix and the risk tolerability scale.

Risk Factor Criteria

The required risk factor criteria will establish:

- What factors are to define the different 'determined' levels of hazard threats;
- What factors are to define the different 'determined' levels of exposure of elements at risk; and
- What factors are to define the different 'determined' levels of vulnerability of elements at risk.

Risk Level Matrix

The matrix will establish how the 'determined' levels of threat, exposure and vulnerability are to be applied in deriving the 'determined' risk level. Different sets of matrices to account for different development types, uses and scales will be required. The rationale for this statement includes:

- Different development types, uses and scales are potentially capable of tolerating different levels of risk and still be considered by the relevant authority (who are reflecting the understood society/community position), to remain acceptable;
- Recognition that different levels of risk can be tolerated by different development, use and scale is indicated in the Guidelines v1.4 where cl 5.5.2 establishes that "different tourism land uses … may require different levels of risk management"; and
- To account for the variation, one risk level matrix could establish a moderate determined risk level for a given development type/use/scale and combination of threat, exposure and vulnerability levels.

  For the same combination of threat, exposure and vulnerability levels but for a different development type/use/scale, a different risk level matrix could establish an extreme determined risk level; and

Risk Tolerance Scale

After the 'determined' risk level has been derived from the risk assessment process, a methodology is required to classify the risk level as either unacceptable, tolerable or acceptable. Currently Bushfire Prone Planning is applying the ALARP principle and associated risk tolerance scale (refer to Appendix 3).

The Current Limitations to Deriving a Determined Risk Level

The required reference information (i.e. the risk factor criteria, sets of risk matrices and the risk tolerance scale) is necessarily required to be provided by the relevant regulatory authorities /decision makers. The rationale for this statement is:

1. The information must reflect the expectations and understanding and accepting of risk as held by society and communities, and directed through its governing bodies;
2. The information must be standardised to the greatest extent possible so that it provides an acceptable and trusted basis on which the determined risk level can be derived and be relied upon in making decisions.
3. Properly establishing the reference information cannot be justifiably relegated to individual assessors with varied expertise, qualification and without any approved responsibility to provide such information. Their expertise might more appropriately be utilised in assisting the responsible authorities to establish the information.

Where the required reference information has not been established and provided by the responsible authorities, determined risk levels cannot be the final outcome when using this risk assessment process. Currently, this reference information does not exist.

HOW THE LIKELIHOOD OF A BUSHFIRE EVENT OCCURRING HAS BEEN DEALT WITH

The approach taken with the applied risk assessment process is to apply the pragmatic assumption that a bushfire will occur. It is assumed it can occur within any timeframe and could result in loss or life or injury, or unacceptable damage to property and or unacceptable disruption to services. This approach accepts that the requirements for fire of fuel, ignition source and oxygen will always exist. That is:

- The fire fuels being considered will always be there unless physically removed permanently;
- A potential ignition source will always exist through lightning and/or human activities; and
- The potential for adverse fire weather conditions to exist at some point within each year will always be present.

This contrasts with applying a quantitative approach based on the historical record of past bushfire event and determining the mathematical probability of a future event. This approach is problematic to achieving increased bushfire resilience at all stages of existing or proposed development/use for these reasons:

- Historical data may not be available or have enough data sets to be accurate. It cannot account for future changes in climate that may result in a different occurrence period. Consequently, further assumptions need to be made;
- Siting, design and construction of development to resist bushfire threats is much easier, more practical (and likely economical), to incorporate at initial planning stages rather than the retro-establishment of protection measures when circumstances change or tolerance of risk decreases;

- Time spent conducting historical research, performing statistical calculations and modifying risk levels, apart from being costly, is likely better spent assessing potential threat, exposure and vulnerability levels and developing appropriate protection measures; and
- The likelihood of occurrence cannot modify the levels of hazard threats, exposure or vulnerability. It can only be applied to reduce the overall risk level. That is, it would be applied as a modifying factor via the established risk level matrix and not the established risk factor criteria. The validity of incorporating such a factor may be indicated when, despite the existence of vegetation that can burn, there are other mitigating physical conditions that exist at the specific site that make the likelihood of ignition and severity of bushfire behaviour very low. How this is applied would need to be established by the authority establishing the relevant risk level matrix.

Table A2.1: Risk matrix for deriving indicative risk levels from the assessed relative levels of threat, exposure and vulnerability.

INDICATIVE RISK LEVEL MATRIX						
Relative Threat Level (a)	**Relative Exposure Level (b)**	**Relative Vulnerability Level (c)**				
		Very Low (1)	**Low (2)**	**Moderate (3)**	**High (4)**	**Extreme (5)**
Very Low (1)	**Very Low (1)**	**VL1**	**VL2**	**VL3**	**L4**	**L5**
	Low (2)	**VL2**	**VL3**	**L4**	**L5**	**L6**
	Moderate (3)	**VL3**	**L4**	**L5**	**L6**	**M7**
	High (4)	**L4**	**L5**	**L6**	**M7**	**M8**
	Extreme (5)	**L5**	**L6**	**M7**	**M8**	**H9**
Low (2)	**Very Low (1)**	**VL2**	**VL3**	**L4**	**L5**	**6**
	Low (2)	**VL3**	**L4**	**L5**	**L6**	**M7**
	Moderate (3)	**L4**	**L5**	**L6**	**M7**	**M8**
	High (4)	**L5**	**L6**	**M7**	**M8**	**H9**
	Extreme (5)	**L6**	**M7**	**M8**	**H9**	**H10**
Moderate (3)	**Very Low (1)**	**VL3**	**L4**	**L5**	**L6**	**M7**
	Low (2)	**L4**	**L5**	**L6**	**M7**	**M8**
	Moderate (3)	**L5**	**L6**	**M7**	**M8**	**H9**
	High (4)	**L6**	**M7**	**M8**	**H9**	**H10**
	Extreme (5)	**M7**	**M8**	**H9**	**H10**	**H11**
High (4)	**Very Low (1)**	**L4**	**L5**	**L6**	**M7**	**M8**
	Low (2)	**L5**	**L6**	**M7**	**M8**	**H9**
	Moderate (3)	**L6**	**M7**	**M8**	**H9**	**H10**
	High (4)	**M7**	**M8**	**H9**	**H10**	**H11**
	Extreme (5)	**M8**	**H9**	**H10**	**H11**	**E12**
Extreme (5)	**Very Low (1)**	**L5**	**L6**	**M7**	**M8**	**H9**
	Low (2)	**L6**	**M7**	**8M**	**H9**	**H10**
	Moderate (3)	**M7**	**M8**	**H9**	**H10**	**H11**
	High (4)	**M8**	**H9**	**H10**	**H11**	**E12**
	Extreme (5)	**H9**	**H10**	**H11**	**E12**	**E13**

Indicative risk level key: VL = very low, L = low, M = moderate, H = high, E = extreme.
The qualitative relative levels are assigned a numerical value.
The indicative risk value is calculated as = (a + b + c) – 2 and range from 1 (lowest) to 13 (greatest).
The indicative risk levels are derived from an assigned a numerical range: very low = 1-3, low = 4-6, moderate = 7-8, high = 9-11, extreme = 12-13.

APPENDIX 3: THE ALARP PRINCIPLE AND THE RISK TOLERANCE SCALE APPLIED

The following information is intended to provide an understanding of the ALARP principle and provide justification for its application in this risk assessment report.

THE ALARP PRINCIPLE

The As Low as Reasonably Practicable (ALARP) principle is based on the belief it is not possible to completely eliminate all risk involved, there will always be a certain level of risk remaining known as residual risk. The term is used to express the expected level of residual risk within a system, activity or, relevant to this document, within a proposed development/use, when good practice, judgement and duty of care are applied to decisions and operations.

The origins of the ALARP (As Low as Reasonably Practicable) principle are from United Kingdom case law and their regulatory framework. It is applied by their Health and Safety Executive (HSE) and is used by regulators and companies around the world as it provides a logical basis for managing risks – including its adaption for use in the following Australian guidelines:

- Australian Institute for Disaster Resilience, 2020; Land use Planning for Disaster Resilient Communities;
- WA Department of Mines, Industry Regulation and Safety, 2020; Petroleum safety and major hazard facility – guide. ALARP demonstration;
- NOPSEMA (Australia's offshore energy regulator), 2020; ALARP and risk assessment guidance notes;
- Department of Planning Lands and Heritage (DPLH), 2019; Coastal hazard risk management and adaptation planning guidelines;
- Planning Institute of Australia, 2015; National Land Use Planning Guidelines for Disaster Resilient Communities; and
- NERAG 2010, an earlier version of NERAG 2020, applied the ALARP Principle.

The ALARP principle has been defined by the United Kingdom Health and Safety Executive (HSE-UK, 2001) to depict the concept that efforts to reduce risk should be continued until the incremental cost in doing so is grossly disproportionate to the value of the incremental risk reduction achieved (see figure). Incremental cost is defined in terms of time, effort, finance or other expenditure of resources – including loss of natural resources. Usually, each incremental reduction in risk will require a greater expenditure of resources.

This concept is depicted in Figure A3.1 where the triangle represents the decreasing risk and the diminishing proportional benefit as risk is reduced. There are also three regions shown in the figure into which general levels of residual risk can fall. The residual risk should fall either in the broadly acceptable region, or near the bottom of the tolerable region. This approach allows higher levels of safety to be provided where it is feasible.

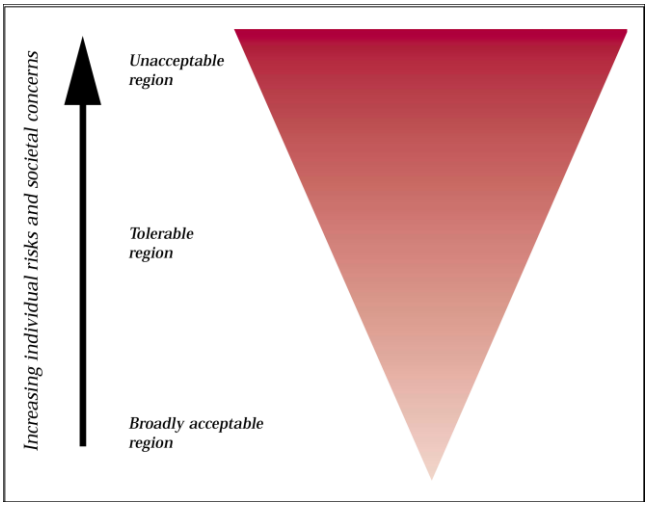


Figure A3.1: HSE framework for the tolerability of risk (source: HSE-UK, 2001)

Moving up the triangle from the region considered broadly acceptable, through a tolerable region (for which a greater range of risk can be considered), to an unacceptable region, represents increasing levels of 'risk' for a particular hazard or hazardous activity (determined through relevant risk analysis). Table A3.1 describes the risks that define each region.

Table A3.1: The risks associated with the risk tolerance regions (adapted from HSE-UK, 2001)

THE ALARP PRINCIPLE – DEFINING THE REGIONS OF RISK TOLERANCE	
Unacceptable Region	For practical purposes, a particular risk falling into this region is regarded as unacceptable whatever the level of benefits associated with the activity. Any activity, practice or use of land giving rise to risks falling in this region would, as a matter of principle, be not approved unless the activity or practice can be modified to reduce the degree of risk so that it falls in one of the regions below, or there are exceptional reasons for the activity, practice or use to be retained.
Tolerable Region	Risks in this region are typical of the risks from activities that people are prepared to tolerate in order to secure benefits, in the expectation that: • The nature and level of the risks are properly assessed, and the results used properly to determine control measures. The assessment of the risks needs to be based on the best available scientific evidence and, where evidence is lacking, on the best available scientific advice; • The residual risks are not unduly high and kept as low as reasonably practicable. This is the region to which the ALARP principle applies; and • The risks are periodically reviewed to ensure that they still meet the ALARP criteria, for example, by ascertaining whether further or new control measures need to be introduced to take into account changes over time, such as new knowledge about the risk or the availability of new techniques for reducing or eliminating risks. • In practice and where possible, the intent should be that residual risk continues to be driven down the tolerable range so that it falls either in the broadly acceptable region or is near the bottom of the tolerable region, in keeping with the duty to ensure health, safety and welfare so far as is reasonably practicable as per the ALARP principal.
Broadly Acceptable Region	Risks falling into this region are generally regarded as insignificant and adequately controlled. Regulators would not usually require further action to reduce risks unless reasonably practicable measures are available. The levels of risk characterising this region are comparable to those that people regard as insignificant or trivial in their daily lives. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks.
Note: The risk tolerability framework is a conceptual model. The factors and processes that ultimately decide whether a risk is unacceptable, tolerable or broadly acceptable are dynamic in nature and are sometimes governed by the particular circumstances, time and environment in which the activity, practice or use occurs or is proposed. Standards change and public expectations vary between societies and change with time.	

RISK TOLERANCE SCALE

The application of a risk tolerance scale is necessary to:

1. Identify which exposed elements must be given priority for the development and application of bushfire protection measures; and

2. Where planning approval is being sought, identify if the determined residual risk levels can be considered as tolerable or acceptable and therefore capable of being approved for this factor, or not.

The risk tolerance scale to be applied within the risk assessment report, when the required risk factor criteria and risk level matrix are available, is established in Table A3.2.

Table A3.2: The applied risk tolerance scale

APPLIED RISK TOLERANCE SCALE - INCORPORATING THE ALARP PRINCIPLE			
Indicative / Determined Risk Level	**Tolerability Description and Action Required**		**Risk Tolerance Level[1]**
Extreme	The risks are unacceptable and require immediate implementation of risk management measures to eliminate or reduce risk to tolerable or acceptable levels. Proposed development giving rise to risks in this region would not be approved unless there are exceptional reasons for the development to proceed.		**Unacceptable**
High	The risks are the most severe that can be tolerated but not unduly high. They require monitoring in the short term as risk management measures are likely to be needed in the short term given the intent should be to drive residual risk lower down the tolerable range where possible.	**Tolerance Regions Subject to ALARP Principle**	**Tolerable** **- if ALARP -**
Medium	The risk is approaching an acceptable level. It can be tolerated and requires monitoring in the short to medium term. Need to consider potential changes over time in the risk and/or techniques for reducing/eliminating risk. Risk management measures may be needed to reduce risk to more acceptable levels where possible – or accept the risk.		**Tolerable / Acceptable** **- if ALARP -**
Low **Very Low**	The risk is accepted as it is generally regarded as insignificant or adequately controlled by existing measures. No additional risk management measures will be required in the short to medium term other than monitoring.		**Acceptable**
[1] Refer to the glossary for definitions of the tolerance levels.			

APPLICATION JUSTIFICATION

The following is taken from the 'National Land Use Planning Guidelines for Disaster Resilient Communities' (Planning Institute of Australia, 2015) and is also referred to in the document 'Land use Planning for Disaster Resilient Communities' (Australian Institute for Disaster Resilience, 2020).

> *Of relevance to planners in the NERAG is the ALARP principle and how it is used in evaluating risks. According to NERAG, the ALARP principle is applied to define boundaries between risks that are generally intolerable, tolerable or broadly acceptable. The ALARP principle will help to prioritise a risk hierarchy and determine which risks require action and which do not. Those that are broadly acceptable naturally require little, if any, action while risks that are at an intolerable level require attention to bring them to a tolerable level.*
>
> *According to NERAG, it is entirely appropriate and accepted practice that risks may be tolerated, provided that the risks are known and managed.*

The ALARP principle is particularly relevant to planners and other built environment professionals as it provides the means to categorise risks according to their severity, and to assign risk treatment options accordingly.

It is important to note that the effect each hazard has on a community and its settlement is different, and therefore land use planning and building responses may not always be appropriate to treat the risk borne by a particular hazard. Equally, the effectiveness or strength of response provided by land use planning or building may not be sufficient to fully address the risk.

In addition, it is likely that through a normal natural hazard management process a range of treatment measures will be proposed, tested and implemented to provide a comprehensive approach to risk treatment that may involve other measures working in concert with land use planning or building responses.

The manner in which land use planning and building responses are deployed to treat specific instances of natural hazard risk will vary depending on location, information availability, community views, broader development intent for the settlement under analysis and the effect of complementary risk treatment measures.

However, the ALARP principle provides a good reference for demonstrating the land use responses for the various ALARP risk categories. Generally speaking, in areas of intolerable risk the strongest land use planning and building responses should apply. Conversely, in areas of acceptable risk only minimal controls should apply, if at all.

The most complex risk category for which to prescribe treatment from a land use and building perspective is those areas of tolerable risk. Such risks in existing settlements may not be sufficiently concerning to warrant severe use restrictions or relocation, however they will need treatment over time to ensure the risk does not increase. Treatment options in this instance may include limiting vulnerable uses in this area, restricting significant intensification of development, and promoting resilient urban design. Such areas of tolerable risk are also best avoided from a greenfield perspective to limit increases in future risk and costs associated with infrastructure failure in these locations that could otherwise been avoided.

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APPENDIX 4: THE BUSHFIRE HAZARD – BEHAVIOUR AND ATTACK MECHANISMS

FACTORS INFLUENCING BUSHFIRE BEHAVIOUR

There are three primary factors that influence the intensity, speed and spread of a bushfire. Any increase in these behaviours will result in greater threat levels, to exposed elements, from the bushfire attack mechanisms.

1. **VEGETATION AND OTHER FUELS:** Key characteristics that will influence fire behaviour include:
    - **Fuel size and shape** – anything less than 6mm diameter/thickness is considered a fine fuel and will ignite and burn quickly. Larger/heavier fuels take longer to ignite but burn for longer, so the threat exists for longer;
    - **Fuel load** – the quantity of available fuel (t/ha) will influence the size of the fire. In particular it is the fine fuel load that determines the intensity of the bushfire and the flame sizes. Vegetation type and period over which it can accumulate will determine fuel loads;
    - **Vegetation type** – this influences the size, shape and quantity of available fuels. For bushfire purposes vegetation types include the classifications of forest, woodland, scrub, shrubland and grassland (with total fuel loads typically decreasing in that order);
    - **Fuel arrangement** – will influence two factors of fire behaviour (1) the speed and intensity of burning and (2) how much of the total fuels are likely to be involved in the fire simultaneously. The first factor is a function of how densely packed or aerated the fuels are with the more available arrangement burning with greater intensity. The second factor is a function of the availability of 'ladder' fuels (i.e. near surface, elevated and bark fuels) to carry fire up the vegetation profile, and the continuity of fuels to carry the fuel across the land; and
    - **Fuel moisture content** – drier fuels will ignite easily and burn quickly. The inherent moisture content of the vegetative fuels is a function of the vegetation type and arrangement and/or the positioning of the vegetation complex near readily available sources of moisture.

    Greater quantities of finer, dryer, aerated and connected fuels will result in more severe behaviours and elevated bushfire threat levels. Large extents of vegetation (broader landscape scale) can have additional implications for the development of extreme bushfire events and the consequent increase in bushfire threat levels (refer to Appendix 5 for additional information).

2. **WEATHER:** Adverse fire weather that results in more severe behaviours and elevated threat levels includes strong winds, high temperatures, low relative humidity and extended periods of these factors.

    Weather events at the broader landscape scale can have implications for the development of extreme bushfire events and consequent increase in bushfire threat levels (refer to Appendix 5 for additional information).

3. **TOPOGRAPHY:** The physical terrain can influence the severity of fire behaviour. At a local scale, it is the influence of ground slope on the rate a fire spreads, that is most relevant. Fire travels faster up slopes (rule of thumb is a doubling of speed for every 10 degrees increase in slope). Greater rates of spread increase fire intensity and the resultant threat levels.

    At the broader landscape scale, the impact of topography can be significant and includes establishing the potential for development of certain dynamic fire behaviours that can lead to extreme bushfire events and elevated threat levels (refer to Appendix 5 for additional information).

BUSHFIRE DIRECT ATTACK MECHANISMS

EMBER ATTACK: Ember attack is the most common way for structures to ignite in a bushfire. Scientific research indicates that at least 80% of building losses from past Australian bushfires can be attributed to ember/firebrand attack (mostly in isolation but also in combination with radiant heat), and the resultant consequential fires. (Leonard J.E. et.al; 2004 – Blanchi R. et.al. 2005 - Blanchi R. et.al. 2006).

Embers are the primary ignition source for consequential fire:

- They accumulate around and on vulnerable parts of structures (roofs, gutters, doors, windows, re-entrant corners)
- They enter gaps in structures envelopes to vulnerable internal cavities and spaces.
- They ignite surface materials such as walls and decks and any accumulated vegetative debris.

Embers can attack structures for a significant length of time before and after the passage of the fire front, as well as during. This potential length of exposure is an important factor in the consideration of the level of threat embers present.

An ember is a small particle of burning material that is transported in the winds that that accompany a bushfire (larger particles can exist as firebrands from certain vegetation types). Typically these consist of plant materials such as bark, leaves and twigs that exist as part of the standing vegetation or has collected or been placed on the ground.

Of the plant materials, bark is the predominant source of embers but built timber elements will also produce embers.

Bark is the primary source of embers and spotting in Australian eucalypt forests due to the key attributes of ease of ignition, extended burnout time and the favourable size to weight ratio and aerodynamic properties. Differences in these attributes strongly influence the spotting potential from different forest types – and therefore the potential hazard rating of the bark.

The type of tree bark will determine the size, shape and number of embers/firebrands which, along with the prevailing fire behaviour and weather conditions will dictate the spotting distances and density of ignitions.

Fine fibrous barks - including stringybarks (e.g. jarrah), have loosely attached fibrous flakes and can produce massive quantities of embers (prolific spotting) for shorter (up to 0.75 km) and medium distances (up to 5 km).

Short distance spotting (including ember showers) are generally the result of embers and firebrands blown directly ahead of the fire with little or no lofting. Density tends to decrease with distance from the fire front.

Medium distance spotting results from embers and firebrands that are lofted briefly in a convection column or blown from an elevated position (e.g., from tree tops on ridges). With sufficient density and coalescing spot fires, this can rapidly increase the size of a fire (deep flaming) leading to dynamic fire behaviours and extreme fire events.

Ribbon/candle type barks - have longer burnout time, extended flight paths and are more likely to be responsible for longer distance spotting > 5 km (with up to 30 km having been authenticated). This results from significant lofting of large firebrands (e.g. curled hollow tubes of bark that can burn for 40 minutes) in well-developed convection columns. These develop as separate, independent fires. Very long distance spotting requires Intense fire, maintenance of a strong convection column (to lift firebrands aloft) and strong winds aloft (to transport the firebrands).

Other bark types - that include coarsely fibrous (e.g. marri) / slab or smooth / platy and papery barks - produce lower quantities of embers and shorter distance spotting. Their highest bark hazard ratings that are lower than fine fibrous or ribbon barks.

(Sources: CSIRO Climate and Disaster Resilience Report 2020 and Overall Fuel Hazard Assessment Guide 4th edition July 2010, Victoria DSE and Cruz, MG (2021) The Vesta Mk 2 rate of fire spread model: a user's guide. CSIRO).

The importance of establishing protection measures to mitigate the potential impact of consequential fire ignited by the ember attack mechanism, cannot be overstated.

RADIANT HEAT ATTACK: This heat radiates in all directions from a bushfire and can potentially be felt hundreds of meters away. The amount of heat that a flame can transfer to other objects is influenced by the flame size and its temperature. These are a function of the characteristics of the fuels being burnt including fuel size, dryness, structure, arrangement and quantity. The bushfire is additionally influenced by the weather and topography factors that can intensify fire behaviour (described at end of this section).

Radiant heat:

- Can damage or destroy elements that are vulnerable to higher levels of heat;
- Can dry and heat vegetation and other fuels (combustible materials such as timber) to a temperature at which they ignite or are more easily ignited by existing flames or embers; and
- Is an extremely significant threat to people when they are not physically shielded. Protective clothing can provide only limited protection.

BUSHFIRE FLAME ATTACK: When flames make contact with structures they can flow over, under and around – impacting surfaces not directly facing the bushfire.

Flames will be longer when fine fuel loads are higher and will move faster up slopes and generally, slower down slopes.

Flame temperatures are highest in the lower parts of the flame and decrease towards the tip. The flame has two distinct regions - the lower solid body flame and the upper part that is a transitory flame (intermittently present). Both flame regions can damage structures.

Note: AS 3959:2018 *Construction of buildings in bushfire prone areas*, establishes both the construction requirements corresponding to each Bushfire Attack Level (BAL) and the methodology for determining a BAL. For a bushfire modelled using this methodology, the derived flame length only provides an estimate of the solid body flame length.

SURFACE FIRE ATTACK: These are low intensity fires (less than 0.5m high) burning along the ground consuming mostly intermittent fine fuels such as vegetation debris, litter, and mulches. They are typically patchy and erratic in their direction and short lived (<40 seconds) when burning in the absence of heavier fuels.

Typically these fires will be on the land immediately surrounding buildings and associated structures and other heavy fuels. Their importance as a threat is the bringing of direct flame contact, higher radiant heat and embers closer to these exposed elements.

BUSHFIRE INDIRECT ATTACK MECHANISMS

DEBRIS ACCUMULATION: The relevant debris are combustible fine fuels that can accumulate (by falling or being windblown) in close proximity to subject structures and their surrounding structures and other heavy fuels. This makes the burning of these structures/fuels much easier and more likely through the ignition of the accumulated debris by ember attack.

This debris can accumulate over long time periods (years) in locations such as:

- On horizontal or close to horizontal surfaces and rough timber surfaces;
- Within re-entrant corners and roof gutters/valleys;
- Against vertical surfaces; and
- Within internal spaces /cavities and under sub-floors when gaps are present.

The potential threat level will be determined by:

- The presence of vegetation types that produce quantities of debris with those that produce in the driest and hottest part of the year presenting a greater threat;
- The extent of this vegetation; and
- The proximity of this vegetation to the exposed and vulnerable structures.

CONSEQUENTIAL FIRE:

Consequential fire Is the burning of vulnerable (combustible/flammable) materials, items and structures that exist within the area surrounding the subject building or structure – the surrounding vulnerable elements.

The burning of these surrounding vulnerable elements can result in the subject building/ structure being exposed to the direct fire attack mechanisms (threats) of flame, radiant heat, embers and surface fire from a close distance.

These are threats that are separate from and additional to the threats generated by the bushfire front itself - which can be and often is, a considerable distance away.

The importance of establishing protection measures to mitigate the potential impact of consequential fire cannot be overstated.

Consequential fire fuels consist of both fine and heavy fuels.

Fine fuels:

- Dead plant material such as leaves grass, bark and twigs thinner than 6mm (or live material less than 3mm thick that can be consumed in a fire involving dead material); and
- Originate from the indirect bushfire attack mechanism of 'debris accumulation' and potentially from other areas of landscaped vegetation.

Heavy and Large Heavy Fuels:

- **Stored combustible / flammable items**:
    - Building materials, packaging materials, firewood, sporting/playground equipment, outdoor furniture, matting, rubbish bins etc;
    - Large quantities of dead vegetation materials stored as part of site use;

- Liquids and gases; and
- Vehicles, caravans and boats, etc.

- **Constructed combustible items**:
  - Surrounding landscaping items - fences/screens, retaining walls, gazebos, plastic water tanks etc;
  - Attached structures - decks, verandahs, stairs, carports, garages, pergolas, patios, etc;
  - Adjacent structures - houses, sheds, garages, carports, etc. Structure to structure fire is a common cause of overall building loss in post bushfire event assessments [9].

FIRE DRIVEN WIND: Severe bushfires are commonly accompanied by high winds due to the prevailing weather conditions. Localised high winds can be induced by the bushfire. When the required factors exist, the bushfire can couple with the atmosphere (pyro-convective) resulting in extreme bushfire events and gusty, severe windspeeds.

These winds can directly damage the external envelope of a building or structure by pressure (low and high) or the carriage of varying types of solid debris. This provides openings for other bushfire attack mechanisms to enter and ignite internal cavities.

TREE STRIKE/OBSTRUCTION: Branches or trees, subject to strong winds and/or tree burnout, can:

- Damage the envelope of a structure creating openings for direct attack mechanisms of bushfire (or consequential fire) to ignite internal cavities or living space:
- Fall and obstruct access to or egress from, a structure or site being impacted by bushfire.

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APPENDIX 5: THE BROADER LANDSCAPE AND EXTREME BUSHFIRE EVENTS

The content of this appendix is an overview of information that supports the assessment approach of section 4.4 of this report. It considers the risk implications arising from what is being learnt from the latest research work within the bushfire science of dynamic fire propagation and extreme fire development.

Any potential for extreme fire events to develop in the broader landscape surrounding the subject site, will result in increased in bushfire hazard threat levels to exposed elements and must be accounted for in the risk assessment.

The selected compilation of information is taken from various sources including peer reviewed research papers [references 1-3, 12, 15, 21, 27, 28, 41, 42].

RECENT BUSHFIRE RESEARCH

Traditionally, bushfire modelling conducted to determine rates of spread, intensity, flame lengths, radiant heat etc and provide measurements of threat levels, has been based on the quasi-steady fire state (i.e. a fire propagating under constant and uniform fuel, weather and topography – after it has finished its growth phase).

More recent research has provided important insights into the dynamic nature of fire spread in the landscape and identified local drivers of bushfire risk and highlighted the role of environmental factors that are significant for large and extreme fire development.

These environmental factors include aspects of the vertical structure of the atmosphere, meso-scale fire weather processes (e.g., sea breezes, cold fronts, squall lines, convective complexes), interactions between the fire and the atmosphere, and the modification of fire weather and fire behaviour due to the local topography.

From this work, a number of processes that can contribute significantly to the level of risk posed by a bushfire have been identified. These include:

- Extreme fire weather processes;
- Dynamic fire propagation; and
- Violent pyroconvection and pyrogenic winds.

Of particular relevance to this risk assessment are the topographic aspects of the broader landscape surrounding the subject site and the potential it might present for dynamic fire propagation, development of extreme fire events and therefore increased bushfire hazard threat levels and consequent risk.

DYNAMIC FIRE BEHAVIOURS

Dynamic fire behaviours (DFBs) result from interactions between the physical factors of fuel, terrain, fire weather conditions, atmosphere and different parts of the bushfire itself. They are physical phenomenon that involve rapid changes of fire behaviour and occur under specific conditions.

Certain DFBs occur at various scales and time frames (e.g. spotting), others only at large scales (e.g., conflagrations and pyroconvective events) and others at small scales and short time spans (e.g. junction fires, fire whirls). The following fire behaviours are considered DFBs:

Spotting

The production of embers/firebrands, carried by the wind/convective currents that ignite spot fires ahead of the bushfire front. Under extreme conditions, with the necessary fuels, mass spotting events can occur. Dependent on fuel types, winds and convective currents, embers can be consumed by the fire front itself or travel tens of kilometres. Spot fire occurrence can be so prevalent that spotting becomes the dominant propagation mechanism – with the fire spreading as a cascade of spot fires forming a 'pseudo' front.

Fire Whirl / Tornado

Various sized (<1m - >150m) spinning vortices of ascending hot air and gases that carry smoke, debris, and flame. The intensity of larger whirls compares to tornados. Can induce fire spread contrary to prevailing wind and ignite spot fires away from the fire front.

Junction Fire

Is associated with merging fire fronts that produces very high rates of spread and have the potential to generate fire whirls / tornadoes.

Crown Fire

Types of tree crown fires have been categorised according to their degree of dependence on the surface fire phase - passive, active, independent - with the last two being considered dynamic fire behaviour.

Active crown fire is "a fire in which a solid flame develops in the crowns of trees, but the surface and crown phases advance as a linked unit dependent on each other."

Independent crown fires "advance in the tree crowns alone, not requiring any energy from the surface fire to sustain combustion or movement."

For a crown fire to start, a surface fire of sufficient intensity is first necessary. The distance between the heat source at the ground surface and the canopy-fuel layer will determine how much of the surface fire's energy is dissipated before reaching the fuels at the base of the canopy. The higher the canopy base, the lower the chance of crowning.

The existence of trees themselves, separated from surface fuels, can offer a degree of protection by absorbing radiant heat, trapping embers and shielding from winds. Necessary considerations include:

- Eliminating understorey fuels;
- Species Issue: Understanding the extent to which the trees will contribute to fuels (leaves/bark/twigs etc) that accumulate on the ground and when moved (wind) become involved in consequential fire away from the tree during the fire season. This needs to be considered against the maintenance capability (regular removal of material) of the responsible entity; and
- Species / Positioning Issue: Requirements include not being highly flammable, no loose stringy bark, less able to trap embers, not being prone to branches breaking in high winds potentially causing structural damage to buildings (allowing ember entry) and keeping crowns separated as an additional measure of safety and allow wind to permeate rather than be totally blocked.

Eruptive Fire

Behaviour where the head fire accelerates rapidly on sufficiently steep terrain with sufficiently strong wind – as a result of fire plume attachment to the surface, bathing it in flames ahead of the front (pre-heating).

Fire Channelling / VLS (vorticity-driven lateral spread)

Behaviour where rapid lateral fire spread, in generated vortices, occurs across a sufficiently steep leeward slope in a direction approximately transverse to the prevailing winds. This results in the rapid increase in width of the fire front. VLS are highly effective at producing mass spotting events.

Conflagrations

These are large, intense, destructive fires. They have a moving front as distinguished from a fire storm (blow up / pyroconvective fire). With sufficient vegetation extent, fuel loads and the development of dynamic fire behaviours, the large amounts of heat and moisture released can cause its plume to rise into the atmosphere and develop large cumulus or cumulonimbus flammagenitus cloud (pyrocumulus or pyrocumulonimbus). Where the extent of vertical development is limited (e.g. a stable atmosphere, or insufficient flaming zone), the fire is likely to remain a surface based event.

Downbursts

These are strong wind downdrafts associated with convective columns of heated air (and associated cloud forms). The consequent falling columns of cooled air induce an outburst of strong winds on or near the ground that radially spread causing fire spread in directions contrary to the prevailing wind.

Pyroconvective Event

A pyro-convective event is an extreme manifestation of a conflagration that develops in an unstable atmosphere and can transition into a towering pyrocumulus or a pyrocumulonimbus (pyroCb's) that can extend to the upper troposphere or lower stratosphere. With the fire/atmosphere coupling, it has evolved beyond a purely surface based fire into dynamic fire propagation rather than quasi-steady propagation. In the violent pyroconvective system:

- As a fire's plume reaches higher into the atmosphere, larger scale mixing can cause drier and higher-momentum upper air to be transferred back to the surface, thereby further exacerbating the potential for more intense fire behaviour, including fire spread contrary to the prevailing wind direction;
- Pyrogenic winds can cause considerable damage to structures, directly or indirectly, increasing their vulnerability to bushfire attack mechanisms; and

- The pyroCb's carry dense ember loads, fire and other burning debris and generate lightning, all with very little rain or hail that would typically occur with an ordinary thunderstorm.

DRIVERS OF DEEP FLAMING

Deep flaming is the fire condition when the active flaming zone is unusually large and flame-front intensity is simultaneously great, resulting in large quasi-instantaneous energy release.

Deep flaming can be produced by numbers of mechanisms on varying terrain (flat, undulating of rugged) when a large enough area of sufficiently heavy fuels is present. These mechanisms include:

- Very strong winds – so the head fire advances more rapidly than the back of the flaming zone;
- Change in wind direction – so the long flank of a fire is transformed into a fast running head fire;
- Eruptive fire behaviour – where steep slopes can cause a fire to accelerate rapidly;
- Vorticity-driven lateral spread (wind channelling) – where strong winds and steep terrain interact to rapidly drive a fire laterally, accompanied by downwind mass spotting and consequent coalescing of spot fires forming large areas of flame (can include the DFB of 'junction fire').

Research has identified strong links between:

- Eruptive fire behaviour, VLS and the occurrence of deep flaming; and
- The development of deep flaming and extreme bushfire events.

EXTREME BUSHFIRE EVENTS

Extreme bushfire events create disproportionate risks to human and environmental. Their development is affected by dynamic feedback processes that result in unpredictable behaviour, and the worsening of rates of spread and intensities - even when environmental conditions are consistent.

The term 'extreme bushfire' is applied in the recent bushfire science literature in two ways:

1. Where it refers to large, intense bushfires in which one or more DFBs are simultaneously involved; and
2. Where it more specifically refers to a fire that exhibits deep or widespread flaming in an atmospheric environment conducive to the development of violent pyroconvection, often manifesting as towering pyrocumulus (pyroCu) or pyrocumulonimbus (pyroCb) storm(s) – also referred to as blow-up fire event(s).

   A distinguishing feature of these types of fires is that they involve a coupling of the fire with an unstable atmosphere to a much greater vertical extent, well above the mixed layer, which modifies or maintains the fire's propagation (e.g. through mass spotting, blustering winds and lightning);

Relevance to Risk Assessment: Given that this risk assessment is concerned with identifying the potential for the broader landscape surrounding the subject site to increase bushfire risk, the following common aspects of the two above descriptions are relevant:

- An extreme fire is a large intense fire, so it requires a sufficient area and sufficient fuels in which to develop; and
- An extreme fire of scale requires the formation of deep flaming to develop.

Consequently, the risk assessment is primarily focused on the extent and fuel types/loads of bushfire prone vegetation and the existence of terrain (topography) properties necessary for the relevant dynamic fire behaviours - rather than the potential for adverse fire weather / atmospheric conditions - whose likely occurrence can be assumed as possible.

Note also that the second description requires an unstable atmosphere - to enable deep/violent pyroconvection and subsequent significant cloud formation and latent heat release. This is not essential for the first. Consequently, this identifies a potential difference between the two defined extreme bushfire events to be considered when assessing risk:

- Large, intense bushfires can occur without deep convective column development. These fires remain as surface fires (essentially wind-driven fires), with a greater predictability of behaviour; and
- Large, intense bushfire that couple with an unstable atmosphere are no longer surface based. They are associated with a higher level of energy, chaos, and nonlinearity due to the enhanced (fire-induced)

interaction between the boundary layer and the free troposphere, which may introduce factors that act to maintain or enhance widespread flaming. The fire behaviour is much more unpredictable.

PHYSICAL REQUIREMENTS OF TERRAIN, FUEL LOAD (AND WINDSPEED) FOR DEEP FLAMING

The dynamic fire behaviours of eruptive fire and VLS and associated mass spotting, along with potential for topographically modified winds to develop, are strongly linked with the development of deep flaming, which is a prerequisite for extreme bushfire events.

There are certain environmental thresholds that are required to be met for these dynamic fire behaviours to occur. These are described below and form part of the assessment of the bushfire hazard in Section 4.5.

Eruptive Fire Behaviour

Eruptive fires are characterised by a rapid acceleration of the head fire rate of spread (exponential increases in rate of spread have been observed). It results in a rapid deepening of the flaming zone (larger area of active flame), from which heat is released into the atmosphere.

Eruptive fire results from the interaction between the slope of the terrain and the fire's plume. In the absence of wind, plume attachment can be expected on terrain that is inclined at roughly 24° or more and the effects of wind could cause plume attachment on slopes inclined at angles of 24° or lower. Consequently, the primary topographic requirement for eruptive fire is sufficiently steep terrain and sufficiently strong wind.

"This mode of fire propagation is completely contrary to that expected under the quasi- steady fire spread paradigm … eruptive fire behaviour poses a serious threat to the successful containment of a bushfire and provides a mechanism that can substantially elevate the risk posed by a bushfire in areas that are prone to its occurrence".

Rugged terrain (areas with local topographic relief >300m), is particularly prone to eruptive fire (and dynamic fire behaviours in general).

Fire Channelling (Vorticity-Driven Lateral Spread)

Fire channelling (VLS) exists when a fire exhibits rapid spread in a direction transverse to the synoptic winds as well as in the usual downwind direction. It is characterised by intense lateral and downwind spotting and production of extensive flaming zones.

VLS is highly effective at producing mass spotting events. A link between deep flaming events caused by VLS and the formation of pyroCb has been demonstrated. Under extreme conditions, spot fire occurrence can be so prevalent that spotting becomes the dominant propagation mechanism.

VLS can only be expected to occur on parts of the landscape, and under certain fire weather conditions. VLS occurrence depends critically on the following:

- Leeward slopes greater than 20-25° are required;
- Wind direction must be within 30-40° of the topographic aspect;
- Wind speed in excess of about 20 km h-1 are required;
- Generally VLS is only observed in heavy forest fuel types with load in excess of 15-20 t ha; and
- Fuel moisture content – dense spotting and downwind extension of the flaming zone are far more likely when fuel moisture contents are around 5% or less.

Topographically Modified Surface Winds - Downslope Winds

In WA the scarp winds are the well-known local occurrence of downslope winds. Similar meteorological phenomena (typically as foehn winds) occur in the lee of mountain ranges in many parts of the world, particularly on ranges with gentle windward and steep leeward slopes.

Scarp winds are nocturnal, strong and gusty winds that develop near the base of the scarp through summer months. The local mechanism is for a synoptic easterly flow, causing air to rise to the top of the scarp from further inland, at which point it is cooler and denser than the surrounding airmass. This produces an unstable situation and consequently the air flows down the scarp as a turbulent density current.

There are implications for enhanced fire activity for a fire located in a region of downslope winds, as they provide a clear mechanism for rapid, irregular direction of fire spread as well as turbulent transport of firebrands and plume development. If a 'hydraulic jump' is also present, the strong vertical motion in the jump region is a mechanism for lofting and dispersal of firebrands further ahead of the bushfire front.

APPENDIX 6: HAZARD REDUCTION BURNING – ADDITIONAL INFORMATION

The following information provides supporting guidance to the relevant bushfire protection measures that reduce bushfire hazard threat levels by reducing fuel levels.

1. SIGNIFICANT AREAS (LARGER) AREAS OF BUSHFIRE PRONE VEGETATION

Annually

Prior to the bushfire season ensure the following management of the identified areas of vegetation is conducted:

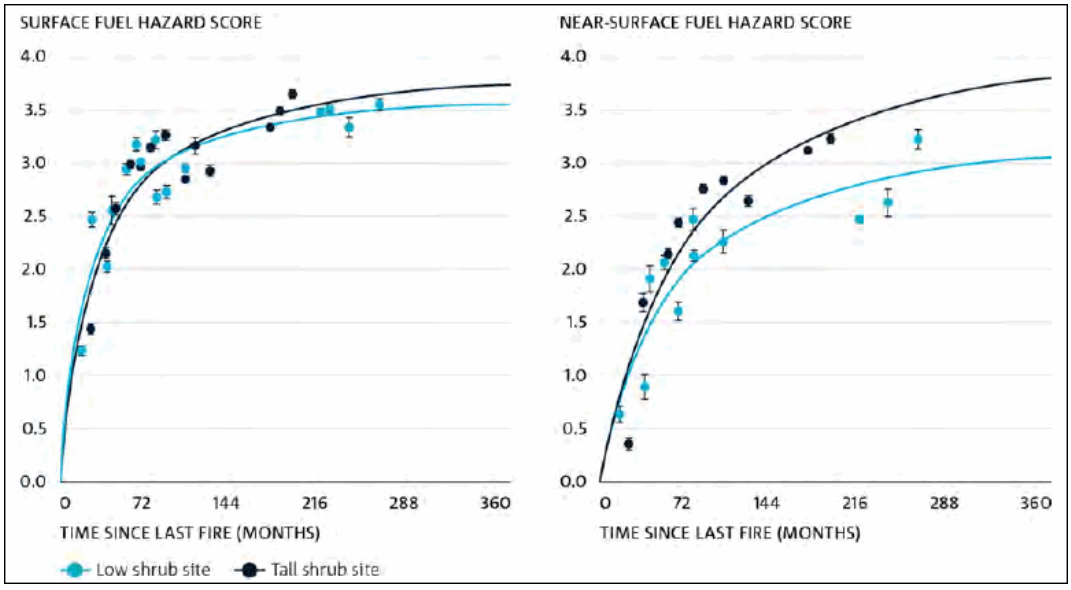
- Maintain the pruning of all trees and tall shrubs to a height of at least 2m from the ground and remove the material; and
- Remove any dead trees (that are not habitat trees), fallen branches and dead shrubs.

Burn Interval

Conduct hazard reduction burns at intervals that will ensure surface and near surface fuel loads (i.e. fine fuels – accumulated leaf litter, combustible plant materials and twigs up to 6mm diameter) remain less than 8 t/ha at all times.

It is likely the burning interval will need to be shorter than that which is typically currently conducted. The following statement and data from the Climate and Disaster Technical Report, CSIRO, 2020 [17] indicates the requirement for increased frequency of hazard reduction due to the rapid increase in surface and near surface fuel loads after hazard reduction burning.

"The only study published on the dynamics and structure of fine fuel in dry eucalypt forest following prescribed fire is that of Gould et al. (2011) utilising data to drive an exponential fuel accumulation relation for the key fuel attributes of surface fuel hazard and near-surface fuel hazard. In this study of time since fire in jarrah forest (Eucalyptus marginata), it was found that, over the 20-year period of the study (1979-1999) while surface fuel loads continued to increase indefinitely (up to and beyond 20 years), attributes such as percent cover and hazard score essentially plateaued after 6-9 years. Similarly, near-surface fuel loads were found to stop increasing significantly after 15-18 years whereas near-surface height and hazard score stopped increasing significantly after 9-12 years and 12-15 years, respectively (Figure 14). Bark hazard was found to be affected by hazard reduction burning for up to 12 years after hazard reduction burning"



"Figure 14 Recovery of surface (left) and near-surface fuel hazard (right) in Jarrah Forest following hazard reduction burning. Under these conditions these fuel attributes returned to equivalent long unburnt state after approximately 12-15 years but the response in the first few years following burning is extremely rapid, ***achieving 75% of fuel hazard within 4 years (surface) and 5-7 years (near-surface) depending on presence of shrub layer*** *(Redrawn from Gould et al. 2011)"*

2. THE BROADER LANDSCAPE

The following information has merit for consideration and is taken from the peer reviewed paper '*A framework for prioritising prescribed burning on public land in Western Australia'; Howard T. et al, DBCA and DFES; International Journal of Wildland Fire 2020, 29, 314-325.*

To develop and apply this protection measure it is likely interested entities, such as local government will need to engage and work with the relevant state government agency responsible for the identified areas of vegetation.

The collaboration will be necessary to establish the required indicators of acceptable risk - as they are determined through the application of the following published framework - and to establish a responsibility to conduct the ongoing management of these areas of vegetation to maintain compliance with the established indicators.

KEY RELEVANT POINTS FROM THE FRAMEWORK (QUOTED)

Introduction to the framework:

- *The framework provides principles and a rationale for programming fuel management with indicators to demonstrate that bushfire risk has been reduced to an acceptable level.*
- *Each bushfire risk management zone is divided into fire management areas, based on the management intent. These are areas where fuels will be managed primarily to minimise the likelihood of fire causing adverse impacts on human settlements or critical infrastructure, to reduce the risk of bushfire at the landscape scale or to achieve other land management outcomes. Indicators of acceptable bushfire risk are defined for each fire management area and are modified according to the distribution of assets and potential fire behaviour in the landscape.*
- *The framework establishes principles and a rationale for programming fuel management and, critically, provides indicators that demonstrate that bushfire risk has been reduced to an acceptable level. The acceptable level of bushfire risk is determined through a risk assessment and prioritisation process.*

Principles for managing bushfire risk applied in the framework:

- ***Consistent with international standard:*** *The regional risk framework commits to applying risk management in a manner that is consistent with AS ISO 31000: 2018 Risk management guidelines (Standards Australia 2018). This involves adherence to the principles of risk management, and applying the risk management process to the identification, assessment and treatment of risk.*
- ***Fuels are managed to reduce the harm:*** *Managing the fuel available to burn is critical to managing the threat posed by bushfire. The available fuel, and its structure, affect the speed and intensity of a bushfire, which, in turn, determine both its potential to cause damage and suppression difficulty. Done at appropriate temporal and spatial scales, managing the quantity, structure and distribution of fuel available has been demonstrated to be an effective and efficient way to reduce the severity and extent of damage by bushfires.*
- ***Fuel management does not eliminate risk:*** *Fuel management aims to reduce the negative consequences of bushfires rather than prevent their occurrence. Given the importance of fire to maintaining ecosystem health and resilience, it is neither desirable nor feasible to eliminate bushfire from natural landscapes and it is recognised that both planned and unplanned fire can have benefits. Fuel management aims to reduce risk to an acceptable level by greatly enhancing and supporting the effectiveness of other measures, including bushfire law, fire suppression, urban planning, building codes for fire-prone areas and community preparedness.*
- Fuel management is planned and integrated. Bushfire management puts people first, risk is managed at an appropriate scale and ecological requirements are considered when managing fuel.

Framework for managing bushfire risk by prescribed burning:

- The framework identifies bushfire risk management zones (BRMZ), recognises different fuel types (and associated fuel accumulation and fire behaviour models), classifies public lands within each zone into fire management areas (FMA) - with the Settlement-Hazard Separation classification being the relevant fire management area for the Mundaring town centre - and develops indicators of acceptable risk.
- ***Bushfire Risk Management Zones:*** *The framework identifies eight bushfire risk management zones (BRMZ) characterised by broad consistency of land use, asset distribution, fire environment (vegetation, fuels and climate) and fire management practices that combine to create a characteristic risk profile (Fig. 2). The Southwest zone includes the majority of the state's population, urban development and infrastructure.*
- ***Fuel Types****: The framework recognises 13 broad types across Western Australia. Fuel types are based primarily on structural attributes of the vegetation that influence fire behaviour. For each fuel type, best available information*

has been assembled regarding post-fire patterns of fuel accumulation, fire ecology, including the requirements of fire sensitive species and communities, harmful fire regimes and fire regimes compatible with ecosystem health. Where possible, the framework assigns each fuel type appropriate fuel accumulation and fire behaviour models and identifies the key weather attributes required to model fire behaviour. These models are used when setting indicators of acceptable bushfire risk, which are defined for different fuels according to the rates of fuel accumulation and the fire behaviour they may support.

- ***Fire Management Areas:*** *Public lands within each BRMZ are further classified into four fire management areas (FMAs) characterised as Settlement-Hazard Separation, Critical Infrastructure Buffer, Landscape Risk Reduction and Remote Area Management. These FMAs are defined by the primary intent of fuel management, which is a function of potential fire behaviour and the type and distribution of assets characteristic of the area. The framework recognises six classes of assets that may be affected by bushfire: settlements, dispersed populations, critical infrastructure, protected species and communities, economic assets and other assets (non-critical infrastructure, ecological, cultural).*
- *The Settlement-Hazard Separation FMA provides an area proximal to settlements where fuels are managed relatively intensively to minimise the likelihood of a bushfire being sustained, damaging properties or endangering people. Here, fuel management to protect settlements takes precedence over other land management objectives, though other land management outcomes can be pursued to the extent that they do not conflict with the primary management intent.*
- *The extent of the area described by each FMA varies according to the fuel type and the BRMZ in which it occurs … The breadth of the Settlement-Hazard Separation FMA is calculated to be sufficient to significantly reduce the likelihood of damage to assets from direct flame contact, radiant heat and ember attack and to provide adequate opportunity for fire suppression. This calculation is based on a combination of data derived from fire behaviour models and expert practitioner judgement. The Settlement-Hazard Separation FMAs are the largest in forest fuels that are prone to long-range spotting, severe ember storms and crown fire behaviour.*
- ***Indicators of Acceptable Bushfire Risk:*** *Are set for bushfire-prone fuel types in each FMA … Indicators are expressed in terms of the proportion of the landscape that is managed such that the treated fuels will not support a head fire of an intensity that precludes effective suppression action under weather conditions corresponding to the 95th percentile fire danger index … Weather conditions (air temperature, relative humidity, wind speed) corresponding to the 95th percentile FFDI are identified and used as inputs to fire behaviour models for calculating forward rate of spread and fire intensity (Table 1).*
- *The intent of fuel management is to reduce the quantity and alter the arrangement of fuels such that a bushfire is likely to spread more slowly, burn with lower intensity, be easier to suppress and cause less damage.*
- ***The indicators of acceptable risk for the Settlement-Hazard Separation FMA for open eucalypt forest and tall/open eucalypt forest is a target of 60% of fuel less than threshold intensity for a distance of 5km surrounding settlements.***

As an open eucalypt forest example at the Perth rural urban interface, the fuel age and load to achieve threshold fire intensity under weather conditions representing 95th percentile values of the FFDI for the Bickley location are stated as 5 years and 8 t/ha.

APPENDIX 7: BUSHFIRE ATTACK LEVELS AND BAL CONTOUR MAPS EXPLAINED

Bushfire attack levels are determined using the methodology established by AS 3959:2018 Construction of buildings in bushfire prone areas. The Standard defines a bushfire attack level (BAL) as a "means of measuring the severity of a building's exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kW/m^2."

Each BAL rating represents a set range of radiant heat flux (see table below). The amount of radiant heat and flame lengths generated by a bushfire is dependent on many factors that are modelled using the Standard's fire behaviour and flame length models. Key factors include vegetation type, terrain and a range of fire weather factors.

The variation that can exist in these factors results in different separation distances, away from bushfire prone vegetation, corresponding to a given BAL rating.

In assessing risk, knowing the separation distances away from each identified area of classified vegetation that correspond to a BAL rating, assists with evaluating threat levels from that bushfire hazard and the exposure levels of elements at risk.

Bushfire Attack Level	**Explanation** [Source AS3959:2018]
BAL – LOW	There is insufficient risk to warrant specific construction requirements but there is still some risk. *Important Note: For AS3959:2018 purposes, BAL-LOW will exist at 100m from classified vegetation (50m for Grassland).* *However, embers/firebrands from certain vegetation types can ignite spot fires ahead of the fire front for significant distances – short range spotting up to 740m, medium range spotting up to 5km and long range spotting has been authenticated up to 30km.*
BAL – 12.5	There is a risk of ember attack. Construction elements are expected to be exposed to heat flux not greater than 12.5 kW/m^2
BAL – 19	There is a risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to radiant heat. The construction elements are expected to be exposed to a heat flux not greater than 19 kW/m^2.
BAL – 29	There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level radiant heat. The construction elements are expected to be exposed to a heat flux not greater than 29 kW/m^2.
BAL – 40	There is a much increased risk of ember attack and burning debris ignited by windborne embers, a likelihood of exposure to a high level of radiant heat and some likelihood of direct exposure to flames from the fire front. The construction elements are expected to be exposed to a heat flux not greater than 40kW/m^2.
BAL – FZ (Flame Zone)	There is an extremely high risk of ember attack and burning debris ignited by windborne embers, and a likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front. The construction elements are expected to be exposed to a heat flux greater than 40 kW/m^2.

THE BAL CONTOUR MAP - ILLUSTRATING THE CALCULATED SEPARATION DISTANCES CORRESPONDING TO BAL RATINGS

The BAL contour map illustrates different coloured contour intervals extending out from each different area of classified bushfire prone vegetation. The minimum and maximum distances of each contour, from each area of vegetation, is a diagrammatic representation of the calculated separation distances that correspond to each BAL rating. These take into account the specific site conditions.

Each coloured contour represents a different bushfire attack level and anything within that contour will be subject to that BAL rating and its corresponding level of radiant heat.

GLOSSARY

APPLIED TERMINOLOGY	
Consequence	The outcome of an event or situation expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. In the emergency risk management context, consequences are generally described as the effects on persons, society, the environment and the economy. *(Source: DPLH 2019)* An impact on the natural, economic, built or social environments as a result of the hazard. The consequences are influenced by the vulnerability of elements at risk, by the exposure of elements at risk to the hazard, and by the characteristics of the hazard. *(Source: PIA, 2015)*. The outcome of an event that affects objectives. Can be a range of consequences; can be certain or uncertain; can have positive or negative effects; can be expressed qualitatively or quantitatively; can escalate through knock-on effects. *(Source: ISO Guide 73:2009)*
Controls	A measure that maintains and/or modifies risk. Controls include, but are not limited to, any process, policy, device, practice, or other conditions and/or actions which maintain and/or modify risk. *(Source: AIDR Knowledge Hub; Glossary)* A control is any measure or action that modifies or regulates risk. Controls include any policy, procedure, practice, process, technology, technique, method, or device that modifies or regulates risk. Risk treatments become controls, or modify existing controls, once they are implemented. *(Source: Praxiom)* *Note: 'Protection Measures' and 'Risk Treatments' will be alternative terms used in this risk assessment report.*
Decision Maker	The Minister for Planning, State Administrative Tribunal, Western Australian Planning Commission, Development Assessment Panel, any other State decision-making authorities, and/or the relevant local government and their delegates that make decisions regarding the application of this Policy. *(Source: SPP 3.7)* For proposed development or use that is not subject to planning approval, the relevant decision makers are those tasked with the development and management of a development or use. Typically this might be an existing development/use for which an improved bushfire performance is being sought.
Elements At Risk	The population, buildings and civil engineering works economic activities, public services and infrastructure, etc. exposed to hazards. (Australian Institute for Disaster Resilience, 2019)
Exposure	Refers to the people and things in the path of potential hazards. *(Source: AIDR* LUPDRC, *2020)* The elements within a given area that have been, or could be, subject to the impact of a particular hazard. Bushfire exposure can refer to property that may be endangered by a fire burning in another structure or by a bushfire. *(Source: AIDR Knowledge Hub; Glossary)* The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard prone areas. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest. *(Source: UNDRR, 2017)*

Hazard	A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards may be natural, anthropogenic or socionatural in origin. • **Natural hazards** are predominantly associated with natural processes and phenomena (note: disasters often follow natural hazards, but there is no such thing a natural disaster); • **Anthropogenic hazards** are human-induced – being induced entirely or predominantly by human activities and choices; • **Socionatural hazards** are associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change. Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity or magnitude, frequency and probability. *(Source: UNDRR Terminology 2017)* A source of potential harm or a situation with a potential to cause loss. A potential or existing condition that may cause harm to people, or damage to property or the environment. A source of risk. *(Source: AIDR Knowledge Hub; Glossary)*
Hazardous Event	The manifestation of a hazard in a particular place during a particular period of time. [Severe hazardous events can lead to a disaster as a result of the combination of hazard occurrence and other risk factors.] (Source: *United Nations Office for Disaster Risk Reduction, 2017)*
Hazard Identification	The process of recognising that a hazard exists and defining its characteristics. *(Australian Institute for Disaster Resilience, 2019)*
Hazard - Bushfire	A fuel complex, defined by amount, type condition, arrangement, and location, that determines the degree of hazard. *(Source: AIDR Knowledge Hub; Glossary)* The term 'bushfire hazard' in this assessment report is intended to refer to both bushfire prone vegetation and the associated potential bushfire event itself. The term 'bushfire' is being applied as the common term for forest, scrub, shrub, and grass fire events.
Hazard - Urban Fire	1. Susceptibility of a material to burn. 2. The presence of combustible materials. 3. A process or activity posing a fire risk if not adequately controlled. *(Source: AIDR Knowledge Hub; Glossary)*
Hazardous Material	A substance or material which has been determined by an appropriate authority to be capable of posing an unreasonable risk to health, safety and property. *(Source: AIDR Knowledge Hub; Glossary)*
Impact	Describes as a quantitative or qualitative measure, the relative potential ability of a threat to adversely affect an exposed element or of a protection measure to reduce threat, exposure or vulnerability levels and consequently, risk levels.
Likelihood	Chance of something happening. The likelihood level reflects the probability of **both the emergency event and the estimated consequences** occurring as a result of the event. *(Source: AIDR NERAG, 2020)* In risk management terminology, the word 'likelihood' is used to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically - such as a probability or a frequency over a given time period. *(Source: ISO Guide 73:2009)*

	The chance of an event occurring. Likelihood may be represented as a statistical probability (such as Annual Exceedance Probability), or where this is not possible, it can be represented qualitatively using such measures as 'likely', 'possible', and 'rare'. *(Source: PIA, 2015)*.
Mitigation	The lessening or minimizing of the adverse impacts of a hazardous event. The adverse impacts of hazards, in particular natural hazards, often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures include engineering techniques and hazard-resistant construction as well as improved environmental and social policies and public awareness. *(Source: UNDRR, 2017)*
Reliability	Refers to the expected reliability of a designed solution (protection measure). Over time it will be a function of: • Its Initial likely reliability; • Its durability which may or may not be a function of maintenance; • The level of maintenance required; • The likelihood of solution being modified over time; and • The influence of other adjoining/adjacent structures or stored materials that may be installed after the initial construction. (Adapted from Kelly M. et al; *Structural Design Options for Residential Buildings in Bushfire Areas,* Australasian Structural Engineering Conference November 2016)
Resilience	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management. (*United Nations Office for Disaster Risk Reduction, 2017)* Is that property of a building, system, or community that facilitates its return to a functional state following an overload. In the context of bushfire damage, resilience will be maximised when: • There is a high probability of an attacked building remaining fit for purpose; and • There is a low time and cost to make badly damaged buildings fit for purpose. (Adapted from Kelly M. et al; *Structural Design Options for Residential Buildings in Bushfire Areas,* Australasian Structural Engineering Conference November 2016)
Robustness	Refers to that property of structural systems that seeks to achieve proportionality of damage to the severity of an overloading event. It will be maximised when bushfire design solutions: • Have few 'weak links' that allow progressive spread of damage from minor sources; • Consist of materials and assemblies that retain physical properties when thermally loaded beyond their design capacity; and • Include protection of inherently vulnerable and brittle elements. Such as openings to internal parts of structures (including doors and windows) and essential services that maintain required functioning (e.g. cabling and plumbing). (Adapted from Kelly M. et al; *Structural Design Options for Residential Buildings in Bushfire Areas,* Australasian Structural Engineering Conference November 2016) As a design principle it means that the design and materials are not easily damaged or compromised, and do not require manual operation or intervention to work (Source: State Government of Queensland, CSIRO, 2020)

Redundancy	Refers to design that ensures the fate of the subject building/structure is not reliant on the effective performance of a single element. (State Government of Queensland, CSIRO, 2020) An example is a roof system that does not rely solely on the roof cladding to resist bushfire threats. It has additional layers of resistance including non-combustible roof/ceiling framing, insulation and ceiling lining, and the sealing/screening of gaps into internal operating spaces.
Risk	Disaster risk is the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. *(Source: UNDRR, 2017)* Disaster risk is a product of a hazard (a sudden event or shock), exposure (the people and things in the path of potential hazards), vulnerability (the potential for those people and things to be adversely impacted by a hazard) and the capacity (the ability for those people and assets and systems to survive and adapt). *(Source: AIDR LUPDRC, 2020)* Risk is the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood. In emergency management it is a concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, communities and the environment. *(Source: PIA, 2015)*
Risk Management	Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses. *(Source: UNDRR, 2017)* Coordinated activities of an organisation or a government to direct and control risk. The risk management process includes the activities of: • Communication and consultation; • Establishing the context; • Risk Assessment (risk identification, risk analysis, risk evaluation); • Risk Treatment; and • Monitoring and Review. *(Source: AIDR NERAG, 2020)*
Risk Identification	Process of finding, recognising and describing sources of risks, their causes and their potential consequences. *(Source: ISO Guide 73:2009)* Is a process used to find, recognise, and describe the risks that could affect the achievement of objectives. *(Source: Praxiom)*
Risk Source	An element which, alone or in combination, has the intrinsic potential to give rise to risk. *(Source: ISO Guide 73:2009)*
Risk Assessment	Disaster risk assessment is a qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people property, services and livelihoods and the environment on which they depend. Assessments include the identification of hazards; a review of the technical characteristics of hazards such as their location, intensity, frequency, and probability; the analysis of exposure and vulnerability, including the physical, social, health, environmental and economic dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities with respect to likely risk scenarios. *(Source: UNDRR, 2017)* The overall process of risk identification, risk analysis and risk evaluation. *(Source: ISO Guide 73:2009)*

Risk Analysis	The process to comprehend the nature of risk and determine the level of risk. Provides the basis for risk evaluation and decisions about risk treatment. *(Source: ISO Guide 73:2009)* Is a process that is used to understand the nature, sources, and causes of the risks that you have identified and to estimate the level of risk. It is also used to study impacts and consequences and to examine the controls that currently exist. How detailed your risk analysis ought to be will depend upon the risk, the purpose of the analysis, the information you have, and the resources available. *(Source: Praxiom)* In this risk assessment report, risk analysis is the part of the risk assessment process that assesses the hazard threat levels, identifies the protection measures (and their effectiveness) that can be applied and derives the levels of exposure and vulnerability of the identified elements at risk, based on the ability to apply protection measures. From this information indicative risk levels can be derived. Where relevant sets of risk factor criteria and a risk level matrix have been established by the relevant authorities, a determined risk level can be derived. The required risk level analysis can be conducted for either each exposed element separately and/or the proposed or existing development/use overall.
Risk Evaluation	The process used to determine risk management priorities by evaluating and comparing the level of risk against predetermined standards, target risk levels or other criteria. *(Source: PIA, 2015)* In this risk assessment report, it is the process of classifying the acceptability of the levels of risk, derived from the risk analysis, by reference to an established risk tolerance scale. The relevant tolerance scale will be that derived from the application of the 'as low as reasonably practicable' principle – 'ALARP' (refer to Appendix 3 for further information). This process can only be conducted when determined risk levels have been derived.
Risk Factor Criteria	In this risk assessment report, the risk factor criteria establish the parameters that will define the different hazard threat levels, the different levels of exposure of elements at risk and the different levels of vulnerability of elements at risk. Different sets of risk factor criteria can exist corresponding to different development types, uses and scale. They are applied as part of the risk analysis. These criteria are established by the relevant authorities as they must reflect societies preparedness to tolerate risk and be determined by those authorities exercising their responsibilities.
Risk Level Matrix	In this risk assessment report, the risk level matrix establishes how the assessed levels of hazard threats, exposure and vulnerability are to be analysed in deriving a determined risk level. It is applied as part of the risk analysis. The matrix is established by the relevant authorities as they must reflect societies preparedness to tolerate risk and be determined by those authorities exercising their responsibilities.
Risk Tolerance Scale	In this risk assessment report the applied risk tolerance scale defines the acceptability of determined risk levels based on the 'as low as reasonably practical' principle (ALARP). The risk tolerance scale can be applied within the risk assessment report when the required risk factor criteria and risk level matrix are available.
Risk - Inherent	In this risk assessment report, inherent risk is considered to be current risk after accounting for existing and any 'planned' protection measures (controls / risk treatments) but before the application of any additional protection measures that have been identified and recommended by the bushfire consultant – and which subsequently determines the residual risk (this approach is supported by the relevant information sourced from the two references below).

	'Planned' protection measures are those that are incorporated into the site development plans and those that exist in an approved Bushfire Management Plan (BMP) and/or Bushfire Emergency Plan (BEP) and for which a responsibility for their implementation has been created. If a BMP or BEP is yet to be developed or is being developed concurrently, the additional protection measures it contains (including any that are part of relevant 'acceptable solutions' established by the 'Guidelines for planning in bushfire prone areas', DPLH as amended), are considered to be additionally recommended protection measures. 1. ***Source: www.fairinstitute.org*** *"Confusion exists between Inherent Risk and Residual Risk … Here are the standard definitions of the two concepts:* • *Inherent risk represents the amount of risk that exists in the absence of controls.* • *Residual risk is the amount of risk that remains after controls are accounted for.* *Sounds straightforward. But these two terms seem to fall apart when put into practice. Applying the above definitions to the clients' scenario uncovered the fact that the 'inherent' risk being described was not a 'no controls' environment, but rather, one that only excluded some controls.* *The flaw with inherent risk is that in most cases, when used in practice, it does not explicitly consider which controls are being included or excluded. A truly inherent risk state, in our example, would assume no employee background checks or interviews are conducted and that no locks exist on any doors. This could lead to almost any risk scenario being evaluated as inherently high. Treating inherent risk therefore can be quite arbitrary. According to Jack Jones, author of Measuring and Managing Information Risk: A FAIR Approach and creator of the FAIR model, much more realistic and useful definitions would be:* • *Inherent risk is current risk level given the existing set of controls rather than the hypothetical notion of an absence of any controls; and* • *Residual risk would then be whatever risk level remain after additional controls are applied."* 2. ***Source: Wikipedia:*** *Inherent risk, in risk management is:* • *an assessed level of raw or untreated risk; that is, the natural level of risk inherent in a process or activity without doing anything to reduce the likelihood or mitigate the severity of a mishap, or the amount of risk before the application of the risk reduction effects of controls; or* • *Another definition is that inherent risk is the current risk level given the existing set of controls, which may be incomplete or less than ideal, rather than an absence of any controls.*
Risk - Residual	In this risk assessment report, residual risk is that which remains after the application of protection measures that are additional to those that already exist or are 'planned' and that establish the inherent risk (see Risk – Inherent in glossary) Is the disaster risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery, together with socioeconomic policies such as safety nets and risk transfer mechanisms, as part of a holistic approach. *(Source: UNDRR, 2017)*

	Is the risk left over after you've implemented a risk treatment option. It's the risk remaining after you've reduced the risk, removed the source of the risk, modified the consequences, changed the probabilities, transferred the risk, or retained the risk. *(Source: Praxiom)* Is the risk remaining after any risk treatment has been applied to reduce its potential likelihood and/or its potential consequences. Residual risk can also be any risk that is chosen to be retained rather than treated *(Source: AIDR* LUPDRC*, 2020)* Residual risk can contain unidentified risk. Residual risk can also be known as retained risk. *(Source: ISO Guide 73:2009)*
Risk Level - Determined	Magnitude of a risk or a combination of risks. In this risk assessment report, as an outcome of the risk analysis, a determined risk level is derived from: 1. The determination of threat, exposure and vulnerability levels by reference to an established set of risk factor criteria that corresponds to each risk level (for each factor); and 2. The determination of the risk level by reference to an established risk level matrix that incorporates threat, exposure and vulnerability levels.
Risk Level - Indicative	Magnitude of a risk or a combination of risks. In this risk assessment report, as an outcome of the risk analysis, an indicative risk level is derived from analysis of the number of bushfire protection measures able to be implemented compared to the number of measures available, and the relative effectiveness of each at reducing threat, exposure and/or vulnerability levels. Overall, more applicable and applied measures is better and the measures with a higher effectiveness rating have greater weighting in the analysis.
Risk - Acceptable	Risks that do not need further treatment. The expression acceptable level of risk refers to the level at which it is decided that further restricting or otherwise altering the activity is not worthwhile e.g. additional effort will not result in significant reductions in risk levels. *(Source: DPLH, 2019)* That level of risk that is sufficiently low that society is comfortable with it. Society does not generally consider expenditure in further reducing such risks justifiable. (Source: AIDR Knowledge Hub) Acceptable risk or tolerable risk is an important sub-term (of disaster risk). The extent to which a disaster risk is deemed acceptable or tolerable depends on existing social, economic, political, cultural, technical and environmental conditions. *(Source: UNDRR, 2017)* ***Note:*** *It is generally accepted that nothing can be absolutely free of risk, everything under some circumstance can cause harm. There are differing levels of risk and consequently levels of safety. In practice, attaining zero risk is not possible. Nevertheless, after risk avoidance, reduction/mitigation, transfer or acceptance - the residual risk may be determined as acceptable, as judged by the participants in an activity and decision makers (who apply societies expectations). For certain land uses, the residual risk may exist at higher levels but still be judged by to be acceptable (or tolerable) on this basis.*
Risk - Tolerable	The willingness to live with a risk to secure benefits and achieve objectives, on the understanding that it is being properly controlled. 'Tolerability' does not mean 'acceptability'. Tolerating a risk does not mean that it is regarded as negligible, or something we may ignore, but rather as something that needs to be kept under review and reduced further, if deemed necessary. *(Source: DPLH, 2019)* Certain levels of risk may be tolerated, provided that the risks are known and managed. *(Source: AIDR LUPDRC, 2020)*

	Risk tolerance is defined as the organisations or stakeholder's readiness to bear the risk, after risk treatment, in order to achieve its objectives. Risk tolerance can be influenced by legal or regulatory requirements. *(Source: ISO Guide 73:2009)* A level of risk that defines the ALARP region, as risks that should be driven to the broadly acceptable region. *(Source: PIA, 2015)*
Risk - Intolerable	A level of risk that is so high that require risk treatment measures whatever their cost, or the elimination of the risk. *(Source: PIA, 2015)* Risk that is unacceptable in any circumstances or at any level. *(Source: DPLH, 2019)*
Risk Treatment	Risk treatment options available as part of the risk management process are generally categorised as follows: • Risk Avoidance: Measures taken to avoid risks from natural hazards. Can include avoiding development in hazardous areas, relocating people or assets away from hazardous areas, or developing buffer zones to the hazard; • Risk reduction/mitigation: Measures undertaken to reduce the risks from natural hazards. Includes building control and development controls; • Risk Transfer: Measures taken to transfer the risk from natural hazards from one party to another; and • Risk Acceptance: The acceptance of risk from a natural hazard. Any realised losses will be borne by those parties exposed to the hazard. This is not specifically a treatment option as no action is taken, but it is an option for addressing risk. *(Source: AIDR LUPDRC, 2020)*
Retrofitting	Reinforcement or upgrading of existing structures to become more resistant and resilient to the damaging effects of hazards. Retrofitting requires consideration of the design and function of the structure, the stresses that the structure may be subject to from particular hazards or hazard scenarios and the practicality and costs of different retrofitting options. *(Source: UNDRR, 2017)*
Structural and Non-Structural Measures	Structural measures are any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems. Non-structural measures are measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education. Common non-structural measures include building codes, land-use planning laws and their enforcement, research and assessment, information resources and public awareness programmes. *(Source: UNDRR, 2017)*
Threats	The mechanisms by which hazards can impact exposed elements.
Vulnerability	The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards. *(United Nations Office for Disaster Risk Reduction, 2017)* The characteristic or property of a community, system or object that makes it susceptible to the damaging effects of a specific hazard. Can be defined according to the responses of people, houses and assets in mitigating the impacts of a hazard. Specifically, it refers to the extent to which a community, building, services or location is likely to be damaged or disrupted by the impacts of a hazard, such as a bushfire.

	Building vulnerability refers to weak points in a building caused by its design, construction, use of materials and management (including maintenance). These weak points are identified in the context that they are not able to withstand the level of hazard they are exposed to. Climate and weather may directly influence the buildings vulnerability through several processes including (i) moisture content of combustible elements around and within buildings (ii) gaps between materials that may shrink and expand due to changes in moisture content and temperature (iii) wind action causing damage or dislocation of elements. *(Source: State Government of Queensland, CSIRO, 2020; Bushfire Resilient Building Guidance for Queensland Homes)*

BIBLIOGRAPHY

[1] Alex Filkov, Tom Duff, Trent Penman: Determining Threshold Conditions for Extreme Fire Behaviour; Annual report 2018-2019 - The Determinants of Crown Fire Runs During Extreme Wildfires in Broadleaf Forests in Australia, University of Melbourne & Bushfire and Natural Hazards CRC

[2] Alexander M.E., Cruz M.G.: The General Nature of Crown Fires (Synthesis on Crown Fire Behaviour in Conifer Forests), Fire Management Today Volume 73 No.4 2014.

[3] Alexander M.E., Cruz M.G.: The Start, Propagation and Spread Rate of Crown Fires (Synthesis on Crown Fire Behaviour in Conifer Forests), Fire Management Today Volume 73 No.4 2014.

[4] AS 3959:2018; Construction of buildings in bushfire prone areas

[5] Australian Government Department of Home Affairs (DHA), 2018; National Disaster Risk Reduction Framework.

[6] Australian Institute for Disaster Resilience (AIDR), 2020; Land use Planning for Disaster Resilient Communities (LUPDRC).

[7] Australian Institute for Disaster Resilience (AIDR), 2020; National Emergency Risk Assessment Guidelines (NERAG).

[8] Australian Institute for Disaster Resilience (AIDR); Knowledge Hub - Glossary

[9] Blanchi R., Leonard J.E. (2005) Investigation of Bushfire Attack Mechanisms Resulting in House Loss in the ACT Bushfire 2003, Bushfire CRC Report – CSIRO MIT Highett, Australia.

[10] Blanchi R., Leonard J., Leicester R.H., (2006) Bushfire risk at the rural–urban interface. In 'Proceedings of Bushfire Conference 2006: Life in a Fire-prone Environment: Translating Science into Practice', 6–9 June 2006, Brisbane, QLD. (Griffith University: Brisbane)

[11] Bowman D. (2021); Asking people to prepare for fire is pointless if they can't afford to do it. It's time we subsidised fire prevention; Article in The Conversation January 12, 2021.

[12] Bushfire Cooperative Research Centre (Melbourne); HighFire Risk Project [http://www.highfirerisk.com.au]

[13] Bushfire Resilient Building Guidance for Queensland Homes (2020); State Government of Queensland and CSIRO.

[14] Bushfire Verification Method - Handbook (ABCB, 2019), © Commonwealth of Australia and States and Territories 2019, published by the Australian Building Codes Board.

[15] Cheney N.P.: Fire behaviour during the Pickering Brook wildfire, January 2005 (Perth Hills Fires 71-80); Conservation Science W. Aust. 7 (3): 451-468 (2010)

[16] Cruz, MG (2021) The Vesta Mk 2 rate of fire spread model: a user's guide; CSIRO, Canberra, ACT. 76pp.

[17] CSIRO (2020) Climate and Disaster Resilience; Technical Report, July 2020

[18] CSIRO (2020) Climate and Disaster Resilience; Overview Report, 30 June 2020

[19] Department of Planning Lands and Heritage (DPLH), 2019; Coastal hazard risk management and adaptation planning guidelines.

[20] Design and Construction of Community Bushfire Refuges – Information Handbook; Australian Building Codes Board and Fire Services Commissioner Victoria, 2014.

[21] Filkov A.I., Duff T.J., Penman T.D. (2020) Frequency of Dynamic Fire Behaviours in Australian Forest Environments // Fire, 2020, 3,1 pp1-17

[22] Guidelines for Planning in Bushfire Prone Areas (Guidelines), Version 1.4, WAPC 2021

[23] Health and Safety Executive (HSE-UK), 2001; Reducing risks protecting people – HSE's decision making process.

[24] Health and Safety Executive (HSE-UK), Guidance - ALARP "at a glance"

[25] Howard T., Burrows N., Smith T., Daniel G., McCaw L. (2020); A framework for prioritising prescribed burning on public land in Western Australia. International Journal of Wildland Fire 2020, 29, 314-325.

[26] ISO Guide 73:2009; Risk Management – vocabulary

[27] Jason J Sharples, University of New South Wales Canberra. Risk Implications of Dynamic Fire Propagation – A Case Study of the Ginninderry Region (Preliminary Report June 2017)

[28] Jason J. Sharples et al. (2016) Natural hazards in Australia: extreme bushfire. Climatic Change (2016) 139:85–99 DOT 10.1007/s10584-016-1811-1

[29] J.E. Leonard, R. Blanchi, N. White, A. Bicknell, A. Sergeant, F. Reisen and M. Cheng (2006); Research and Investigation into the Performance of Residential Boundary Fencing Systems in Bushfires; Bushfire CRC Melbourne.

[30] Leonard J.E., Blanchi R., Bowditch P.A.; (2004) Bushfire Impact from a House's Perspective (CSIRO MIT)

[31] Leonard, J., Short, L. (2016) *Guidelines for Building in Bushfire Prone Areas – Wye River and Separation Creek* (v 2.0).

[32] Leonard et al, Wye River / Separation Creek – Post-bushfire building survey findings (2016) CSIRO Client Report EP16924.

[33] NASH Standard – Steel framed construction in bushfire prone areas. National Association for Steel Framed Housing 2014 (Amendment A 2015)

[34] National Construction Code Series, Volume 2. Australian Building Codes Board. 2015

[35] NOPSEMA (Australia's offshore energy regulator), 2020; ALARP and risk assessment guidance notes.

[36] Peace M, McCaw L, Santos B, Kepert J.D., Burrows N and Fawcett R.J.B.: Meteorological drivers of extreme fire behaviour during the Waroona bushfire, Western Australia, January 2016; Journal of Southern Hemisphere Earth Systems Science (2017) 67:2, 79-106. DOI: 10.22499/3.6702.002

[37] Pearce M., Kepert J.; Extreme Fire Behaviour: Reconstructing the Waroona Fire Pyrocumulonimbus and Ember Storms; Hazard Note Issue 48 June 2018 Bushfire and Natural Hazards CRC

[38] Planning Institute of Australia (PIA), 2015; National Land Use Planning Guidelines for Disaster Resilient Communities.

[39] Praxiom Research Group Limited; ISO 31000 2018 Risk management definitions in plain English.

[40] Prof. Jason J Sharples (School of Science. University of NSW, Canberra) Submission to the Senate Select Committee into Lessons to be Learned in Relation to the Australian Bushfire Season 2019-20

[41] Sharples J.J., McRae R.H.D., and Wilkes S.R.: Wind-terrain effects on the propagation of wildfires in rugged terrain: fire channelling; Article in International Journal of Wildland Fire · May 2012

[42] Sharples J.J., Mills G.A., McRae R.H.D., and Weber R.O.: Foehn-Like Winds and Elevated Fire Danger Conditions in Southeastern Australia; 2010 American Meteorological Society DOI: 10.1175/2010JAMC2219.1

[43] State Planning Policy 3.7 (SPP 3.7); Planning in bushfire prone areas, WAPC, 2015

[44] United Nations Office for Disaster Risk Reduction (UNDRR), 2017; Report on Indicators and terminology relating to disaster risk reduction.

[45] United Nations Office for Disaster Risk Reduction (UNDRR); Global Platform for Disaster Risk Reduction (PreventionWeb) https://www.preventionweb.net/

[46] United Nations Office for Disaster Risk Reduction (UNDRR) – Understanding Disaster Risk. https://www.preventionweb.net/understanding-disaster-risk/component-risk/disaster-risk

[47] WA Department of Mines, Industry Regulation and Safety, 2020; Petroleum safety and major hazard facility – guide. ALARP demonstration.