

Tight-fitting skylight to avoid ember entry and non-combustible frame to avoid ignition from ember accumulation

Steel roof structure

Non-combustible insulation

Non-combustible roof sheeting

Steel roof sheeting

Non-combustible gutter

Steel tight fitting fascia (less than 2m)

Steel

Non-combustible fascia

Non-combustible soffit

Standard glass with non-combustible frame or class 1 durability timber frame, install metal mesh on openable window

OR  
non-combustible bushfire-rated shutter\*

Non-combustible external cladding steel top hat sections

Wall membrane (as required)

Non-combustible insulation

# Koolewong Bushfire Resilience Guide

JDA Co.

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### About This Guide

This Bushfire Design Guide has been developed drawing on a combination of established research, best-practice guidelines, and expert input. In particular, it is informed by the Queensland Reconstruction Authority (QRA) Bushfire Resilient Building Guidance and the City of Gold Coast Bushfire Resilient Design Guidelines, which provide practical, evidence-based approaches to improving building performance in bushfire-prone areas. The guide also incorporates insights from the research of Dr Justin Leonard of CSIRO, whose work in post-bushfire analysis and building performance has been instrumental in shaping contemporary bushfire resilience strategies. These sources have been brought together and tailored to reflect the specific conditions and risks relevant to Koolewong.

## Introduction to Bushfire Resilient Homes

### Bushfire Resilient Building Guidance for Koolewong Homes

Bushfires are a natural part of the Australian landscape, but they can have devastating consequences on people and communities. The purpose of this guideline is to help the people of Koolewong mitigate these effects. The guideline provides innovative, practical and affordable solutions for adapting homes and gardens to be more bushfire and heat resistant.

Preparing for bushfires is critical to minimising their associated risks. This is especially important for people living in bushfire prone areas. Where and how we live and the way we organize our communities will determine the way we prepare and respond to bushfire threats. The guideline provides information about bushfire hazards and how they interact with buildings and landscapes.

The guideline also describes the various measures that can be taken to improve the chances of both people and property surviving a bushfire.

The guideline identifies a suite of best practice building and landscaping measures, using tailored, site-specific solutions to adapt buildings for bushfire resilience. The guideline is based on extensive research into the attack mechanisms of bushfires and the different ways that buildings and gardens may be vulnerable to these attacks.<sup>1</sup>

This document provides guidance to stakeholders that can be used to design and build new homes. It can also be used to design or upgrade the landscape immediately surrounding the home, for better bushfire outcomes. It provides guidance on bushfire resilient design principles, constructions details, types of material, landscaping, and highlights the importance of maintenance and preparation.



Home under fire threat. Source: Prodocdrone/stock.adobe.com

1. See for example, Barrow, 1945; Ramsay et al. 1996; Leonard et al. 2006, 2009, 2016; Bianchi and Leonard, 2008; Arena et al., 2018.

### Understanding your bushfire risk

Understanding how bushfires behave and how buildings are typically impacted is essential for determining what measures can be taken to mitigate bushfire risks. Research has shown that house loss is a complex phenomenon that is dependent on a combination of factors, including fire severity, house design, and the type and arrangement of surrounding objects. For any bushfire event, it is important to assess the potential intensity of the fire and to know how to respond to the different types of bushfire attack.

Information on how bushfires spread, how to identify your own bushfire risk and who to contact for advice is provided in **Part 1: Bushfire essentials**.

### Climate change

Climate change has led to longer and more intense periods of extreme weather and more elevated fire weather days. From a building perspective, this means an increase in the chance of bushfire and an increase in the potential severity of the bushfire itself.



Firefighter intervention. Source: Roni Bintang/Getty Images

### Protecting yourself and your family

For all individuals living in bushfire prone areas, it is vitally important to develop a bushfire survival plan and implement a routine of building and landscape maintenance (refer to **Part 6 Ongoing maintenance**). Bushfires are chaotic and dangerous for even the most experienced firefighters, and the consequences of failing to respond properly (both before and during the event) may be catastrophic.

A bushfire survival plan helps your household to make important and potentially life-saving decisions when threatened by bushfire. A well-thought-out plan will protect the lives of your family and will assist you in preparing your home to survive the event.

A bushfire survival plan must be completed well ahead of the bushfire season to allow time to prepare yourself, family and home. Each occupant should read and understand the plan, and a hard copy version should be kept in case digital systems are not working.

The plan should step through each decision the household needs to make and agree on the steps you will each take in the event of a bushfire. For example, will you stay and defend, or will you leave early, and if you leave, what will you take with you?

To develop and prepare a bushfire survival plan, refer to the online guide provided by NSW Rural Fire Service, available at: <https://www.rfs.nsw.gov.au/resources/bush-fire-survival-plan>

## How to use this guideline

Bushfire resilient building and landscape designs should be tailored to different building types and environments. Identifying which strategies are suitable for which situations can be difficult, therefore we recommend following the step-by-step user guide below.

### Step 1 – Understand Bushfire Behaviour (pages 04–15)

Develop an understanding of how bushfires behave and how buildings are affected, including the different types of bushfire attack. Refer to pages 4–15 for an overview of bushfire behaviour, ignition mechanisms, and common vulnerabilities of buildings and surrounding elements.

### Step 2 – Assess Your Bushfire Risk (pages 16–17)

Identify the bushfire hazards relevant to your site, including vegetation, topography, and surrounding combustible elements. Refer to pages 16–17 to assess your Bushfire Attack Level (BAL) and identify hazards on and around your property that may influence design decisions.

### Step 3 – Plan Siting and Site Layout (pages 26–29)

Position the building and plan the site layout to reduce exposure to bushfire hazards and support safe access and egress. Refer to pages 26–29 for guidance on siting buildings in relation to vegetation, neighbouring structures, access routes, and defensible space.

### Step 4 – Apply Bushfire Resilient Design Principles (pages 20–50)

Use design principles to determine how the building should respond to the identified hazards and improve its overall resilience. Refer to pages 20–50 for guidance on design strategies, protection levels, and how different building elements can be designed to reduce vulnerability.

### Step 5 – Select Construction Systems, Materials and Landscaping

Choose appropriate construction systems, materials and landscaping strategies to support the design intent and reduce bushfire risk.

Refer to:

- Pages 50–64 – for construction systems
- Pages 65–72 – for materials
- Pages 73–92 – for landscaping
- Pages 93–100 – for ongoing maintenance



Koolewong fire aftermath. Source: JDA Co.

## How Buildings Ignite

There are many ways that a bushfire can attack property, and these attacks often work in combination to cause damage to a property or home. Fires that affect properties typically start from small ignitions that grow to a size where they can burn or ignite other combustible elements on the property (decking, windows, water tanks and garden beds). In worst cases, this can cause breaches in the building envelope, leaving the inside of the house vulnerable to attack.

Understanding how bushfires attack property will help you understand how resilient protection measures can prevent them from happening and minimise their damage.

### Ember attack & wind-borne debris

Ember attack is the most common means by which homes may be attacked by bushfires. An ember is a small burning particle which is driven by wind and can ignite dry fuels (e.g. leaf litter) or combustible building materials (e.g. timber windows). Embers can enter through gaps (e.g. vent holes, cracks in cladding, flues) in buildings reaching combustible elements and causing homes to ignite from within.



Figure 7.1: Ember attack & wind-borne debris

### Radiant heat attack

Radiant heat is the extreme heat produced from a bushfire. This is the heat you feel when sitting near a campfire, and during a bushfire this heat is intense and can be felt hundreds of metres away. Radiant heat can damage vulnerable building elements such as PVC downpipes, window screens and plastic water tanks etc. Radiant heat also dries and heats elements making them more readily ignitable.



Figure 7.2: Radiant heat attack

### Bushfire flame front / direct flame contact

Flame front attacks and direct flame is when the bushfire itself is physically in contact with buildings or structures, with flame contacting and wrapping around your property.

Flames can destroy windows, flow under eaves, floors and enter small gaps. Flame front attack is most common in areas surrounded by dense vegetation.

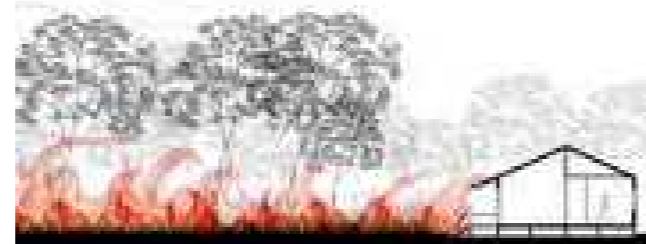


Figure 7.3: Bushfire flame front / direct flame contact

### Surface flame

Surface fires burn along the ground consuming low lying fuels such as grasses, ground litter, mulch and other debris. These fires can be unpredictable. They become a severe threat to building loss if they are immediately adjacent to a building or structure, where they can give rise to direct flame contact, radiant heat exposure and ember attack.



Figure 7.4: Surface flame

### Consequential fire

A consequential fire is a term given to the ignition of an object, building or structure from fire spreading through the built environment (e.g. house-to-house). These are ignited heavy fuel sources such as sheds, decks, cars, wheelie bins, and neighbouring houses that produce their own ember attacks, flame, radiant heat and surface fire. As density increases and lot sizes get smaller, the threat of house-to-house fire can cause a domino effect of building loss.

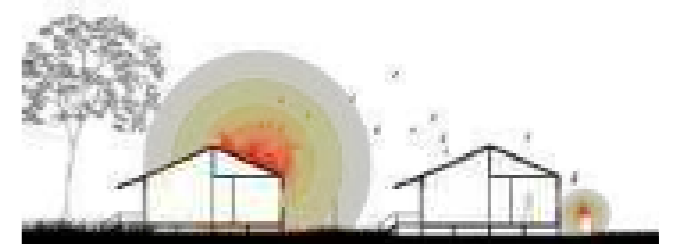


Figure 7.5: Consequential fire

### Debris accumulation

The ignition of a building or structure is made easier by the accumulation of debris on, under and within cavities. During a bushfire, embers blow into these locations and ignite the accumulated debris. Debris typically gathers in gutters, along roof valleys, in corners (re-entrant corners – see part 4.2), closed stair risers, and wedged in gaps in the envelope and decking.



Figure 7.6: Debris accumulation

### Wind attack & tree strike

Bushfires require wind to build to hazardous levels, and these same winds will carry debris which can strike the house. In certain fire events, the fire front can create its own winds which produce gusts in excess of forecasted wind gusts.

Trees and branches can fall and strike the house, due to wind or by burning trees. Houses struck by trees will likely sustain structural damage or have their windows smashed, leaving the inside of the house exposed to further attack.



Figure 7.7: Wind attack & tree strike

### Vegetation (fuel)

Vegetation, including trees, grasses, shrubs and leaf litter, acts as the primary fuel source for bushfires across New South Wales. Different vegetation types have varying effects on fire behaviour, as do the structure and arrangement of fuels, their moisture content, and terrain (fire spreads more rapidly uphill than downhill). Vegetation communities across NSW can present vastly different levels of hazard. For example, rainforests and moist gullies typically have higher moisture content and are less likely to ignite, whereas dry sclerophyll forests and grasslands are more prone to burning. Fuel sources are generally classified into two categories:

- Fine fuels are thinner than approximately 6 mm in diameter (e.g. grass, leaves and twigs). These ignite easily and burn quickly. Fire fronts move through the landscape primarily consuming fine fuels.
- Heavy fuels (logs, branches and tree trunks) burn more slowly but for a much longer duration. Long after the fire front has passed, heavy fuels can continue to smoulder and radiate heat.

It is important to recognise the role of vegetation within NSW's biodiversity and land management framework, and that not all vegetation presents the same level of hazard. Appropriate landscape design, garden layout and plant selection can help reduce exposure to radiant heat, embers and debris, while maintaining ecological values. Refer to relevant landscaping guidance for further detail.

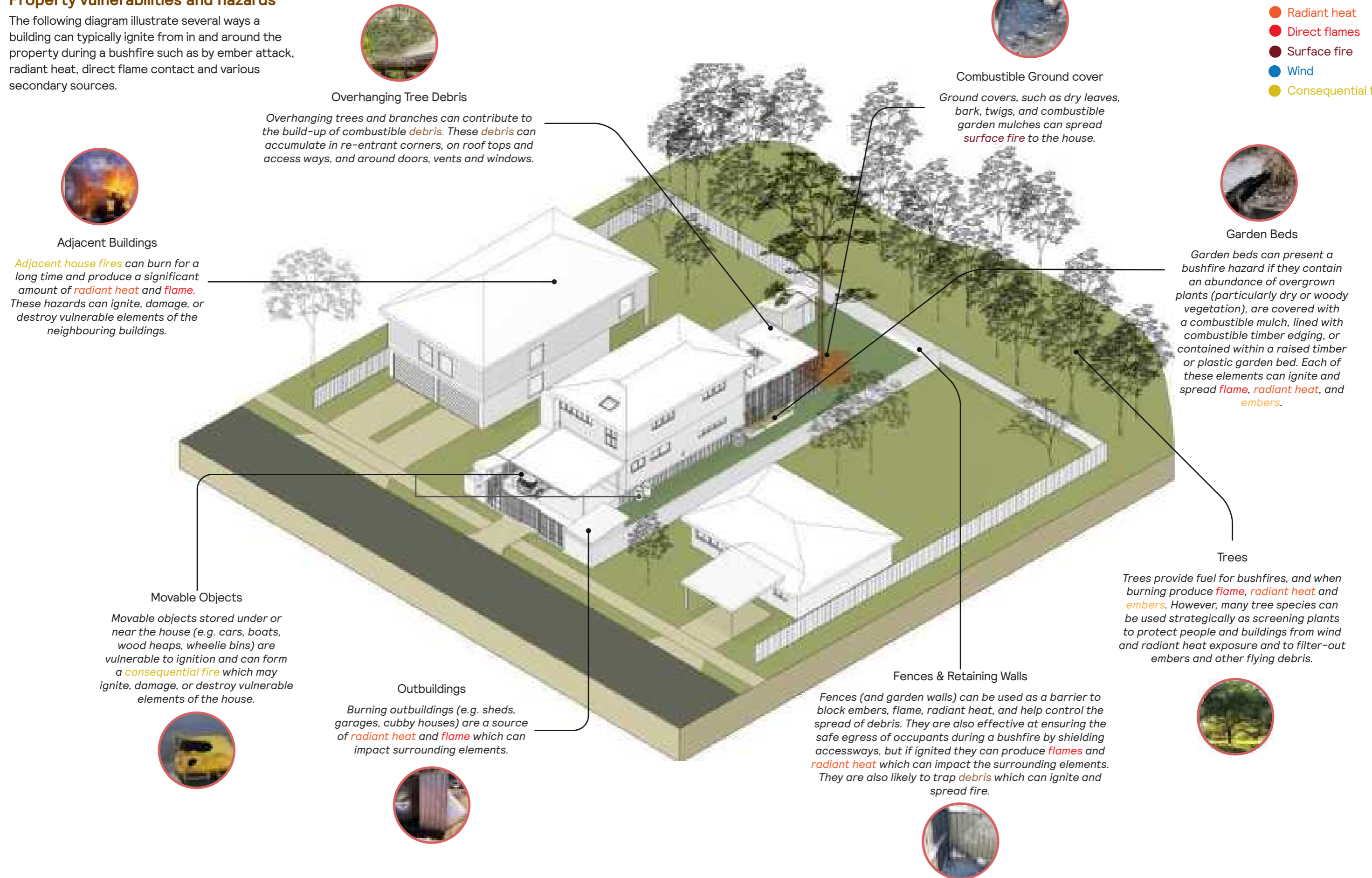
### Vegetation (conservation)

The natural assets are essential to the lifestyle and identity of New South Wales, and we must enhance and safeguard these areas. As reflected in the State's conservation strategies, native vegetation targets, and habitat connectivity goals, living in balance with nature is fundamental to development across NSW. Landholders in bushfire-prone areas should consider the broader role of native vegetation, wildlife, and biodiversity.

- Debris
- Embers
- Radiant heat
- Direct flames
- Surface fire
- Wind
- Consequential fire

### Property vulnerabilities and hazards

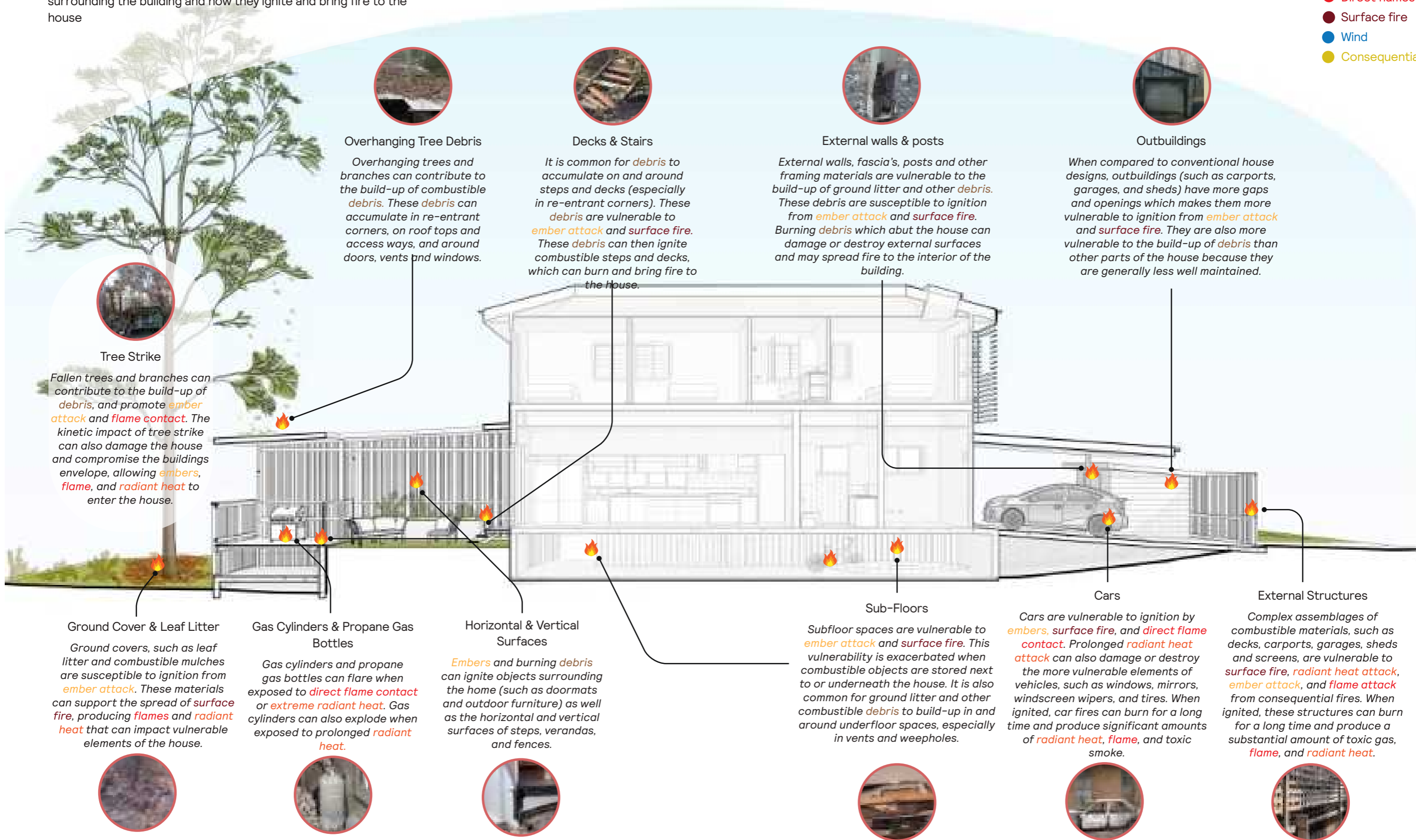
The following diagram illustrate several ways a building can typically ignite from in and around the property during a bushfire such as by ember attack, radiant heat, direct flame contact and various secondary sources.



- Debris
- Embers
- Radiant heat
- Direct flames
- Surface fire
- Wind
- Consequential fire

### Vulnerability of elements around the house

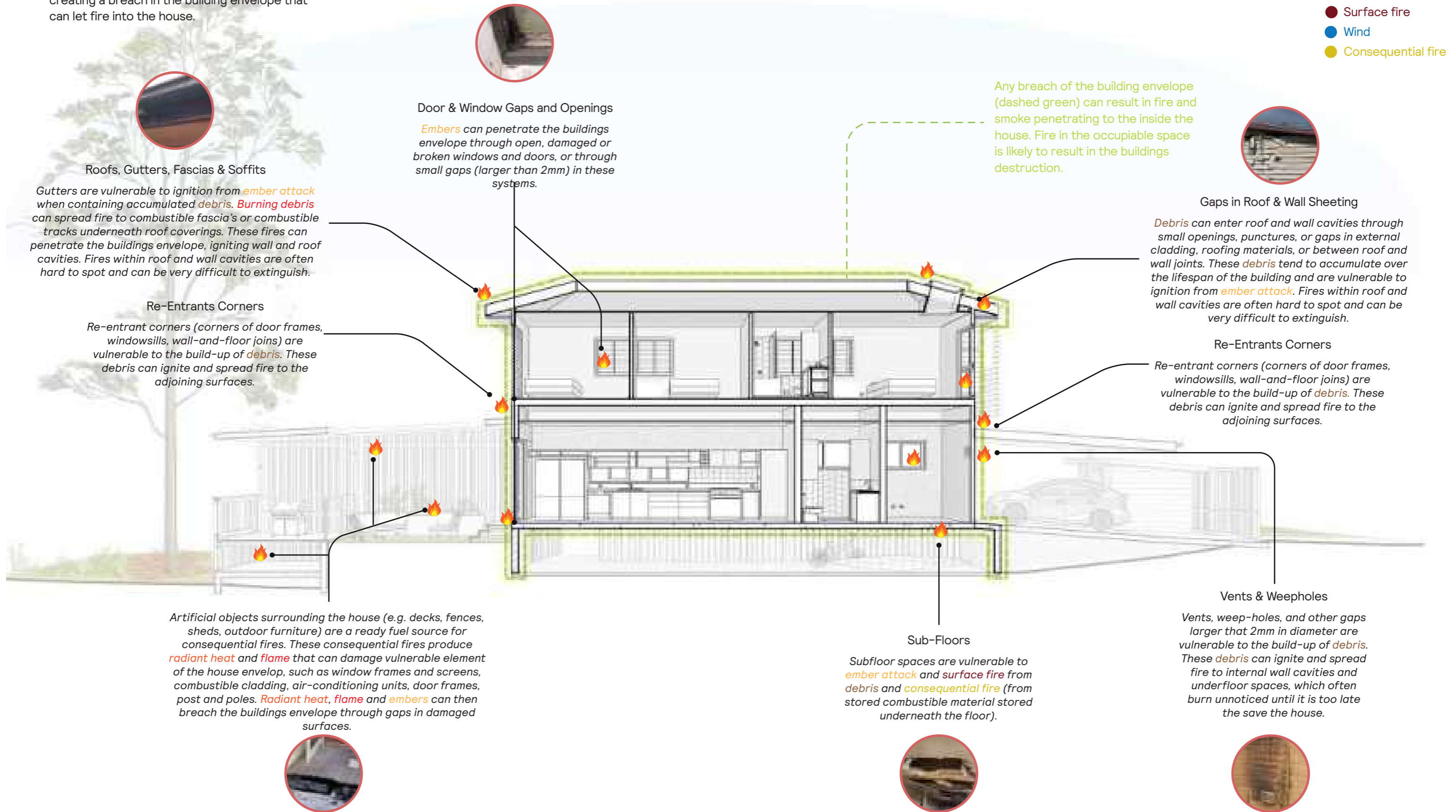
The following diagram illustrates the vulnerabilities of elements surrounding the building and how they ignite and bring fire to the house



- Debris
- Embers
- Radiant heat
- Direct flames
- Surface fire
- Wind
- Consequential fire

### Vulnerability of the house

The following diagram illustrates the vulnerabilities creating a breach in the building envelope that can let fire into the house.



#### Roofs, Gutters, Fascias & Soffits

Gutters are vulnerable to ignition from **ember attack** when containing accumulated **debris**. **Burning debris** can spread fire to combustible fascia's or combustible tracks underneath roof coverings. These fires can penetrate the buildings envelope, igniting wall and roof cavities. Fires within roof and wall cavities are often hard to spot and can be very difficult to extinguish.

#### Re-Entrants Corners

Re-entrant corners (corners of door frames, windowsills, wall-and-floor joins) are vulnerable to the build-up of **debris**. These debris can ignite and spread fire to the adjoining surfaces.

#### Door & Window Gaps and Openings

**Embers** can penetrate the buildings envelope through open, damaged or broken windows and doors, or through small gaps (larger than 2mm) in these systems.

Any breach of the building envelope (dashed green) can result in fire and smoke penetrating to the inside the house. Fire in the occupiable space is likely to result in the buildings destruction.



#### Gaps in Roof & Wall Sheeting

**Debris** can enter roof and wall cavities through small openings, punctures, or gaps in external cladding, roofing materials, or between roof and wall joints. These **debris** tend to accumulate over the lifespan of the building and are vulnerable to ignition from **ember attack**. Fires within roof and wall cavities are often hard to spot and can be very difficult to extinguish.

#### Re-Entrants Corners

Re-entrant corners (corners of door frames, windowsills, wall-and-floor joins) are vulnerable to the build-up of **debris**. These debris can ignite and spread fire to the adjoining surfaces.

Artificial objects surrounding the house (e.g. decks, fences, sheds, outdoor furniture) are a ready fuel source for consequential fires. These consequential fires produce **radiant heat** and **flame** that can damage vulnerable element of the house envelop, such as window frames and screens, combustible cladding, air-conditioning units, door frames, post and poles. **Radiant heat, flame** and **embers** can then breach the buildings envelope through gaps in damaged surfaces.



#### Sub-Floors

Subfloor spaces are vulnerable to **ember attack** and **surface fire** from **debris** and **consequential fire** (from stored combustible material stored underneath the floor).



#### Vents & Weepholes

Vents, weep-holes, and other gaps larger than 2mm in diameter are vulnerable to the build-up of **debris**. These **debris** can ignite and spread fire to internal wall cavities and underfloor spaces, which often burn unnoticed until it is too late to save the house.



## How to assess your bushfire hazards

The potential bushfire hazards a house may experience are a combination of the:

- potential intensity of the bushfire including:
  - the vegetation that can carry a fire front proximal to the house
  - weather and topography, which will influence the intensity of the bushfire and the potential impacts that the house could experience
  - separation of the house from vegetation
- vegetation and other combustible objects near the house.

Defining and mapping bushfire hazards (including other generic fire hazards such as neighbouring buildings and combustible material on your property) will help you to understand how a bushfire might impact your house or future house location. This information will help you determine the type of measures you might wish to employ in terms of bushfire resilient construction and landscaping to adequately address these hazards.

Table 1 Bushfire Attack Level

<b>Bushfire Attack Level (BAL)</b> The Bushfire Attack Level or BAL is a method for categorising local bushfire intensity. BAL provides a local estimate of the potential radiant heat and flame exposure (from potential flame front traveling through unmanaged vegetation only) at a given location, which can help owners to better site new buildings or to better manage existing ones (see Table from Australian Standard (2018)).		
Bushfire Attack Level (BAL)	Heat flux thresholds (kW/m <sup>2</sup> )	Predicted bushfire attack and levels of exposure
BAL-12.5	≤ 12.5	The significant ember attack, burning debris and radiant heat up to a level of 12.5 kW/m <sup>2</sup>
BAL-19	12.5 - 19	Increasing levels of ember attack, burning debris and radiant heat up to a level of 19 kW/m <sup>2</sup>
BAL-29	19 - 29	Increasing levels of ember attack, burning debris and radiant heat up to a level of 29 kW/m <sup>2</sup>
BAL-40	29-40	Increasing levels of ember attack, burning debris and radiant heat up to a level of 40 kW/m <sup>2</sup> . Direct flame contact on the house from the fire front is possible.
BAL-FZ	≥ 40	Increasing levels of ember attack, burning debris and radiant heat in excess of 40 kW/m <sup>2</sup> . Direct flame contact on the house from the fire front is likely with the possibility of flame wrapping around the house and acting on all sides.

### Hazard assessment

The following steps will help you to identify and understand the bushfire (and non-bushfire) hazards on your property. It provides information on hazards to consider when choosing a design for your house and landscape.

#### Step 1:

Gain an understanding of the bushfire hazard at your property using the NSW Rural Fire Service Bush Fire Prone Land mapping tool, which identifies whether land is classified as Bush Fire Prone Land (BFPL) and shows the vegetation categories and buffer areas used to determine bushfire risk. This mapping can be accessed through the Bush Fire Prone Land Viewer:

[www.rfs.nsw.gov.au/plan-and-prepare/building-on-bush-fire-prone-land/bush-fire-prone-land](http://www.rfs.nsw.gov.au/plan-and-prepare/building-on-bush-fire-prone-land/bush-fire-prone-land)

The mapping indicates:

- Vegetation Category 1 – highest bushfire hazard
- Vegetation Category 2 – moderate bushfire hazard
- Buffer areas – land potentially affected by bushfire attack

These categories are used to determine whether a **Bushfire Attack Level (BAL)** assessment is required and inform planning and construction requirements under the **Planning for Bush Fire Protection guidelines**.

#### Step 3:

Calculate the potential **Bushfire Attack Level (BAL)** for the proposed building location using a BAL calculator or through a formal assessment in accordance with Planning for Bush Fire Protection 2019, published by the NSW Rural Fire Service.

BAL calculations estimate the level of radiant heat exposure, ember attack and potential flame contact a building may experience during a bushfire.

The assessment typically considers:

- Vegetation type surrounding the site (e.g. forest, woodland, shrubland or grassland)
- Distance between vegetation and the building site
- Slope of the land under the vegetation
- Slope between the vegetation and the building
- Regional Fire Danger Index (FDI) used for the assessment

The resulting BAL rating (BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 or BAL-FZ) determines the construction requirements for the building under AS 3959 – Construction of buildings in bushfire-prone areas.

#### Step 4:

Identify other hazards on and around your property.

It is important to understand how elements in the wider landscape might affect your building's survival in terms of slowing, stopping or promoting the spread of fire. As a first step, consider all existing structures on your own property or allotment and then work outwards to account for elements on neighbouring or nearby lands. For example, note the locations of the following elements:

- isolated trees
- fences
- retaining walls
- sheds
- neighbouring buildings
- movable objects, e.g. cars and caravans.

Also consider your property boundary, easements, street setbacks, the local road network and access.

## Bushfire myths and misconceptions

It is important to be aware of the misconceptions and common myths about bushfires that could endanger lives.

### **Myth 1: The spread of fire is best slowed by removing trees**

Fire fronts move faster in thinned forests and open grasslands compared to thicker forests.

This is because thick forest limits the wind speeds experienced below the forest canopy, causing the fire front speed to slow.

Reducing fine fuels in the environment has the greatest influence on slowing the spread of a conventional flame front-driven bushfire. Fine fuel is defined as dead material thinner than a pencil and live material thinner than a match.

### **Myth 2: Buildings not directly near bushfires are safe**

Embers can travel hundreds of metres from their source. Many houses are lost due to embers lighting fine fuels, which then ignite nearby structures or combustible elements. For example, igniting timber retaining walls near a house can then ignite the house. Small parks, gardens and creek lines within urban areas can also be ignited by embers. These areas will burn at much lower intensity than larger areas, but are still able to generate new embers that may reach further into an urban area.

Research tells us that buildings are most commonly ignited by embers and other wind-driven burning debris, rather than bushfire flames. Spotting from ember attack has been known to occur up to 40 kilometres away from the main fire front, but most spotting (around 80 per cent) occurs within 100 metres of burning vegetation.



Prescribed burn. Source: Binikins/stock.adobe.com



*Reducing fine fuels around the house has the greatest influence on slowing the spread of a conventional flame-front driven bushfire.*

### **Myth 3: Embers only arrive from the direction of the prevailing wind**

Embers are wind driven. However, the wind direction experienced at ground level and out in the open is not a reliable indication of all possible wind directions an ember may experience.

Wind strength and direction can change at any moment. Additionally, higher altitude winds can also affect where embers travel, with the wind sometimes moving in different directions at different altitudes. Multiple wind direction changes can be experienced during bushfire events, including moving in the opposite direction from the prevailing wind.

### **Myth 4: Leaves are the main source of embers**

Leaves and other fine fuels, such as grass clippings and seed pods, can produce embers, but tree bark is by far the most common source.

### **Myth 5: Canopy fires start when trees self-combust from internally stored heat**

Crown or canopy fires are usually ignited by flames reaching up into the canopy. These flames are produced by fine fuels on the ground, which then spread fire up into the canopy via a ladder of fine fuels, such as nearby shrubs. This crown fire can then spread as a running canopy fire (between trees) but only when there is a high amount of both surface and elevated fuels. The presence of surface fuel is essential for the spread of a canopy fire, as the fire will not spread if there are insufficient surface fuels to project flame into the crown.

Crown fires in eucalypt forests are nearly always associated with an uphill (upslope) run of fire or fire runs driven by very strong winds.

### **Myth 6: Australia's bushfires are so severe, there is nothing we can do about them**

This is false. Both buildings and their surrounding landscapes can be designed and managed in a way that improves their bushfire resilience. This can greatly improve the chances of people and buildings surviving a bushfire.

# Bushfire Resilient Design Principles

## Introduction to Bushfire Resilient Design

Using design principles to mitigate the impacts of bushfire is called bushfire resilient design. The objective of bushfire resilient design is to reduce, eliminate or counter the effects of:

-  **Ember attack**
-  **Radiant heat**
-  **Bushfire flame front contact**
-  **Surface fire**
-  **Consequential fire**
-  **Tree strike**
-  **Wind**
-  **Debris accumulation**



*Bushfire resilient home under construction, using flame resistant sarking. Source: Ian Weir*

These objectives should be achieved without the use of materials or designs that might present additional hazards (such as significant levels of toxic smoke) to occupants if they happen to be present or are attempting to leave the house.

A bushfire resilient design can be achieved via three complementary design strategies:

1. siting<sup>14</sup> (positioning buildings) the house in a way that minimises its exposure to multiple hazards that cannot be readily addressed by building design (see page 21 on how to recognise and optimise the trade-offs between siting and building design)
  2. using bushfire resilient landscaping by planning, selecting and managing bushfire resilient plantings and other garden features in the area around the house to reduce bushfire attack.<sup>14</sup>
  3. using design and construction materials appropriate for the combined bushfire hazards presented to each aspect or element of the house.
- There are usually multiple ways to manage the risks presented by the same hazard(s). Some of these hazards are more easily addressed through siting and landscaping, while others are more easily addressed through construction. For example, to protect the house from flame front attack, it is more cost effective to locate the house away from the source of the flames (where possible) rather than construct the house to resist it. Conversely, constructing a house to resist ember attack is relatively cheap and effective compared to site relocation, or extensively clearing many hundreds of metres of vegetation.
- The best level of protection for a given budget is often a measured combination of siting, landscaping and construction.

### Designing new buildings

NSW's building and planning regulations seek to ensure that new developments are designed and constructed with bushfire protection in mind.

These regulations provide a minimum set of requirements aimed at improving the chances that occupants and properties will survive a bushfire. Note that some of the bushfire attack mechanisms described in this guide are not accounted for in the official regulations. For example, building regulations do not address the full range of consequential fire sources that present hazards to a house (e.g. neighbouring houses or boundary fences).

Some readers may find the level of house protections provided by the regulations acceptable, while others may wish to aim for a higher likelihood of survival by considering the widest range of hazards that a house may face during a bushfire.

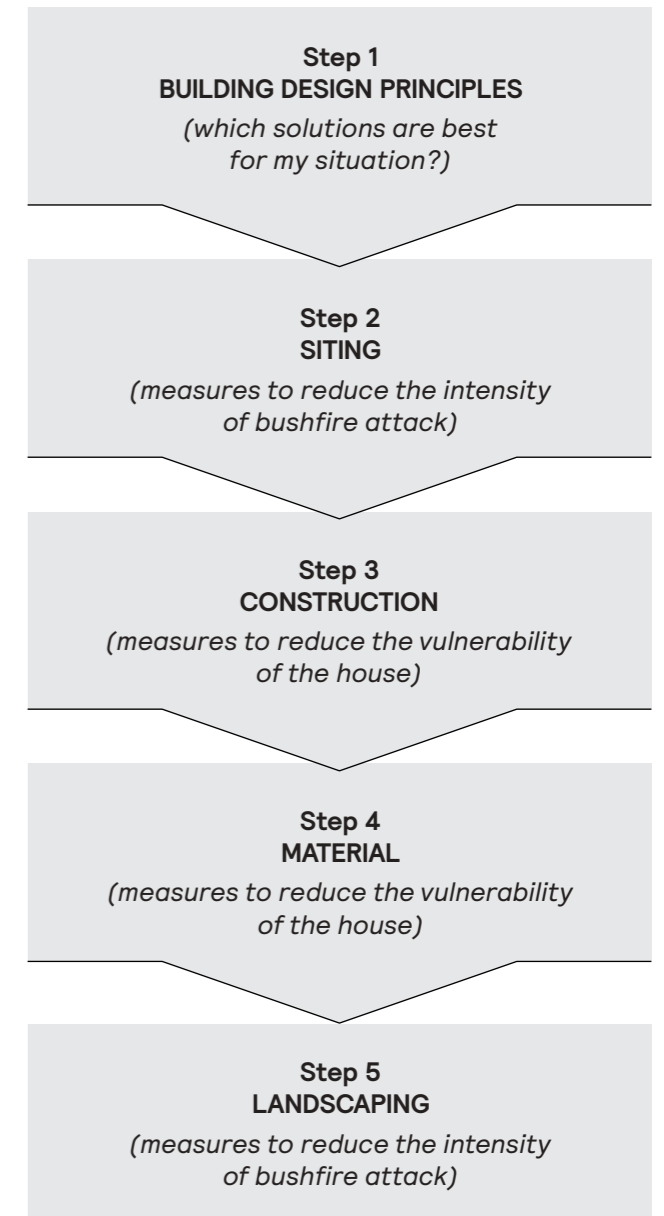
Many of the design principles found in this guide go beyond what is required under current building and planning regulations, but in doing so they provide a higher level of bushfire resilience. In many cases, these principles can be incorporated with minimal additional cost.

Hence, most of the time it is important to prioritise ember attack and surface fire resilience before moving onto radiation and flame front contact.



*Example of bushfire resistant building. Source: Paul Whittington*

How to navigate your design:












<sup>14</sup>. You may need to check with your local government to determine if there are any specific requirements relating to siting.

**Bushfire resilient design principles**





Design principles in response to each bushfire hazard (surface fire, consequential fire, wind, radiant heat, tree strike) are outlined in the following Design principles table. Bushfires have a range of impacts that vary in their difficulty to address. For each hazard, the preferred design response

(siting, construction or landscaping) is outlined alongside comments in relation to the effort and financial costs required to implement them, and the response’s effectiveness.

Icon	Hazard Mitigation	Design Principles	Ease of Mitigation Siting vs Construction
	<b>Bushfire flame front contact</b> on the house from adjacent vegetation.	<p>Site buildings away from vegetation (bush). Try to maximise the distance between the home and vegetation.</p> <p>Buildings can be constructed using non-combustible materials, or the building can be built partly or wholly underground; however, both options may be significantly expensive compared to other design approaches.</p>	<p>Siting Construction</p> 
	<p>When adjacent fixed structures (e.g. neighbouring buildings) burn, they can heat or ignite the house.</p> <p>Adjacent structures can burn for a long time, producing dangerous levels of heat and toxic smoke.</p> <p>When adjacent movable objects burn, they can heat or ignite the house.</p> <p>For example, vehicles can burn for a long time, producing moderate levels of heat and dangerous levels of toxic smoke.</p>	<p>Site the home away from neighbouring buildings and other fixed structures. Ideally, you should provide a separation distance of at least 12 metres between vulnerable elements of the house and other structures.</p> <p>Buildings can be constructed using non-combustible materials.</p> <p>Consider non-combustible barriers between the house and neighbouring buildings (e.g. fences and earthworks).</p> <p>Position vehicles away from the home. Consider how to design parking spaces (e.g. for vehicles, caravans and boats) away from the home.</p> <p>Constructing a house to resist flame and radiant heat from burning vehicles can have a high cost. Therefore, we recommend siting as the best design response (provided there is adequate space on the allotment).</p>	<p>Siting Construction</p>  <p>Siting Construction</p> 

Icon	Hazard Mitigation	Design Principles	Ease of Mitigation Siting vs Construction
	Reduce attack by <b>radiant heat</b> from burning vegetation.	<p>Site the home away from vegetation.</p> <p>Buildings can be constructed using non-combustible materials.</p> <p>For lower intensity bushfires, appropriate construction materials and designs may be used to prevent damage to the home.</p> <p>Consider non-combustible barriers (e.g. fences) and earthworks (e.g. retaining walls) to reduce the impact from radiant heat.</p>	<p>Siting Construction</p> 
	<p><b>Wind</b> can carry embers and burning debris that can ignite vehicles, buildings and vegetation.</p> <p><b>Strong winds</b> (greater than 75 km/h) can damage buildings and impede the movement of people.</p> <p>Designing for bushfire-based wind resilience will also provide protection against severe wind events, such as tropical cyclones.</p>	<p>Site buildings in locations that have low wind exposure.</p> <p>Avoid the top or side of ridges – these locations are especially vulnerable to wind attack.</p> <p>Use landforms, hedges and trees to screen the house from the strong winds that may accompany a bushfire. Take advantage of any existing terrain features to minimise exposure to wind attack.</p> <p>Non-combustible barriers (e.g. fences and earthworks) can shield against wind exposure.</p> <p>Building codes related to wind are primarily focused on preventing the complete structural collapse of the house, rather than preventing superficial damage of the type that can lead to other ignitions during bushfire.</p> <p>Use construction measures to resist superficial damage from wind loading. Wind attack has a moderate-cost implication when building the house to resist wind exposure (remember that wind attack can directly damage buildings, promote the spread of fire, and spread wind-driven debris).</p>	<p>Siting Construction</p> 

Icon	Hazard Mitigation	Design Principles	Ease of Mitigation Siting vs Construction
	<b>Ember attack</b> and the accumulation of unburnt debris.	<p>Ember protection is primarily achieved by limiting the ember's ability to ignite any aspect of the house or its surrounding features. These may be external features, such as cladding and building fascias, or internal features, such as building cavities and internal furnishings. To mitigate ember attack:</p> <ul style="list-style-type: none"> <li>• use non-combustible construction materials, both externally and within building cavities</li> <li>• use designs that limit the ability for embers and unburnt debris to enter the house or its cavities, such as cavity-less construction (e.g. slab on ground flooring, solid masonry walls, skillion roofs) and tight-fitting cladding on roof and subfloors.</li> <li>• use designs that limit accumulation points for unburnt debris and embers (e.g. use a simple house shape and simple roof lines).</li> </ul> <p>A secondary strategy is to reduce the total exposure of embers and unburnt debris on the building by:</p> <ul style="list-style-type: none"> <li>• using screening plants to filter embers and other wind-driven debris</li> <li>• using proximal plants with low bark hazard</li> <li>• using non-combustible barriers (e.g. fences and earthworks) to shield buildings from ember attack</li> <li>• removing overhanging trees that may drop debris onto or around the house.</li> </ul>	<p>Siting    Construction</p> 
	<b>Smoke</b> , including toxic gases, can exacerbate asthma and other respiratory conditions, as well as irritate the eyes, nose and throat and cause coughing, shortness of breath or suffocation. Fine particles can also penetrate deep into the lungs and cause long-term health problems.	<p>Mitigating smoke exposure is best achieved through two approaches:</p> <ul style="list-style-type: none"> <li>• Build the house to be as airtight as possible; meaning that the rate of air exchange between the inside and outside of the house is as low as practical when all windows, doors and vents are closed. This approach is the same as those used to achieve a high level of energy efficiency.</li> <li>• Use appropriate construction materials that, when exposed to embers, radiant heat and flame, do not emit toxic smoke. Sources of smoke immediately adjacent to or within building cavities will contribute to the build-up of toxic smoke within the house more than sources further away.</li> </ul>	<p>Siting    Construction</p> 

Icon	Hazard Mitigation	Design Principles	Ease of Mitigation Siting vs Construction
	<b>Surface fires</b> move through grasses, forest litter, mulch, bark and garden beds. These fires have short flame lengths (below knee height) and can impact buildings, vehicles and vegetation elements at that level.  Surface fires can also produce significant levels of radiant heat, which can damage building elements at greater heights.	<p>Create an open space (using non-combustible surfaces, such as non-combustible pathways, or ground cover) around the outside of the house.</p> <p>Avoid dense plantings of shrubs—plant individual or small clusters of shrubs, separated by breaks (e.g. open spaces, or non-combustible walls or fences). Use non-combustible mulches.</p> <p>Use non-combustible materials when building near combustible ground fuels.</p>	<p>Siting    Construction</p> 
	<b>Tree strike</b> can damage buildings, spread fire, and injure, kill or trap people. Trees can fall either due to strong winds or the burning of the tree.	<p>Site the home away from trees—create a separation distance to 1.5 times the height of the tallest tree.</p> <p>Buildings can be constructed to withstand tree strike using heavy construction materials; however, appropriate designs can be extremely expensive to build.</p>	<p>Siting    Construction</p>  <p>(new house only)</p>

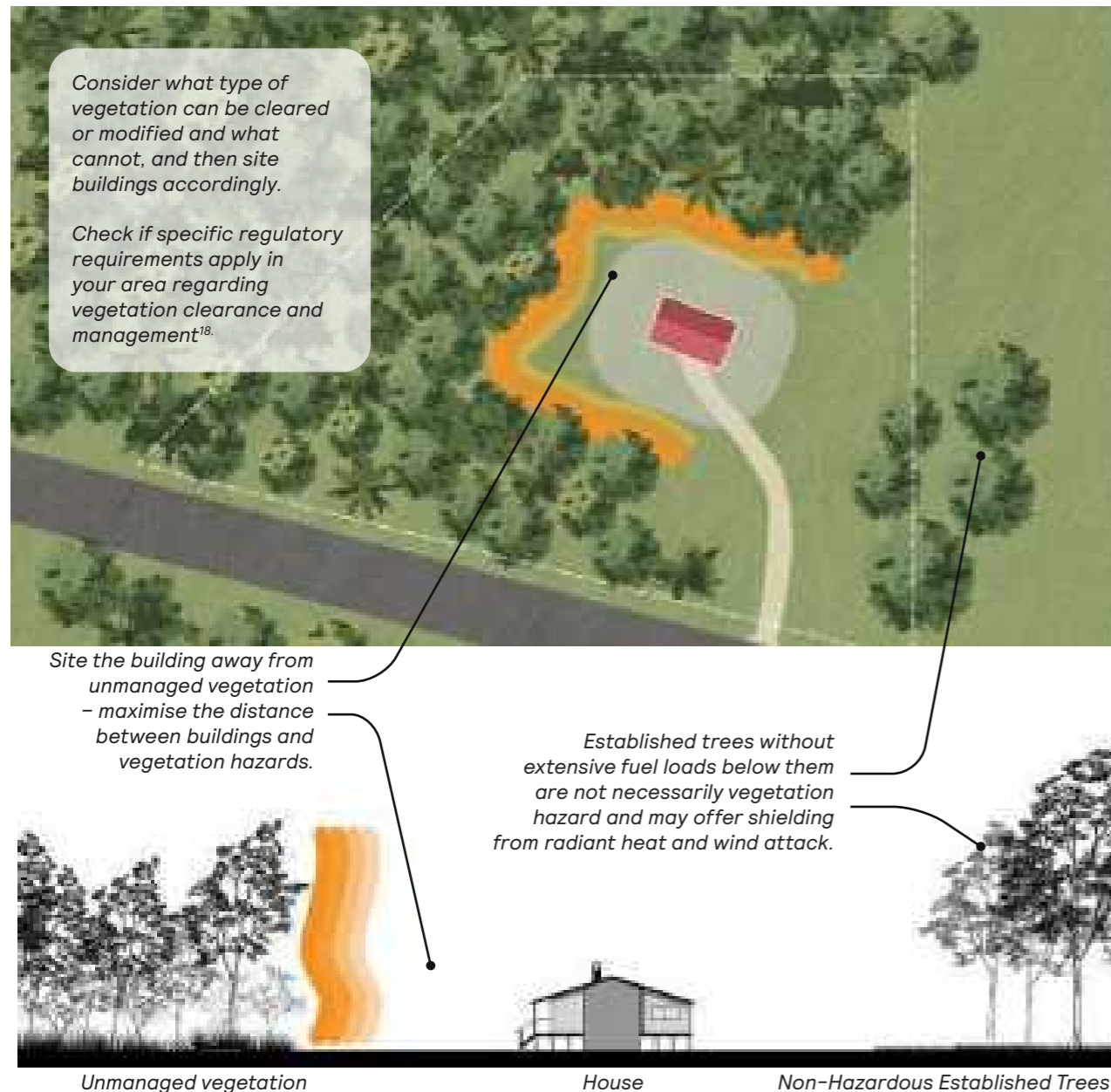
## Siting

Siting can reduce the intensity of bushfire attack by reducing the building's exposure to vegetation and other bushfire fuels by maximising the distance between the house and vegetation, or by using barriers. This section provides advice to assist you in identifying the best location to site (position) your home or other buildings in relation to both bushfire and consequential fires hazards. Ideally, buildings should be located away from steep vegetated slopes, narrow ridges and dense vegetation. Buildings should also (ideally) be located close to public roads or open spaces that contain managed vegetation.

### Siting for vegetation hazards

**Design principle:** Site to reduce exposure from vegetation hazards.

Figure 7 Siting for vegetation<sup>18</sup>



18. Check whether vegetation clearing approvals are required under NSW native vegetation management rules (see NSW Local Land Services guidance).

### Siting for best access

**Design principle:** Site driveways and pathways to provide access to and from the property. Consider positioning the house and other structures to minimise the risks associated with access and exit.



- Identify potential points of access to and from the property on your building plan to determine the best siting option or options.
- Consider the benefits of a short driveway close to a main public road versus the costs and benefits of a longer driveway.
- Identify any terrain features that might aid or hinder access.
- Reduce or eliminate nearby hazards, e.g. the possibility of trees or branches falling on driveways from adjacent or overhanging vegetation, or flame attack from adjacent vegetation or combustible objects.
- As a potential second exit, consider access through an adjacent block of land that has been cleared of surface and near-surface fuels.
- Determine whether the surrounding land (in the immediate vicinity of the house and further out) is accessible and has a large enough area to allow vehicles to turn (including a minimum
- 12 metres outer radius turning circle for medium rigid fire-fighting appliances), with clearance up to 4.8 metres in height and 4.0 metres in width.

## Siting for existing structures (including neighbouring houses and outbuildings)

**Design principle:** Site to reduce exposure to combustible objects, such as existing fixed structures.



Site buildings away from fixed structures. If possible, ideally create a separation distance of 12 metres between the house and other structures or large combustible objects.

For smaller sites (where a 12 metre separation is not possible), consider incorporating construction measures to reduce risk for wall(s) and roof with any view of an adjacent structure less than 12 metres away. These construction measures are detailed in Part 3.

Figure 9 Siting for existing structures

## Prepare for contingency – siting for pathways and secondary places

**Design principle:** Identify both primary and alternative places of shelter and associated escape routes as part of a bushfire survival plan.

Bushfires can be unpredictable: changes in wind direction or an unforeseen hazard may block or obstruct the escape route to a place of shelter.

Therefore, you should identify backup options for shelter and escape if the planned options are compromised (the more options the better).

Places of safe shelter or last resort may include (not in order of preference):

- a well-prepared bushfire resilient home (yours or a neighbour's house)
- a purpose made and approved bushfire shelter
- a stationary vehicle in an open area
- open spaces (e.g. ploughed paddock or reserve)
- bodies of water (e.g. beaches, pools, dams)
- community fire refuges.



Potential issue with exit path on fire damaged stairs. Source: CSIRO

Maintain a suitable escape route between your house and the alternative place(s) of shelter. Ensure that each occupant can safely exit the house (be mindful of children, the elderly and people with impaired mobility). Ensure that these exit routes do not involve passing over, through or next to combustible surfaces, substructures, retaining walls, fences and other buildings.

It is important to avoid the use of combustible decking or stairs along exit and access routes, as these combustible objects can create a bushfire hazard.

## Siting for defensible space or asset protection zone

Depending on your location, you may be required to establish an asset protection zone (APZ) around your home to better facilitate its defence. 21

An APZ is a specified area of land that enables emergency access and operational space for firefighting. Vegetation is modified and maintained within the APZ to reduce fuel load in a way that reduces the risk of flame contact and radiant heat attack.

Make the following considerations when siting a defensible space:

- Consider the local landscape and the actions required to create a defensible space.
- Create the defensible space (Asset Protection Zone) in accordance with guidance provided by the NSW Rural Fire Service.<sup>21</sup>
- Consider integrating accessways in the design of the defensible space.
- Design the defensible space with aesthetic values in mind, consider how to make the space both functional and practical.

*Think of yourself and your house as being at the centre of an onion; focus most attention on the innermost layers being the house's immediate surroundings.*

*Each layer around you needs to be bushfire-ready.*

21. For guidance on determining the required size of an Asset Protection Zone (APZ), see the Planning for Bush Fire Protection 2019 and associated NSW RFS guidance.

## Applying Design Principles

The use of bushfire resilient design and construction materials should be considered the last layer of bushfire defence. Buildings located in bushfire prone areas should be able to withstand attack from bushfire and other consequential fires, at the intensity expected at their location. However, prevention (preventing hazards from reaching the house) should be your primary goal.

Carefully review the hazards identified in your guided hazard assessment developed in 'How to assess bushfire hazards', paying attention to which hazards are relevant for each side of the house.

When deciding which hazards are relevant for any given side, remember that some hazards, such as ember attack and flame contact, can involve sides of the house other than those facing the bushfire front. Knowing which hazards are present will help you choose the most appropriate design solutions.

It is important to consider the design of all elements in proximity to the house (not only the design of the house itself).

This includes the design and siting of parking spaces,

decking, verandahs, stairs, retaining walls, water tanks, outbuildings and exit path strategies. Such elements may bring additional hazards to the home, for example, a parking space close to the house may require additional design and construction measures to protect the building in the event of the car burning. Consider the trade-off between different strategies, and experiment with different design configurations until you are satisfied with the result.

The design solutions outlined on the following pages are categorised according to four increasing levels of protection.

	Level of Protection
<p>Level 1*w</p>	Provides protection from ember attack, surface fire from burning debris, fine fuels (maintained to less than 50mm height) and radiant heat up to 12.5kW/m2(#), and a separation of at least 6 times the height^ of any consequential fire sources.
<p>Level 2*</p>	Provides protection from ember attack, burning debris, fine fuel surface fire (maintained to less than 150mm), provides protection from radiant heat up to 29kW/m2 (#), or a separation of between four and six times the height^ of any consequential fire sources.
<p>Level 3*</p>	Provides protection from ember attack, burning debris, fine fuel surface fire of any height, provides protection from direct flame contact from a bushfire front, and from consequential fire for sources with a separation of between two and four times their height^.
<p>Level 4*</p>	Provides protection from ember attack, burning debris, fine fuel surface fire of any height, direct flame contact from a bushfire front, and from consequential fire from sources with a separation of less two times their height^.
<p>*If large combustible elements (e.g. deck, car park) are present or preferred, then refer to level 4 house construction so that the house can be adequately designed to resist the additional fire load from consequential fire.</p> <p>#Where a radiation heat level is identified, this roughly corresponds to the recommended separation distance from unmanaged fuels identified in the BAL calculator.<sup>22</sup></p> <p>^Where the consequential fire source is a structure then the maximum eave height is a reasonable measure of maximum height.</p>	

22. [best-practices-assessment-tool.herokuapp.com/#calculator](https://best-practices-assessment-tool.herokuapp.com/#calculator)

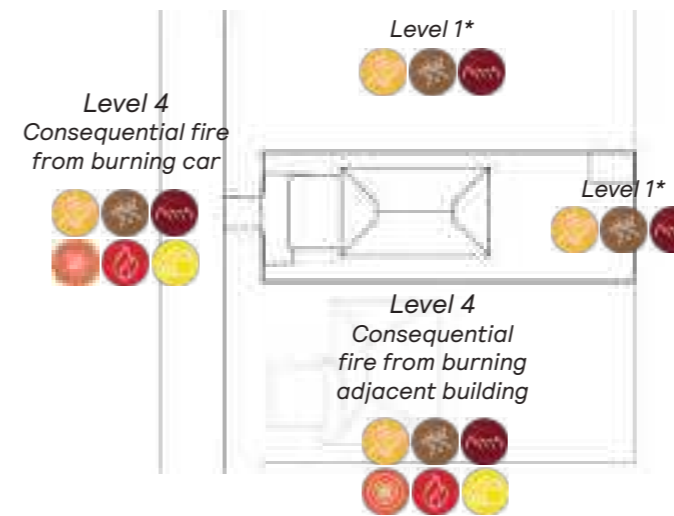


Figure 10 Consider hazard on 4 sides of the house

Choose designs and materials carefully:

- Consider **robust** design principles. Robust means that they are not easily damaged or compromised, and do not require manual operation or intervention to work. An example of this might be to choose non-combustible building elements rather than the combination of combustible elements and a water spray protection system.
- Consider design **redundancy**. This ensures that the fate of your house is not reliant on the effective performance of a single element. An example of this would be to secure metal screens over window glazing. Another would be to use a complete wall system that is non-combustible; this not only includes the facade, but all the materials used within the wall cavity like insulation, wall framing, and framing for windows and doors.
- Cost effective design solutions often involve **simple and practical strategies** that reduce or eliminate design details that can be problematic in a bushfire. An example of this could be to either enclose the subfloor area or build using a slab on the ground in order to prevent subfloor exposure. Another is to use simple roof layouts that avoid valleys and minimise the number of ridges that need protection details. Yet another is to use simple building footprints that avoid re-entrant corners where debris may accumulate and burn.
- Many design solutions can work **together** with other requirements. For example, window screens and shutters can also provide insect and solar protection.

### Choosing a design

The following section describes design principles aimed at bushfire resilience. These principles are categorised according to their effective level of protection (level 1, 2, 3 or 4).<sup>23</sup> While using the recommended construction for a level is appropriate, construction solutions for higher levels will offer useful alternatives, with the added benefit of greater robustness and redundancy.

It is important to understand the strengths and weaknesses of your design. Some design decisions have implications for how well the rest of the building will perform. It is important to be aware of how each system may interact with adjacent elements and the building as a whole. A good example could be the choice of thick non-combustible wall cladding to protect the combustible framing elements underneath. This is a sound approach, but if the subfloor area is not fully enclosed, then flames may be able to reach the combustible wall framing elements and burn behind the thick cladding.

Your building (and the building's envelope—the physical separator between the internal space and the outside environment) is made up of walls, floors, roof sections and subfloors. Identify which elements of the building are vulnerable to ignition, and which parts may be difficult to extinguish once burning (e.g. roof cavities, wall cavities and subfloor spaces).

- Consider the merits of non-combustible framing and cladding versus combustible framing for walls, roofs and subfloors.
- Consider whether it is possible to remove cavities from the design (e.g. by building on a slab on the ground or using solid masonry).
- Avoid mixed solutions. For example, if you use a non-combustible cavity design for wall and floor systems, we recommend a similar non-combustible cavity approach for the design of the roof. The use of a combustible system may undermine the value of adjacent non-combustible systems. Remember that the resilience of a building in a bushfire is governed by the weakest link principle.

23. Every effort has been made to ensure that this best practice guidance either meets or exceeds the minimum requirements in both AS3959, Australian Standards (2018) and the NASH construction standards (2014); however, we recommend that you check the relevant standards to ensure that you meet or exceed these regulatory requirements.  
\* If no other combustible object or vegetation is threatening the house.

Steps to navigate the following guidance is outlined below

**Step 1**

To help choose a general strategy, refer to the building design house examples on pages 33–36 for an overview of different bushfire resilience strategies applicable to common building types in New South Wales. Sectionals 1 and 2 provide examples of buildings with non-combustible framing and cladding.

**Step 2**

Refer to the materials flow (pages 37–44). The flow chart outlines different design and material solutions and their associated levels of protection, for:

- wall systems (including insulation, framing and cladding)
- floor systems (including the floor, supporting floor system and enclosure)
- roof systems (including the internal insulation, framing and cladding)
- window and door systems
- vents
- verandahs, decks and carport systems.

**Step 3**

Refer to Part 3 for information about bushfire resilient construction systems.

For additional guidance on construction details at different level of exposure (e.g. wall system, roof and deck), refer to Australian Standard AS3959 and the NASH construction standard.

**Step 4**

Refer to bushfire resilient materials (Part 4, pages 65–72) for guidance on the use and performance of common material in bushfire.

**Building design house examples**

The following sectional house examples identify a few different residential types, systems of construction and materials to reduce bushfire attack vulnerabilities. The diagrams provide examples of bushfire resilient house designs and explain the strategies and principles applied for both new builds. The strategies refer to the protection levels on page 29, as there are often multiple solutions depending on the level of protection your situation requires.

**#1: Typical new two-storey slab on ground house**

This house is a typical suburban two storey house, with a slab on the ground floor and a carport and backyard terrace.

See pages 33–34

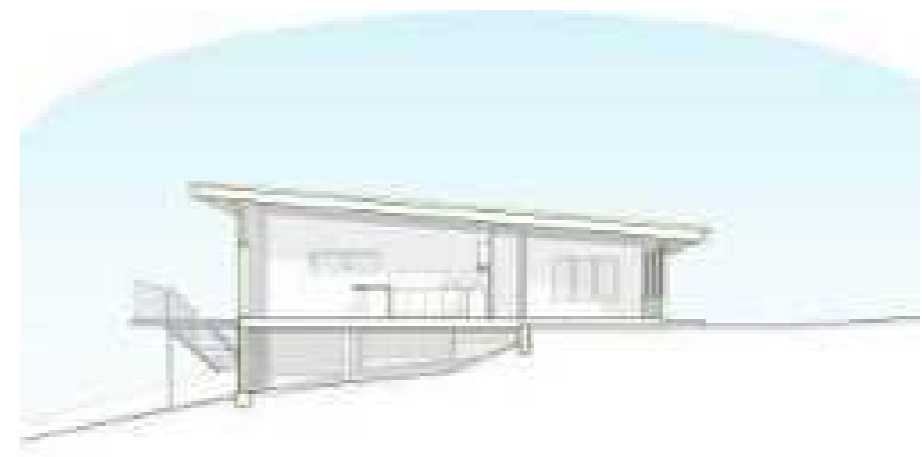


**#2: Building a new raised house on a sloped site**

Houses on slopes are often partially or completely raised off the ground, and as such require care when it comes to protecting the floor structure.

This design outlines principles that can be used to design raised houses.

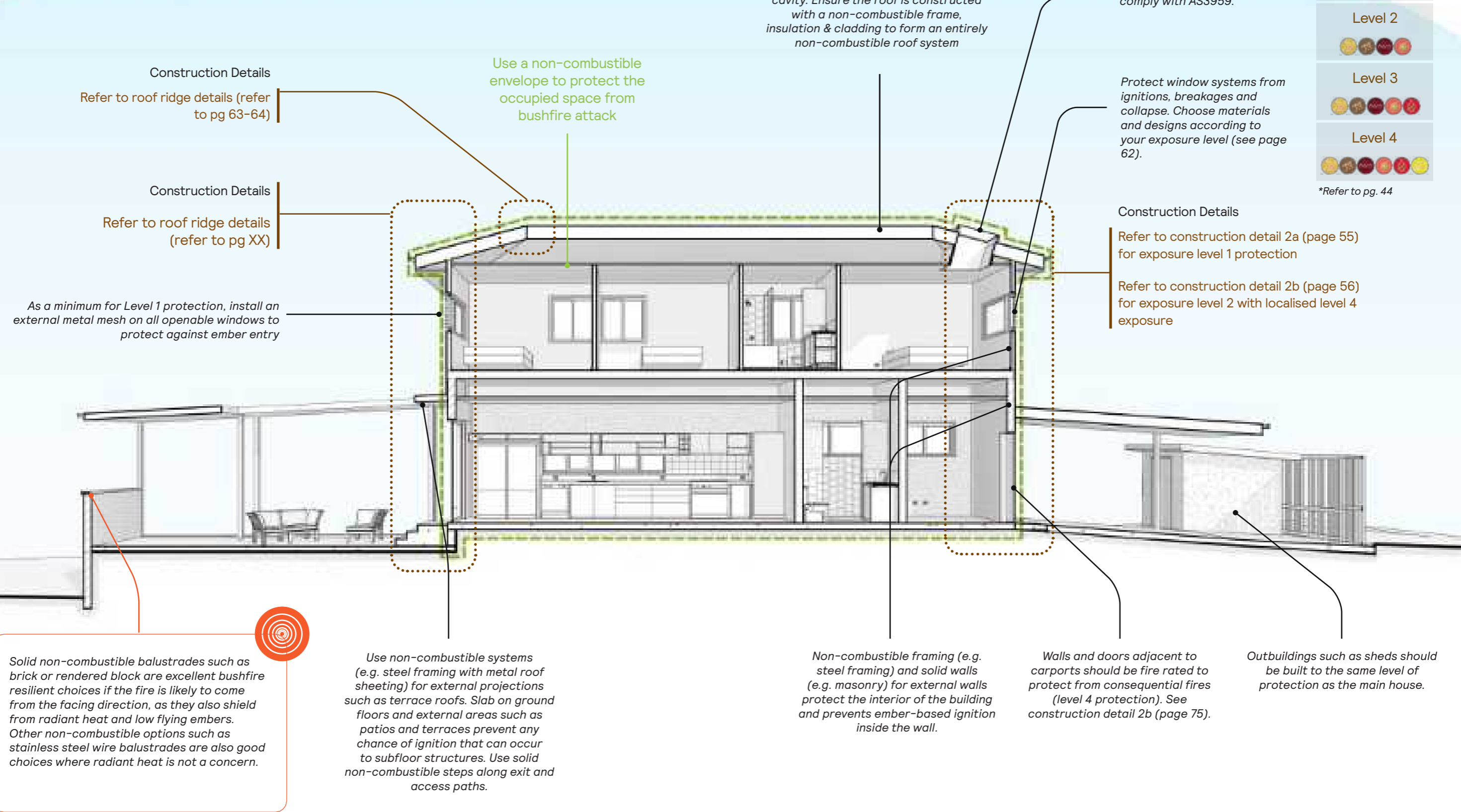
See pages 35–36



**Building design: Typical new house on a flat site or gentle slope (example house 1)**

Typical suburban double-storey up to level 3 protection.

Non-Combustible Framing and Cladding | Gentle Slope | Slab on Ground | 2-Storey.



Protection Levels*	
Level 1	
Level 2	
Level 3	
Level 4	

\*Refer to pg. 44

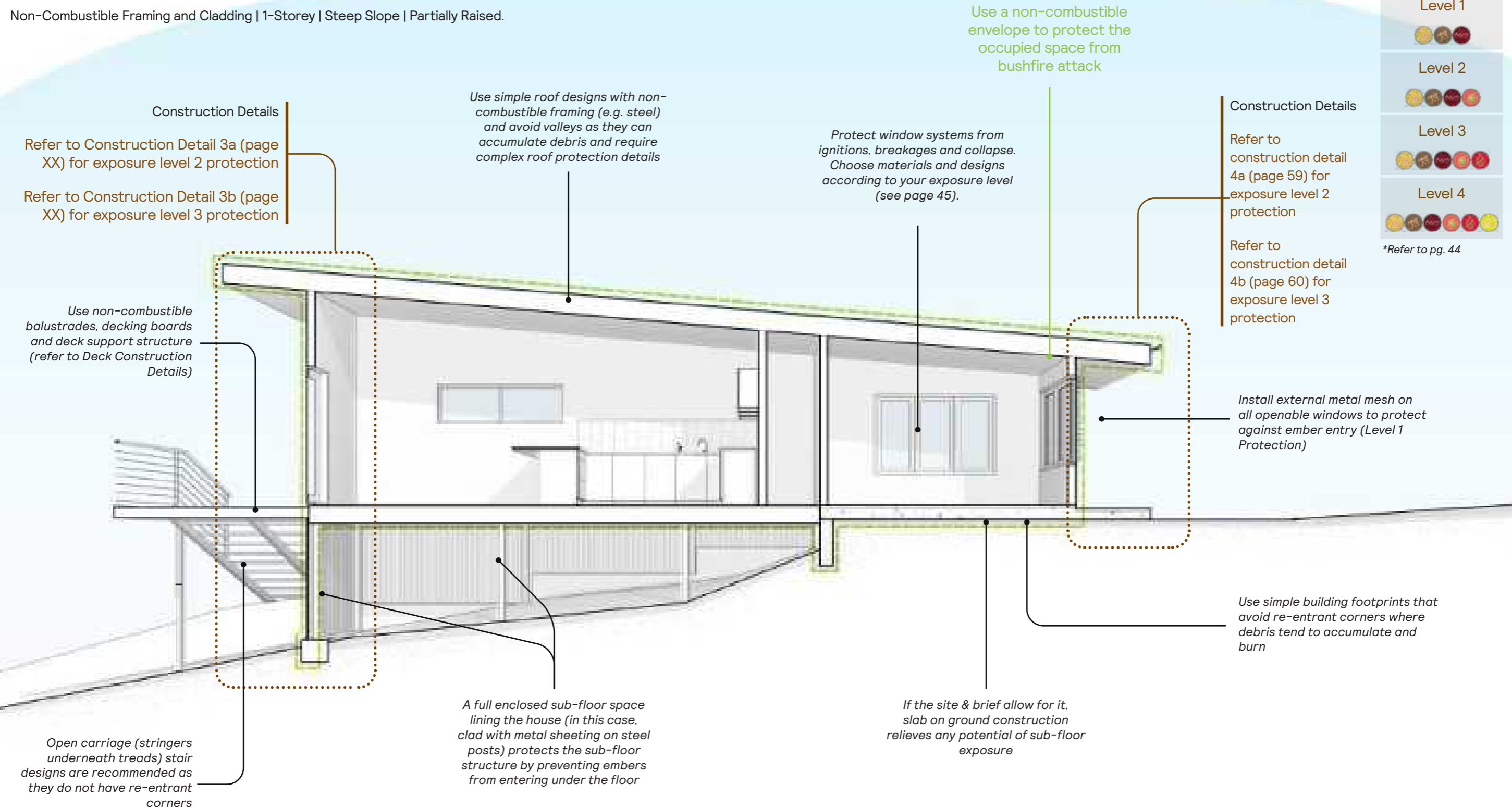
**Building design: Building a new house on a sloped site (example house 2)**

Built on a slope and partially raised of the ground. Simple building footprints and roof shapes reduce the number of areas where debris and embers can accumulate and eliminate potential ignition points.

Non-Combustible Framing and Cladding | 1-Storey | Steep Slope | Partially Raised.

Protection Levels*
Level 1 
Level 2 
Level 3 
Level 4 

\*Refer to pg. 44



### Choose a wall system

Embers can ignite combustible wall cladding either by direct attachment to certain materials like rough sawed timber, or by accumulating against cladding, causing localised flame contact. This flame contact is especially prevalent in re-entrant corners.

Localised flames can burn external facades or enter through small gaps in the facade and then burn the internal face of the facade, and adjacent framing.

Wind can assist this process by depositing additional debris onto the same locations where embers are likely to land. Radiation can promote ignition by drying out and heating facades increasing the likelihood and severity of flame spread from ember ignition. Wall cladding can be damaged by direct flame contact from surrounding burning objects.



Damaged wall from burning vegetation. Source: CSIRO

### Design principles for external wall systems (including frames and wall claddings):

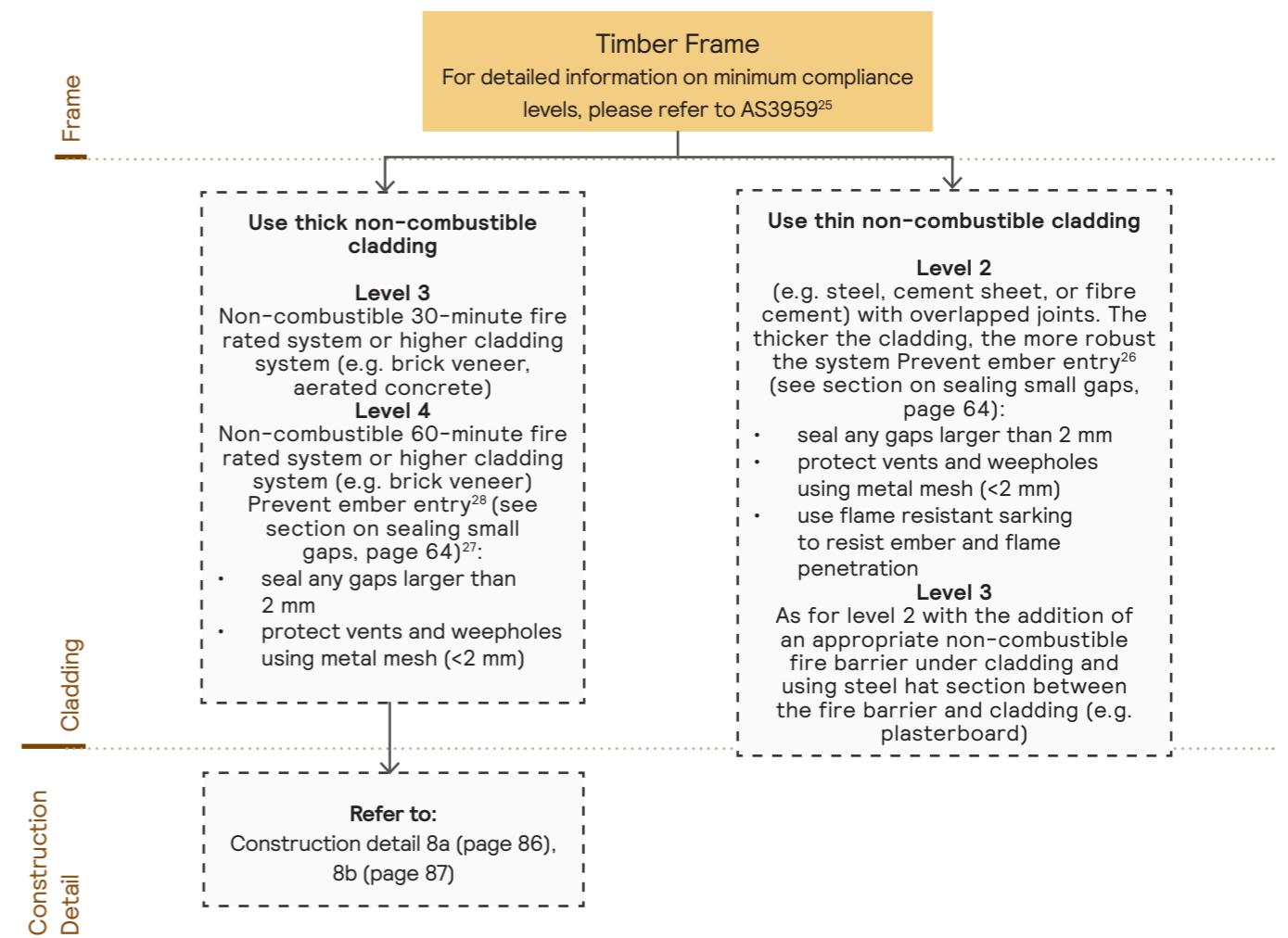
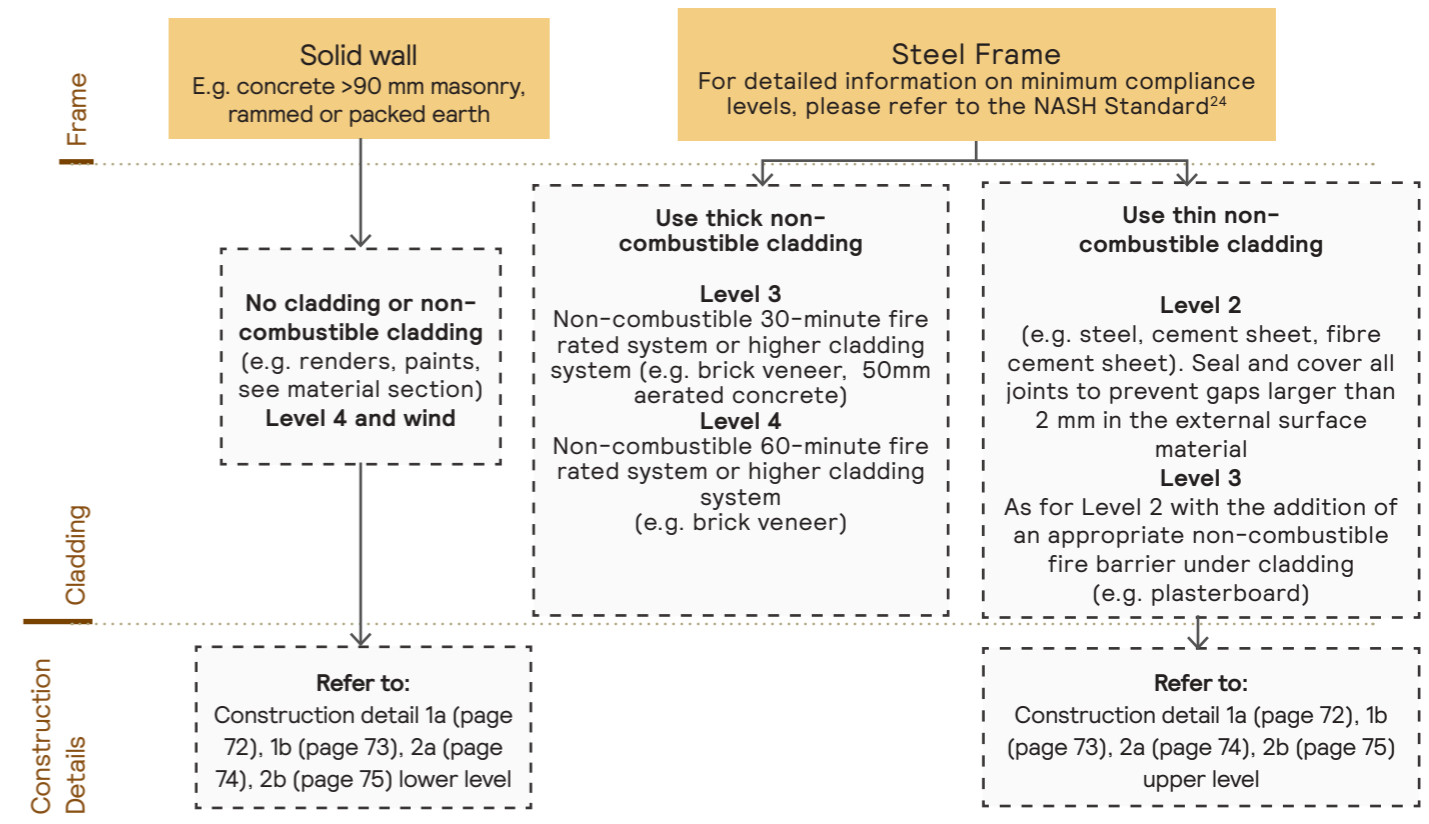
- Resist ember entry into wall cavities and the interior of the building, and prevent ember-based ignition of combustible debris, which have accumulated outside and inside the wall.
- Resist ignition by radiant heat flux and flame contact with both the exterior and interior of the building.
- Resist wind loads and wind-driven debris.
- Eliminate or reduce the use of wall junctions with other building elements which create re-entrant corners where embers can accumulate (e.g. a carport roof).
- Prevent wall systems from burning and producing toxic gases that may spread to the interior of the building and exit routes.
- Where the framing is combustible, multiple layers of non-combustible cladding should be used and great care should be taken around wall perforations and edge details in order to prevent flame contact.
- Consider a robust approach, using both non-combustible cladding and framing materials.



Example of house built using non-combustible framing material (steel frame). Source: KNK Builders

#### Avoid the following:

- Relying on external wall cladding to resist ember entry or flame contact from burning debris unless the framing material is non-combustible.
- Relying on conventional sarking (including flammability index 5 rated) to protect combustible framing. The typical building wraps (sarking) used under cladding offer little resistance to the spread of flame to the combustible framing underneath.
- Use combustible jointing strips.
- Seal gaps using timber beading strips.



24. NASH Standard (2014) Steel framed construction in bushfire areas.

25. Australian Standards, AS 3959 (2018) Construction of buildings in bushfire-prone areas.

26. If using for a new build or recladding the house, add fire resisting sarking and class 1 durability timber (level 1 only).

27. As specified in Australian Standard AS5604 (2005) Timber - Natural durability ratings.

### Floor System

Embers and surface fire can ignite unprotected underfloor spaces, underfloor enclosures and combustible supporting posts. It is common for debris to build up in these areas and present a considerable fine fuel source. It is also common for people to store heavy fuels, such as firewood, building materials, sporting equipment and gardening equipment in their underfloor spaces. However, this practice should be avoided in unenclosed floor spaces, as these elements are vulnerable to ignition and the subsequent fire can threaten the floor and its support systems.



Underfloor damage caused by burning garden bed, suppressed by fire agency before it burnt into the house. Source: CSIRO

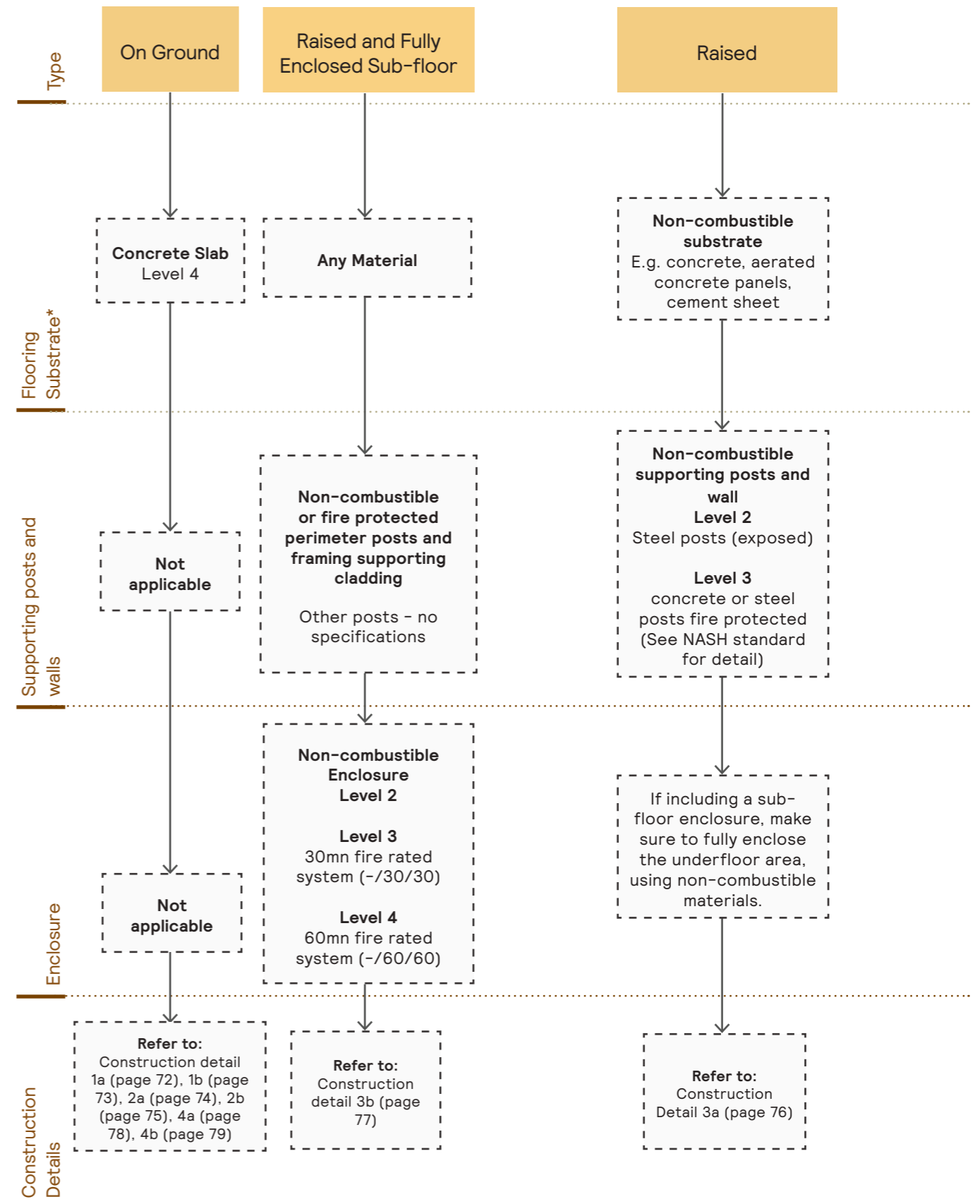
### Design principles for flooring systems (including supporting posts and enclosures)

- Resist surface fire and ember attack from entering the underside of the building.
- Resist ignition from radiant heat flux and direct flame contact.
- Protect floors and subfloors from burning, collapse, displacement, breach and producing additional heat to:
  - the interior of the building
  - other building elements
  - exit routes.
- Prevent floor systems from burning and producing flames and toxic gases that may threaten the interior of the building and exit routes.

**Avoid the following:**

- Storing combustible objects in open underfloor spaces, if present.
- Installing a combustible access door in an enclosed underfloor space, if present.
- Using combustible support structures or framing behind thin cladding to enclose under floor spaces even if the cladding is non-combustible.
- Exposing combustible flooring, irrespective of the height of the floor above ground level unless underfloor volume is fully enclosed.

\*Flooring substrate refers to the underside of your floor lining, e.g. timber floorboards on a concrete slab would be described as having a non-combustible flooring substrate



### Choose a roof system

Ember attack can ignite combustible eaves, fascia, and debris matter that has accumulated in gutters, along ridge lines, in roof valleys, against roof penetrations and inside the roof cavity. This debris is vulnerable to ignition and the subsequent fire can ignite surrounding elements if they are combustible such as the eaves, fascias, roof framing and roof battens. The sarking, including flammability index 5-rated sarking, does not offer a barrier to flames. Ember and potential flame entry into the roof cavity is often difficult to spot and is almost certain to result in total house destruction if the roof contains combustible framing or other combustible elements.



Debris accumulation in gutter.

### Design principles for roof systems (including supporting posts and enclosures)

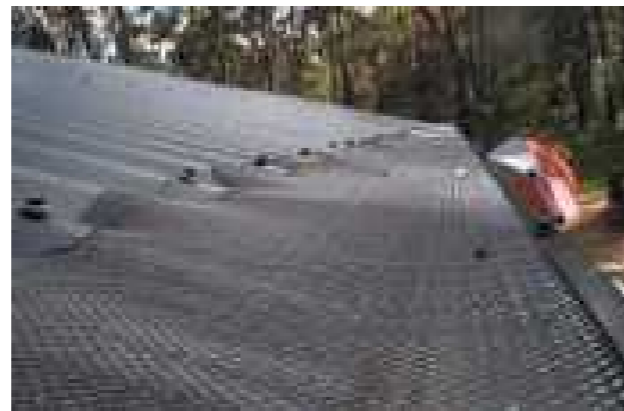
- Safeguard the roof system from igniting, collapse, displacement and breach.
- Prevent ember accumulation and entry into the roof cavity.
- Prevent roof systems from igniting, burning and producing additional heat to:
  - the interior of the building
  - other building elements
  - exit routes.

Choose a simple roof profile to avoid debris and ember accumulation but if a ridge or valley are present, refer to construction detail 10a and 10b.

### Gutters and gutter guards

Accumulated debris and ember attack can build up in gutters and provide flames to adjacent roof elements:

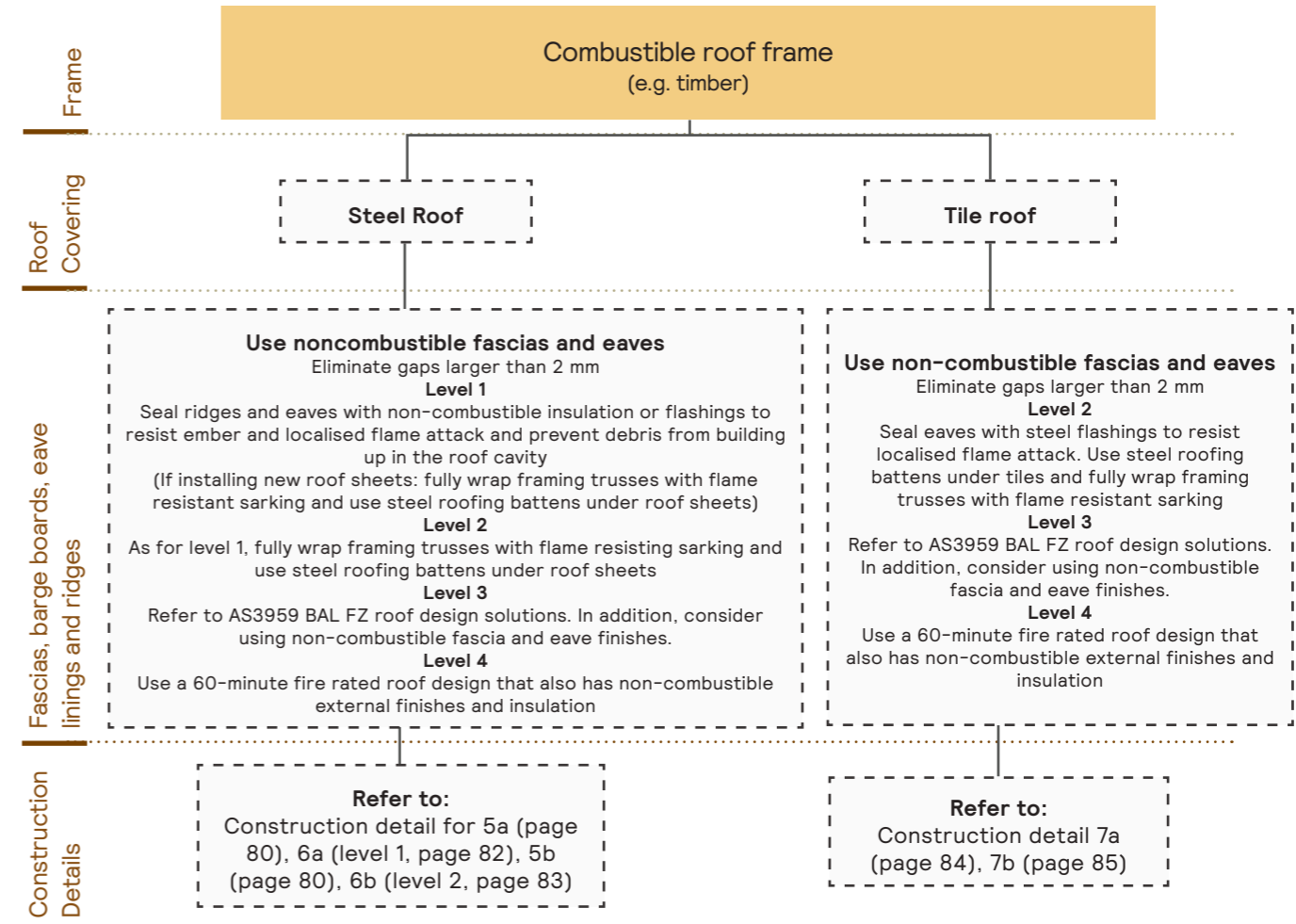
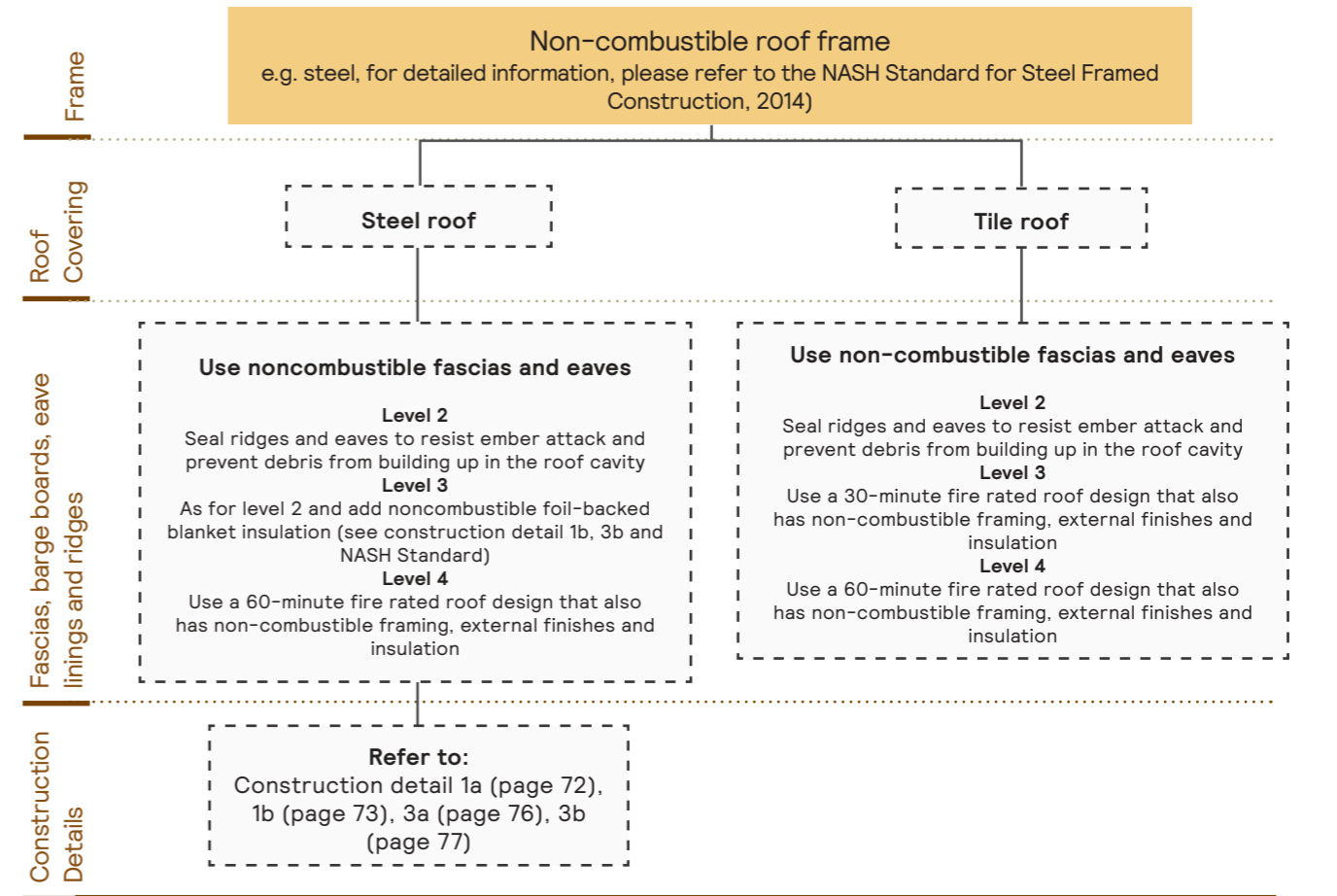
- use non-combustible gutters and gutter guards
- avoid adjacent combustible elements such



Metallic gutter guard. Source: Paul Whittington

#### Avoid the following:

- Complex roof forms with many valleys and ridges as they require complex roof protection details to prevent ember entry.



## Window and glazing systems

Combustible window components, such as frames and seals, can ignite when exposed to ember attack, flame contact or radiant heat attack.

Glazing can crack or shatter when exposed to radiant heat or flame, depending on the duration and intensity of the exposure. Damaged glazing can provide a point of entry for ember attack, which can ignite internal furnishings.

### Design principles for window systems (including glazing, frames, screens and shutters)

- Safeguard window systems from ignitions, breakages and collapse.
- Prevent embers from accumulating and gaining entry through windowsills.
- Resist ignition burning, and production of additional heat.



Cracked window from adjacent vegetation burning. Source: CSIRO

### Design strategies

Glazing:

- Standard glass (annealed glass)–**level 1**
- Toughened glass–**level 2**
- Fire rated window–**Level 3 or 4**<sup>29</sup>
- Alternative is to use bushfire shutters–**level 4**<sup>30</sup>

Frame:

- Class 1 durability timber acceptable<sup>32</sup>, non-combustible preferred–**level 1**
- Window frames, sills, reveal should be constructed using non-combustible materials–**level 4**

Openable section windows 31:

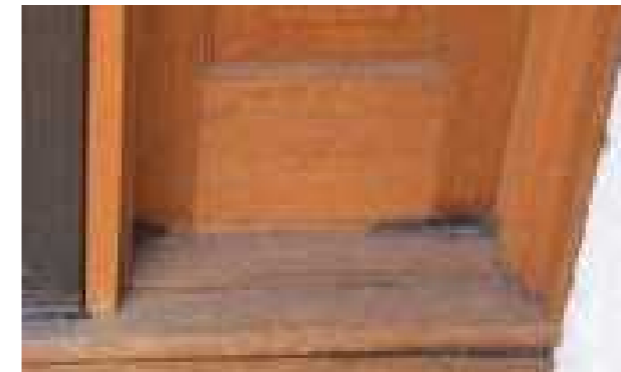
- Install external metal mesh on all openable windows to protect against ember entry (with aperture no larger than 2mm) –**level 1 to 4.**

Windows that extend to the floor need to follow specific building requirements:

- Toughened safety glass or glass blocks for all glazing within 400 mm of ground and screen (for additional details, please refer to AS 3959).

## Door Systems

Combustible parts of the door can ignite when exposed to ember attack, direct flame contact or radiant heat attack. These attacks may come from consequential fires (e.g. door mats) or from the bushfire itself. Glazing included in door systems can break when exposed to radiant heat or flame, depending on the duration and intensity of the exposure, the type of glass and type of seal. See Window and glazing systems for more information. Doors may form a key part of an exit pathway.



Embers attack in re-entrant corners. Source: CSIRO

### Design principles for door systems (including materials, frames, screens and shutters)

- Prevent all doors (including thresholds, framing, door materials, fixtures and draft excluders) from collapse, displacement and burning.
- Prevent embers from gaining entry through the door threshold sill.
- Prevent door systems from igniting, burning and producing toxic gases that may then threaten either the interior of the building or an exit route.

### Design strategies

All exposed components should be made of non-combustible materials. Fixtures and materials should be durable and heat resistant. Fixtures and materials should be rated to withstand the extreme wind conditions and heat loads expected during a bushfire event. Doors should be self-closing and easily opened from the inside without the use of a key or deadlock. Also ensure there are no gaps between the door and the door frame (including the threshold).

Doors, framing and thresholds

- All doors should be tight fitting, with gaps smaller than 2 mm. If this is not possible, install weather draft strips and seals to ensure there are no gaps greater than 2 mm.
- Non-combustible, the use of class 1 durability timber solid core doors is acceptable–**level 1**
- Should be constructed using non-combustible materials–**level 2**
- Non-combustible fire rated 30 minutes –**level 3**<sup>30</sup>
- Non-combustible fire rated 60 minutes –**level 4**<sup>30</sup>

Door protection:

Screens\*

- Install a non-combustible screened security door which is self-closing (with apertures no larger than 2 mm).

Glass sliding door

- As for windows for the equivalent level.

Avoid the following:

- Using combustible cladding around the window.
- Putting combustible objects close to the window.
- Relying on shutters alone to protect windows as they are often not in their closed position when the bushfire arrives.



Avoid the following:

- Do not use combustible cladding on or around the door




29. See manufacturer specifications.

30. See manufacturer specifications.

31. Any installation should be compliant with AS3959.

32. Australian Standard AS5604 (2005) Timber-Natural durability ratings.


## Active protection systems

System	Design Principles	Design Strategies*
<b>Shutters</b>	Tight fitting shutters offer protection to window systems by preventing embers from accumulating on windowsills and by blocking flame, radiant heat and, airborne debris from reaching the window glass, frame and seals.	<ul style="list-style-type: none"> <li>• Shutters should be permanently fixed to the house and ideally incorporate a reliable means of automated deployment.</li> <li>• Shutters should be made of non-combustible materials.</li> <li>• Ensure the system is tight fitting to avoid gaps larger than 2 mm.</li> <li>• Bushfire shutter must comply with AS3959 and should be non-combustible.</li> </ul>
<b>External spray systems</b>	<p>External spray systems can wet down combustible external elements such as eaves, facades, decking and surface fuels. External spray systems are not effective in sealing gaps or preventing the spread of fire to parts of the house that are sheltered from the weather, such as the roof cavity, wall cavities, under floor areas and the occupied areas of the house.</p>  <p>Because of these limitations, external spray systems should be considered as one part of a wider holistic approach to bushfire resilience. External spray systems should be used in combination with other design measures to reduce the overall bushfire risk rather than expecting them to provide a complete solution.</p>	<ul style="list-style-type: none"> <li>• Maintain a supply of water, with adequate water pressure that can continue to operate if both mains water pressure and power supply are lost.</li> <li>• Consider using automatic activation using a combination of smoke or heat sensors.<sup>34</sup></li> </ul>

34. For detailed information refer to regulation and product specifications, including Standards Australia (2012) AS 5414-Bushfire water spray systems. Sydney: SAI Global.

Service	Design Principles	Design Strategies*
<b>Internal sprinkler systems</b>	Internal sprinkler systems offer protection against internal ignition, and can control the spread of fire within buildings and increase the duration of time the building may remain tenable. In some situations, internal sprinkler systems may prevent the total loss of the building. In bushfires, the ignition can occur externally, in the building cavities or within the occupied space of the house. Domestic building sprinkler standards cover ignition and spread within the occupied spaces of the house and may be compromised by fire spread within building cavities that may either damage sprinkler pipework or lead to rapid entry into multiple rooms (e.g. a roof cavity fire leading to multiple ceiling collapse).	<ul style="list-style-type: none"> <li>• Follow the relevant standards for domestic building sprinklers.</li> <li>• Consider using additional sprinkler heads in the roof cavity, and under floor spaces if they contain or are composed of combustible materials.</li> <li>• Consider linking the system with an external spray system if there are external combustible facades or adjacent features.</li> </ul>

Services

System	Design Principles	Design Strategies*
<p><b>Water</b></p> <p>Maintain a water supply to the house for both active and passive defense.</p> <p>A static water supply should be adequately sized for the combination of all possible uses in a bushfire and full to this level through a bushfire season. The tank and pipework should be able to remain viable throughout the bushfire event. Pumping systems should be designed to be able to continue to provide adequate water pressure for all uses assuming that both mains water pressure and mains power are lost.</p> <p>Systems that can automatically switch over are preferred.</p>  <p><i>Combustible pipe fitting melted. Source: CSIRO</i></p>	<ul style="list-style-type: none"> <li>• Water tanks should be constructed using non-combustible material, such as metal or concrete, or alternatively can be installed underground (as a subterranean tank).</li> <li>• Avoid plastic water tanks.</li> <li>• Use non-combustible pipework.</li> <li>• Where possible, use static water pressure if there is suitable terrain to support this.</li> <li>• If an external water pump is required or desired, ensure the water pump is designed and protected to allow it to operate under extreme bushfire conditions. Electric, petrol and diesel pumps are susceptible to radiant heat and flame contact, while petrol and diesel pumps have the added susceptibility to ember attack and elevated air temperatures, which can cause fuel vaporisation or air inlet filter ignition. Careful consideration of the refueling requirements of these pumps is also important. Having a fuel tank that is sized so as not to require refuel during a bushfire event is the preferred option. The logistics of accessing the pump and safely refueling it in the middle of a bushfire event presents a range of life safety issues.</li> <li>• Size the water tank for all possible uses including firefighting and static water supply.</li> <li>• Use non-combustible tank and pipework for all elements that are less than 150 mm below the earth.</li> <li>• Ensure the water pump is designed and protected to allow it to operate under extreme bushfire conditions.</li> </ul>	

Service	Design Principles	Design Strategies*
<p><b>Electricity</b></p> <p>Maintain an electricity supply and manage electrical infrastructure appropriately.</p> <p>Protect electrical infrastructure on the property in a way that does not exacerbate bushfire hazards or obstruct firefighting.</p> <p>Consider the merits of a backup electrical power supply.</p>	<ul style="list-style-type: none"> <li>• If possible, install electrical infrastructure underground.</li> <li>• Create a cleared, open space between vegetation and any exposed electrical infrastructure (such as poles and wires).</li> <li>• For a backup power supply, consider either a battery backup system linked to a solar power system, or a protected generator. In each case, an automatic switch over is preferred to a manual one as failure of electricity supply is most common during the peak of the fire event.</li> </ul>	
<p><b>Gas (piped)</b></p> <p>Protect gas lines from bushfire actions both external to the house and within the cavities within the house. Isolate gas supply prior to fire arrival and follow gas safety procedures when reactivating gas supply after an event.</p>	<ul style="list-style-type: none"> <li>• Install gas lines below ground to minimise the risk of explosion.</li> <li>• Use metal connections, pipes and fittings in all above ground locations, including within building cavities.</li> <li>• Avoid using PEX gas piping above ground and in building cavities, as it can lose integrity at 80°C which could be achieved within building cavities during a bushfire.</li> </ul>	
<p><b>Gas (cylinders)</b></p> <p>When a gas bottle vents, it can ignite the house or any combustible materials in the path of the flare.</p> <p>Protect people from the hazards associated with gas cylinders. A gas tank that is not secure may fall and if the tank continues to be heated in this position it may violently explode. Such explosions are common in the period following the passage of the fire front and pose a significant threat to people and houses.</p> <p>Protect gas cylinders from falling by attaching them to a solid steel or masonry structure that cannot collapse even if the adjacent structure burns.</p>	<ul style="list-style-type: none"> <li>• Refer to local installation regulations.</li> <li>• Securely attached gas cylinders to a solid structure with a metal chain or cable.</li> <li>• Ensure the area around the cylinder is clear of vegetation and other combustible materials.</li> <li>• Use metal connections, pipes and fittings.</li> <li>• Direct the vent on the gas cylinder away from structures and exit pathways.</li> </ul>	

# Bushfire Resilient Construction

## How to use this section

This section provides information about bushfire resilient construction systems applicable to:

- wall systems
- floor systems
- roof systems
- verandahs and decks.

The details in this section refer to the protection levels on page 29 as there are often multiple solutions depending on the level of protection your situation requires.

These are examples of construction designs, for complete information refer to the Australian Standards AS3959 and NASH Standard. Refer to the bushfire resilient materials table for information about the advantages and disadvantages of various material types.

**Protection Levels\***

Level 1

Level 2

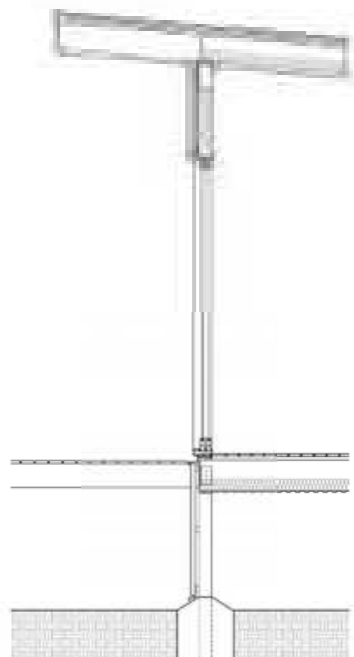
Level 3

Level 4

\*Refer to pg. 44

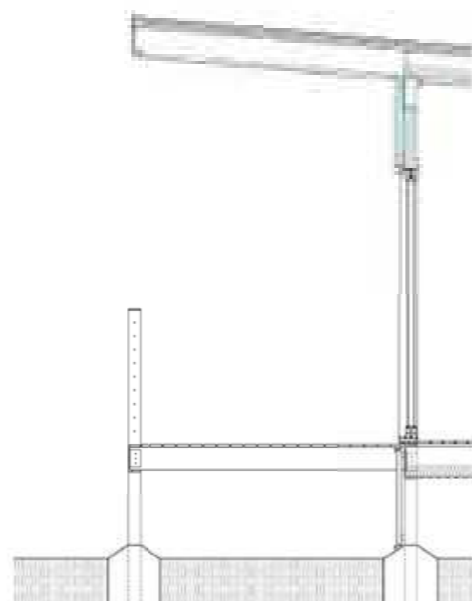
### 1. Complete wall detail section: new house

Details 1-4



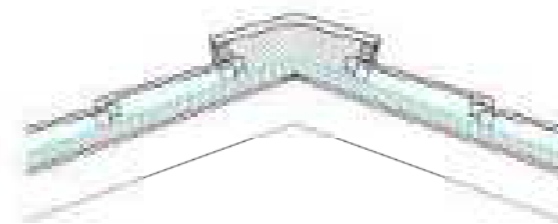
### 3. Deck construction: new deck

Detail 9



### 5. Roof ridges: new

Details 9-10



### 6. Roof valleys: new

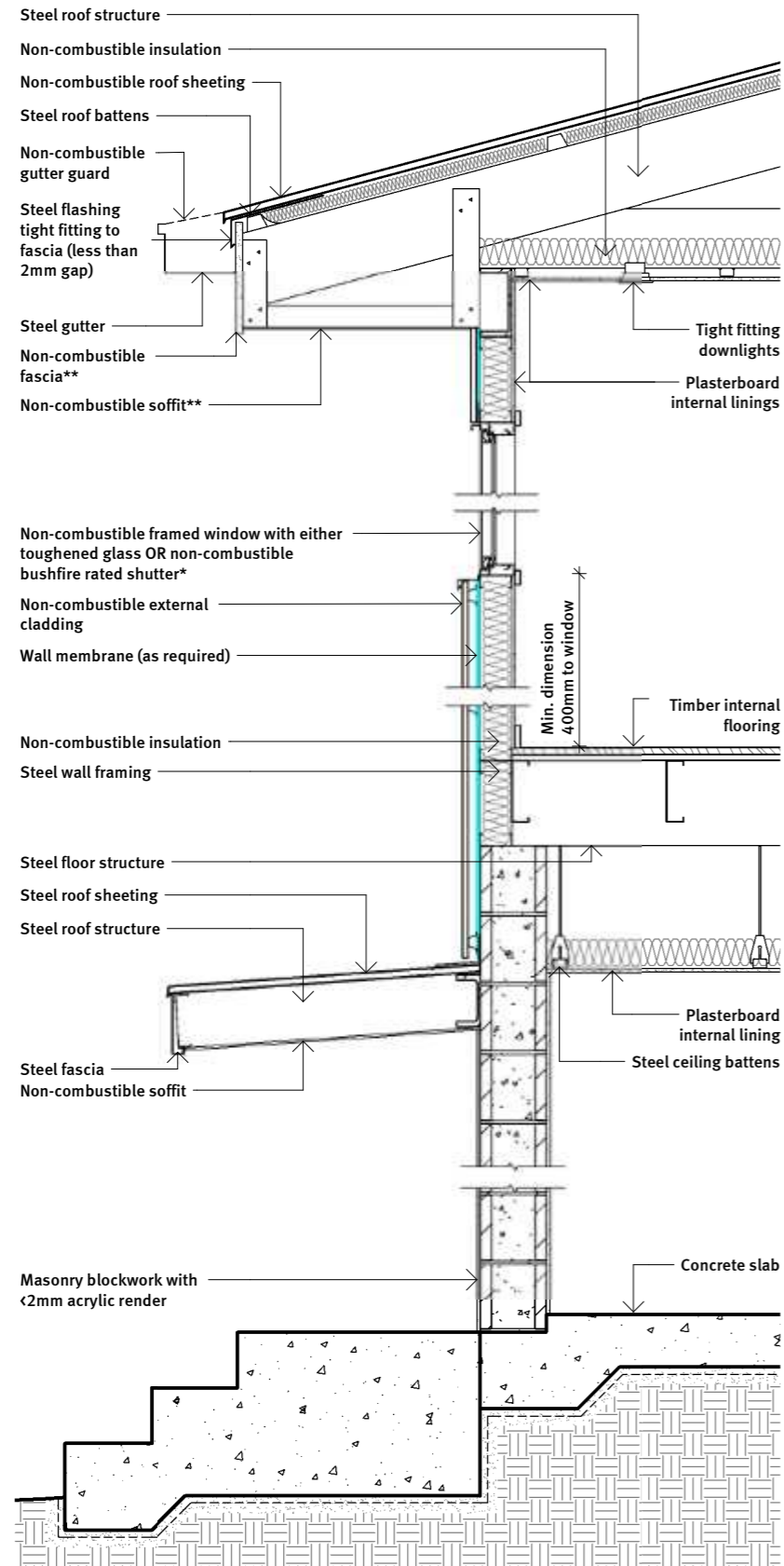
Details 9-10



### Construction detail example 1a

#### Non-Combustible Frame- Level 2 Exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, an external window and adjoining awning roof that is resilient up to a level 2 exposure.

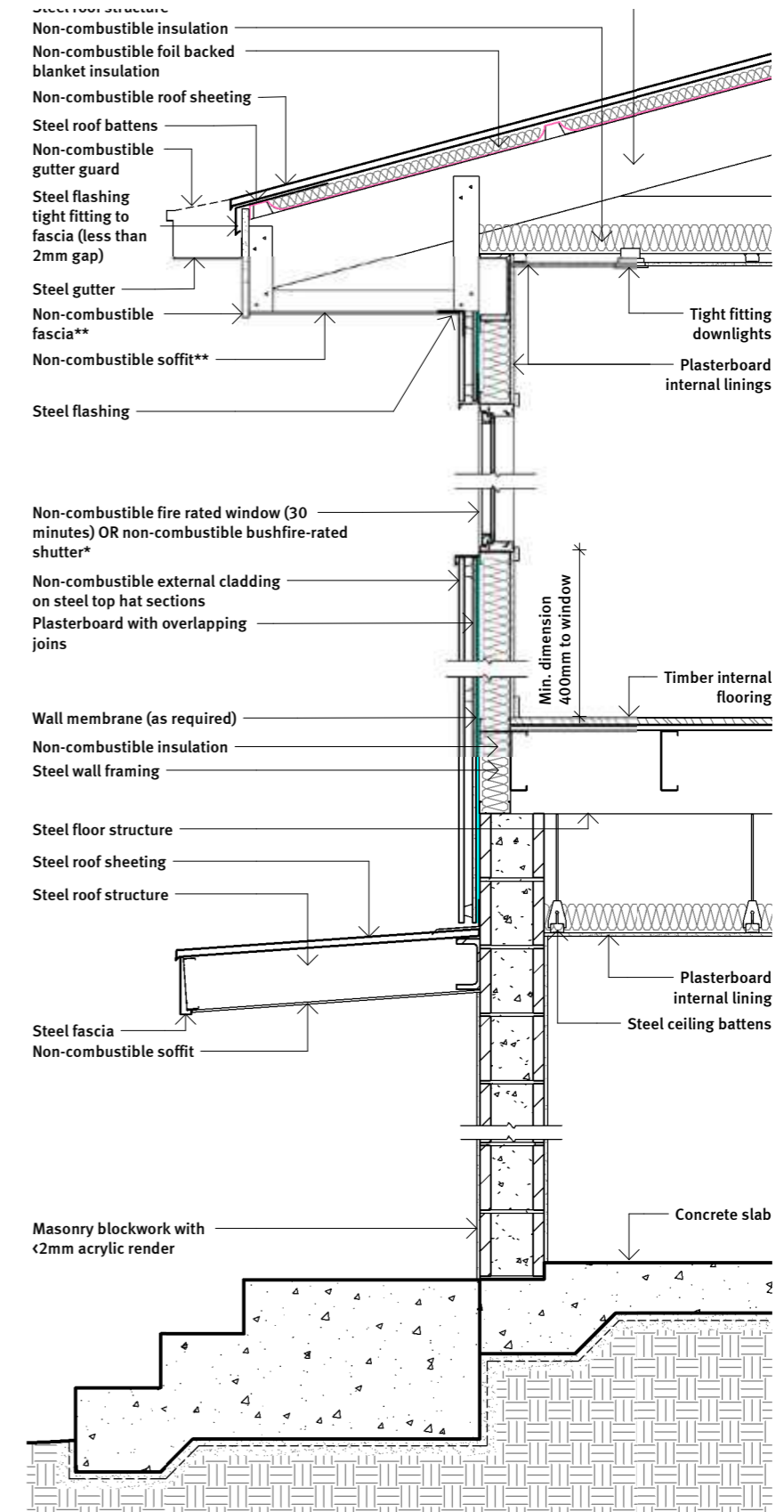


\* For more information refer to AS3959:2018  
 \*\* Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion

### Construction detail example 1b

#### Non-Combustible Frame - Level 3 Exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, an external window and adjoining awning roof that is resilient up to a level 3 exposure.



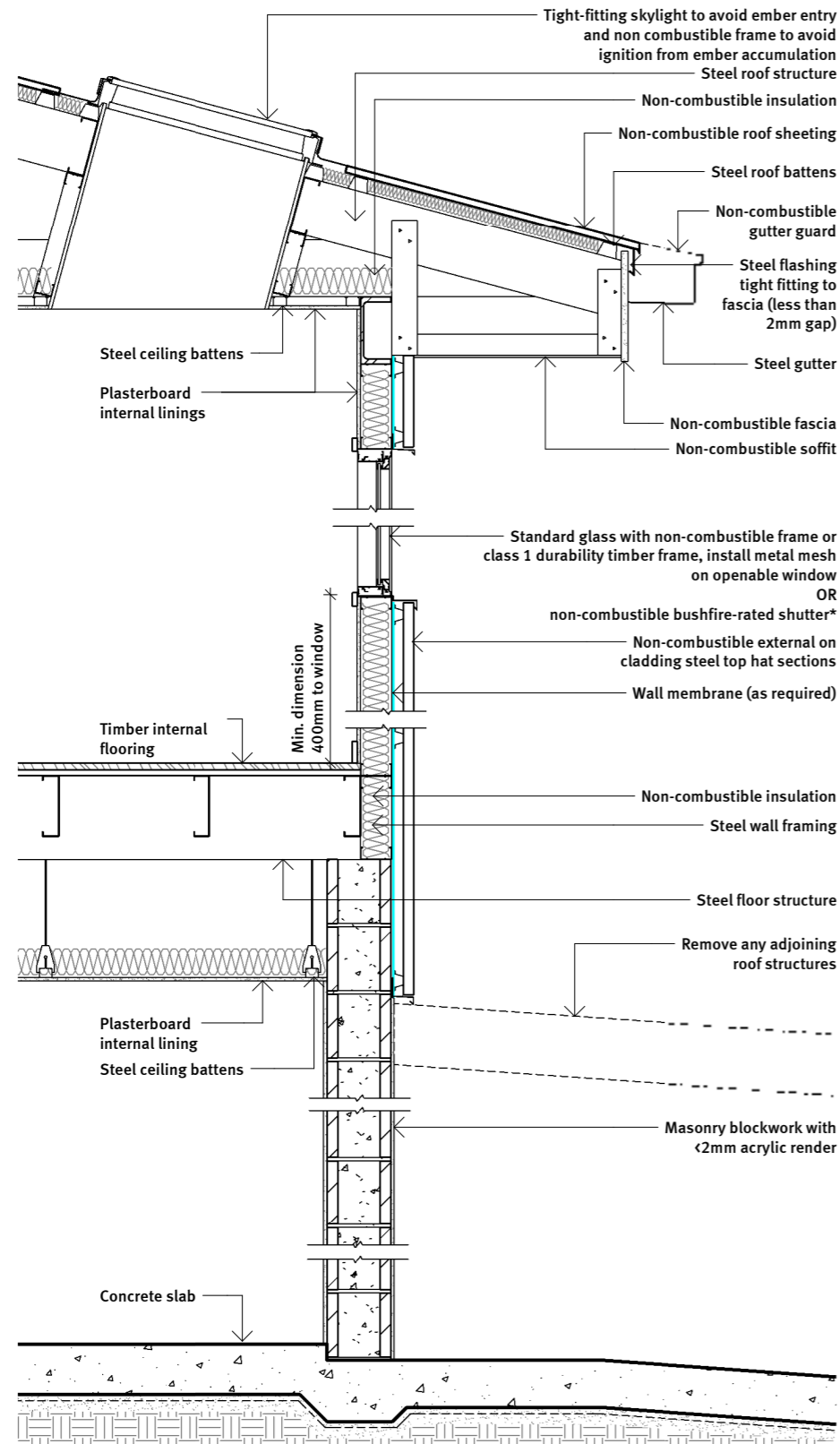
— Non-combustible foil backed insulation

\* For more information refer to AS3959:2018  
 \*\* Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion

### Construction detail example 2a

#### Non-combustible frame - Level 1 Exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, a skylight and external window that is resilient up to a level 1 exposure.

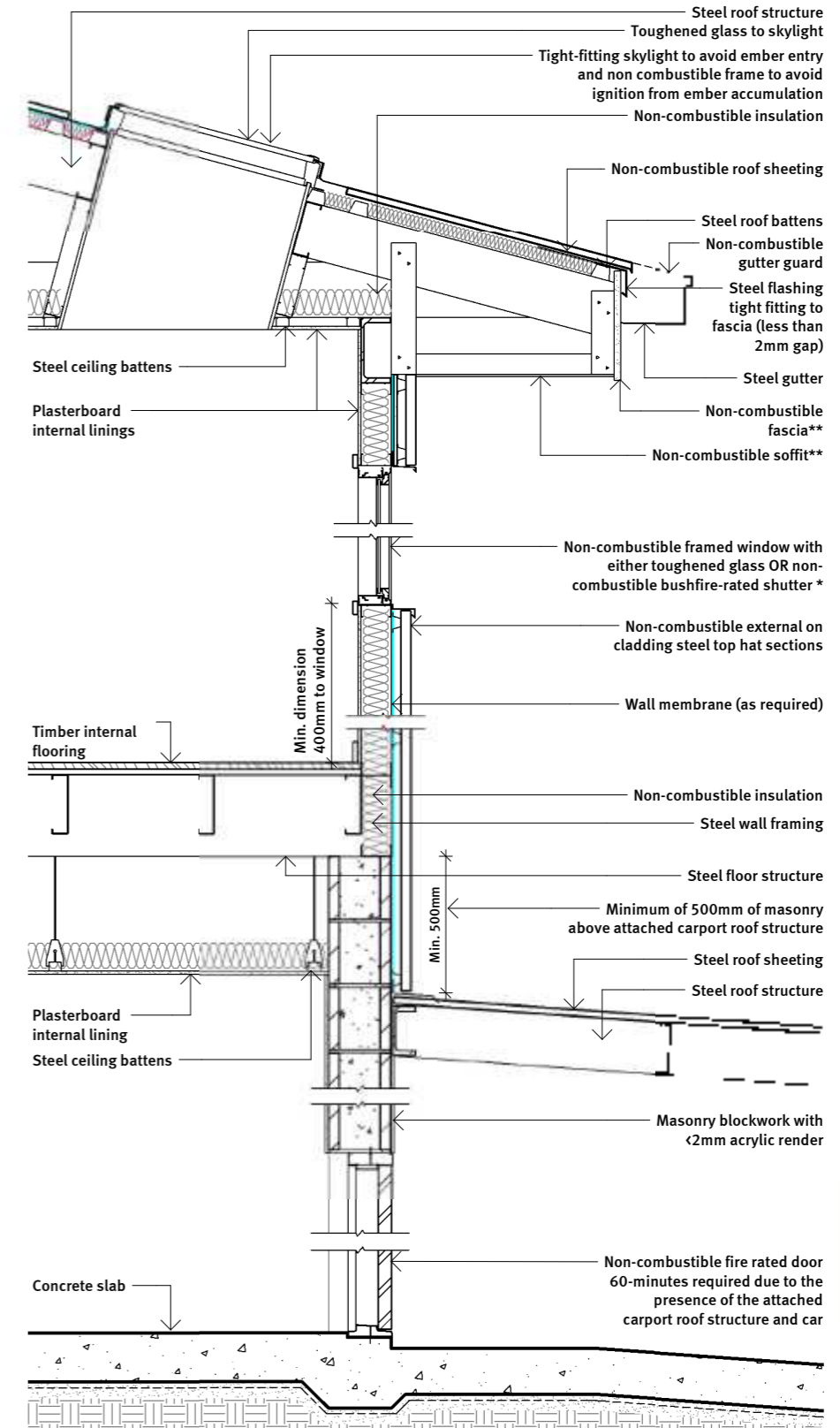


\* For more information refer to AS3959:2018

### Construction detail example 2b

#### Non-combustible frame - Level 2 with localised Level 4 exposure

The following scenario shows an example of a house with non-combustible external masonry walls on the lower level, non-combustible steel framed walls on the upper level, a skylight, external window and adjoining carport roof that is resilient up to a Level 2 exposure. In this scenario, a fire rated door is required at the adjoining roof structure.



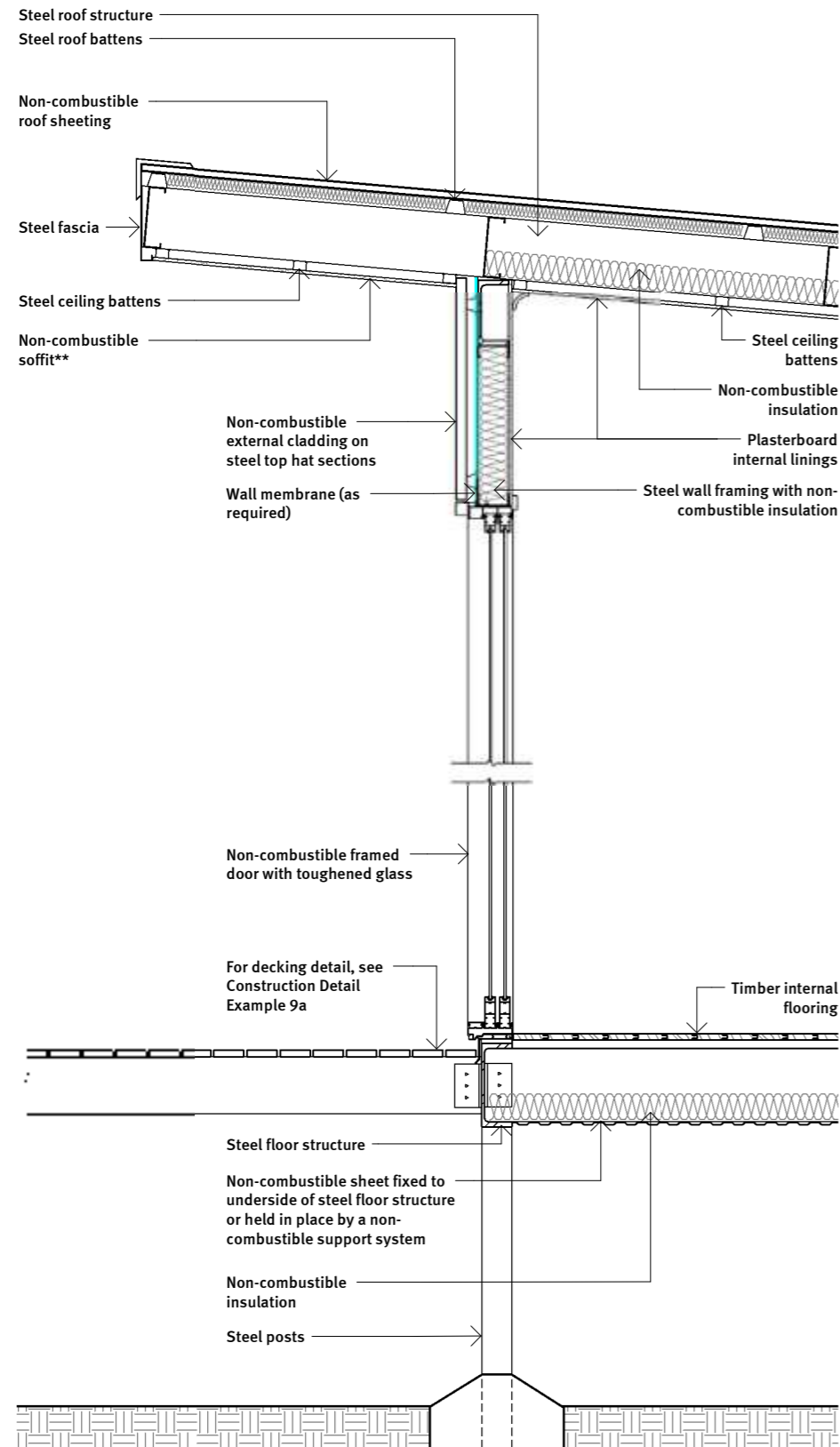
\* For more information refer to AS3959:2018

\*\* Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion

### Construction detail example 3a

#### Non-combustible frame - Level 2 exposure

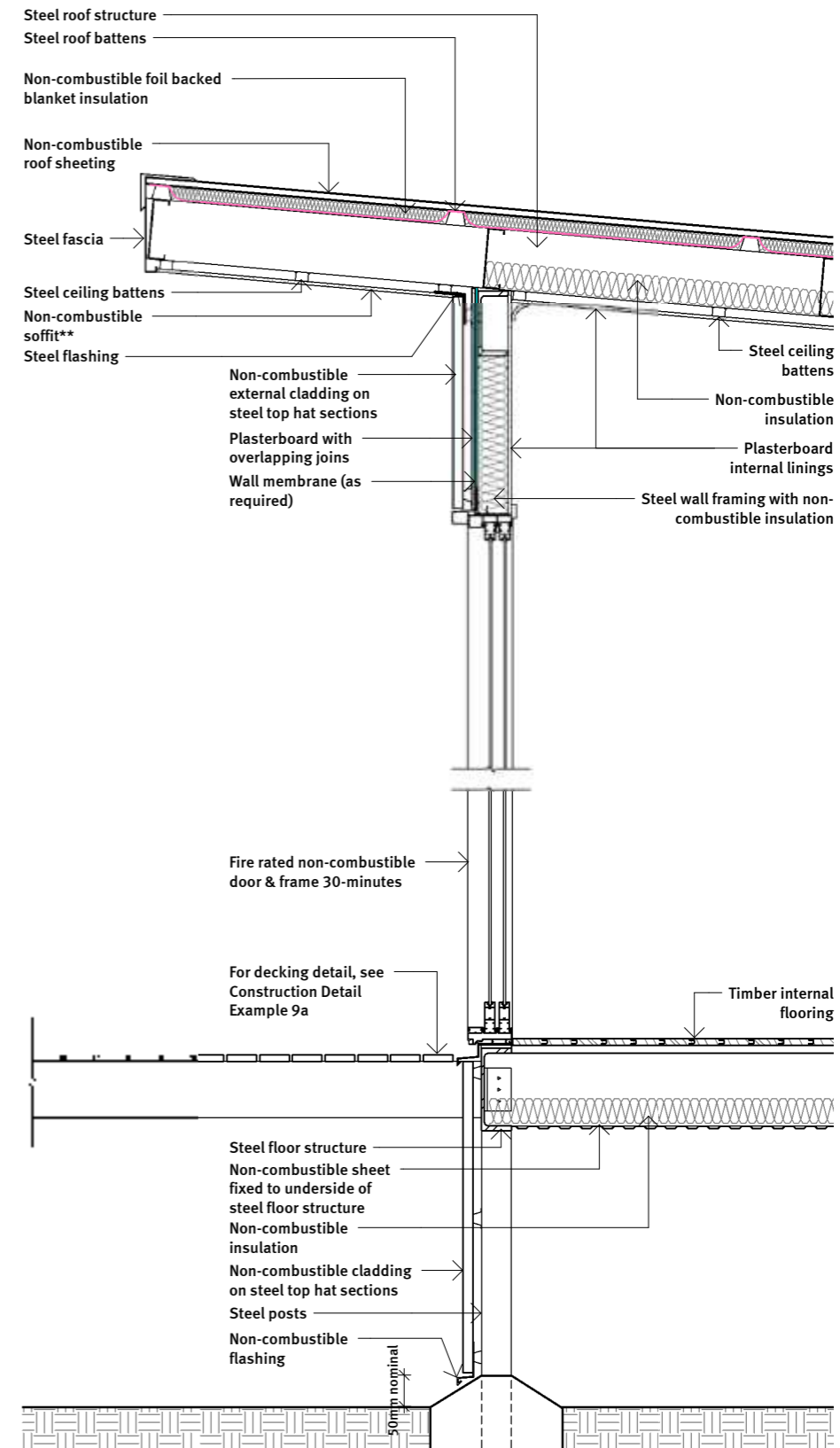
The following scenario shows an example of a raised, non-combustible framed house with a skillion roof, external door and adjoining deck that is resilient up to a level 2 exposure.



### Construction Detail Example 3b

#### Non-combustible frame - Level 3 exposure

The following scenario shows an example of a raised, non-combustible framed house with a skillion roof, external door and adjoining deck that is resilient up to a level 3 exposure.

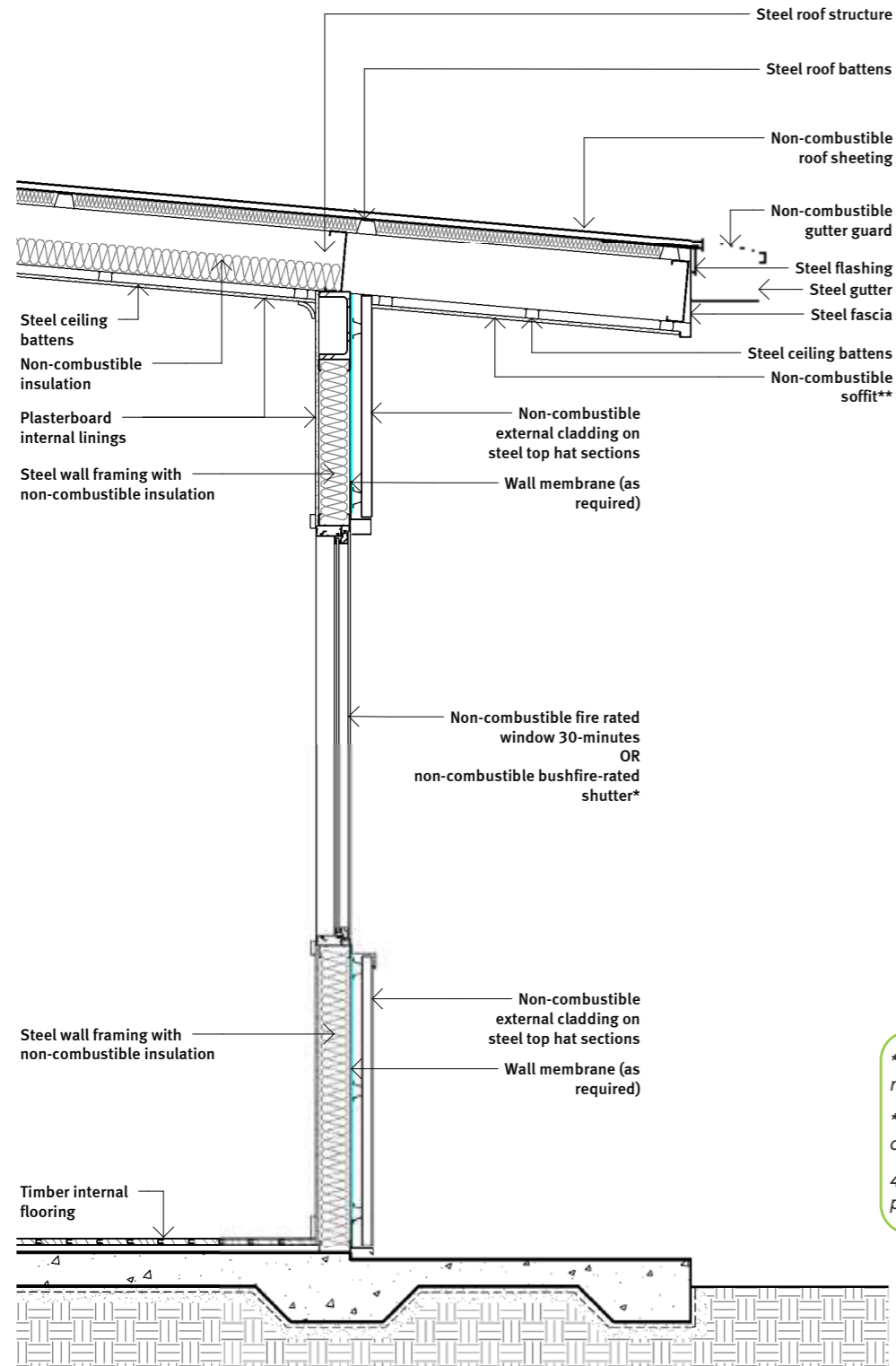


Non-combustible foil backed insulation

### Construction detail example 4a

#### Non-combustible frame - Level 2 exposure

The following scenario shows an example of a non-combustible framed house with a skillion roof that is resilient up to a level 2 exposure.

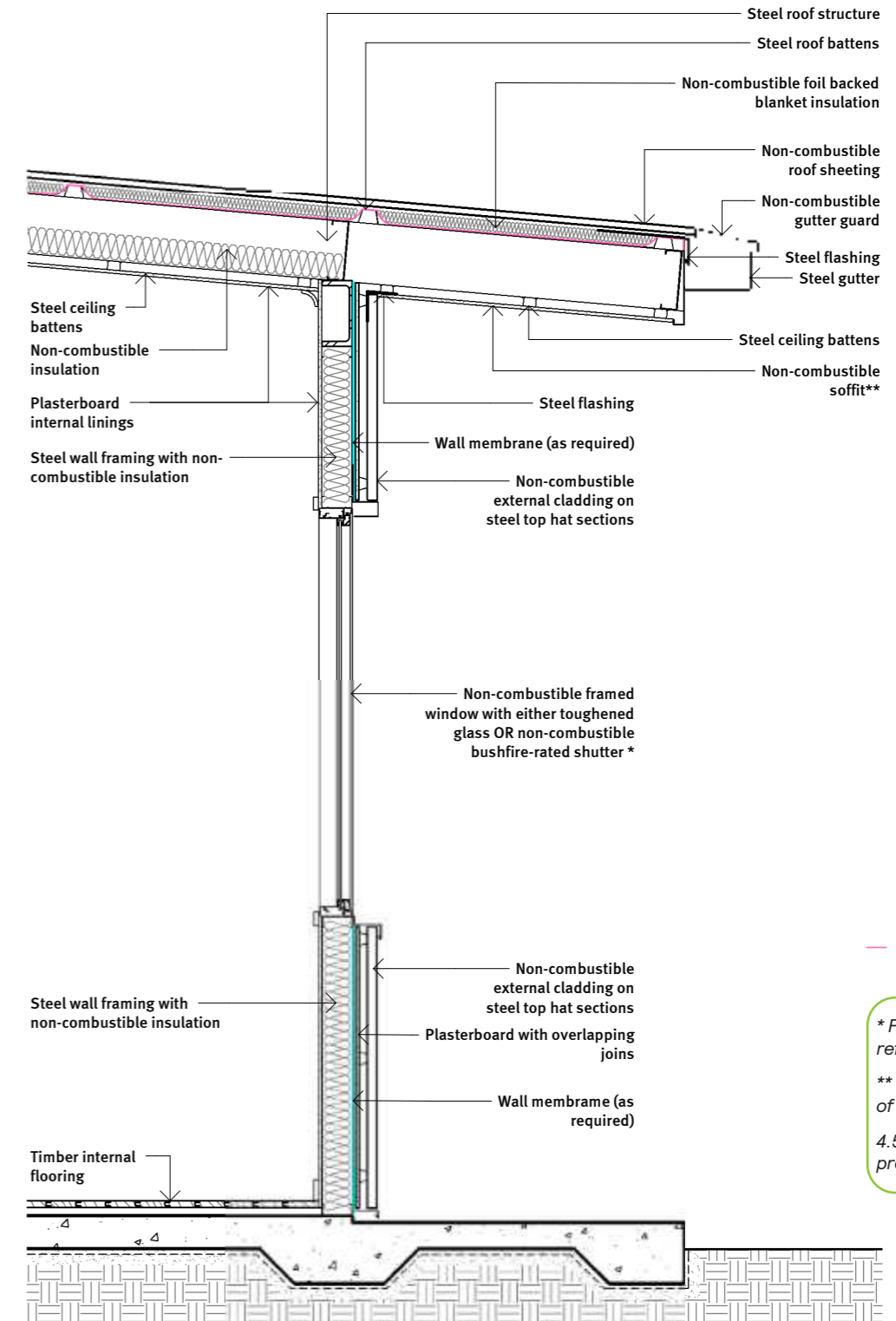


\* For more information refer to AS3959:2018  
 \*\* Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion

### Construction detail example 4b

#### Non-combustible frame - Level 3 exposure

The following scenario shows an example of a non-combustible framed house with a skillion roof that is resilient up to a level 3 exposure.

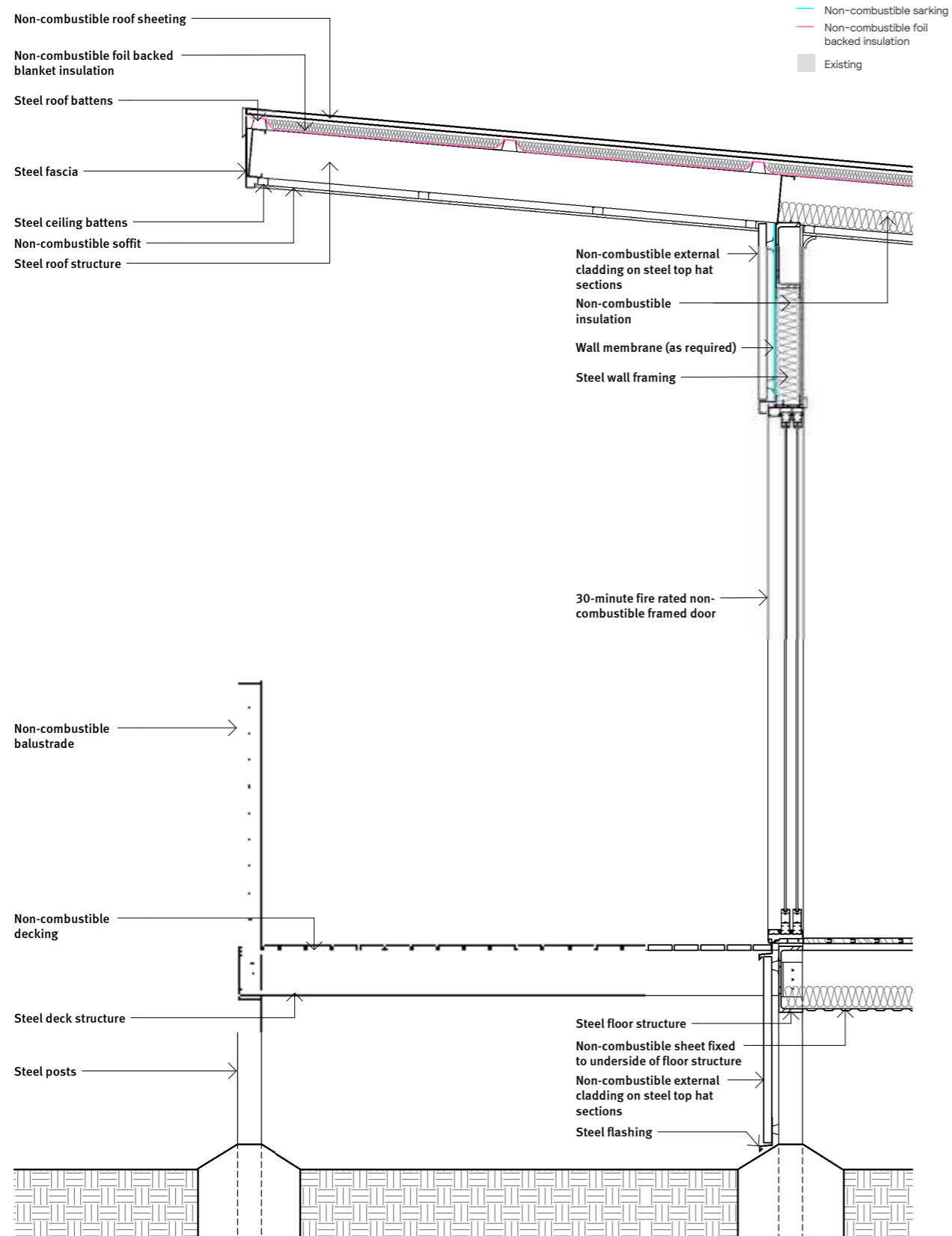


— Non-combustible foil backed insulation  
 \* For more information refer to AS3959:2018  
 \*\* Fibre cement sheet of a minimum of 4.5 mm or greater to prevent FC distortion

## Construction detail example 9

### Verandahs & decks - adjoining a combustible frame - Level 2 Exposure

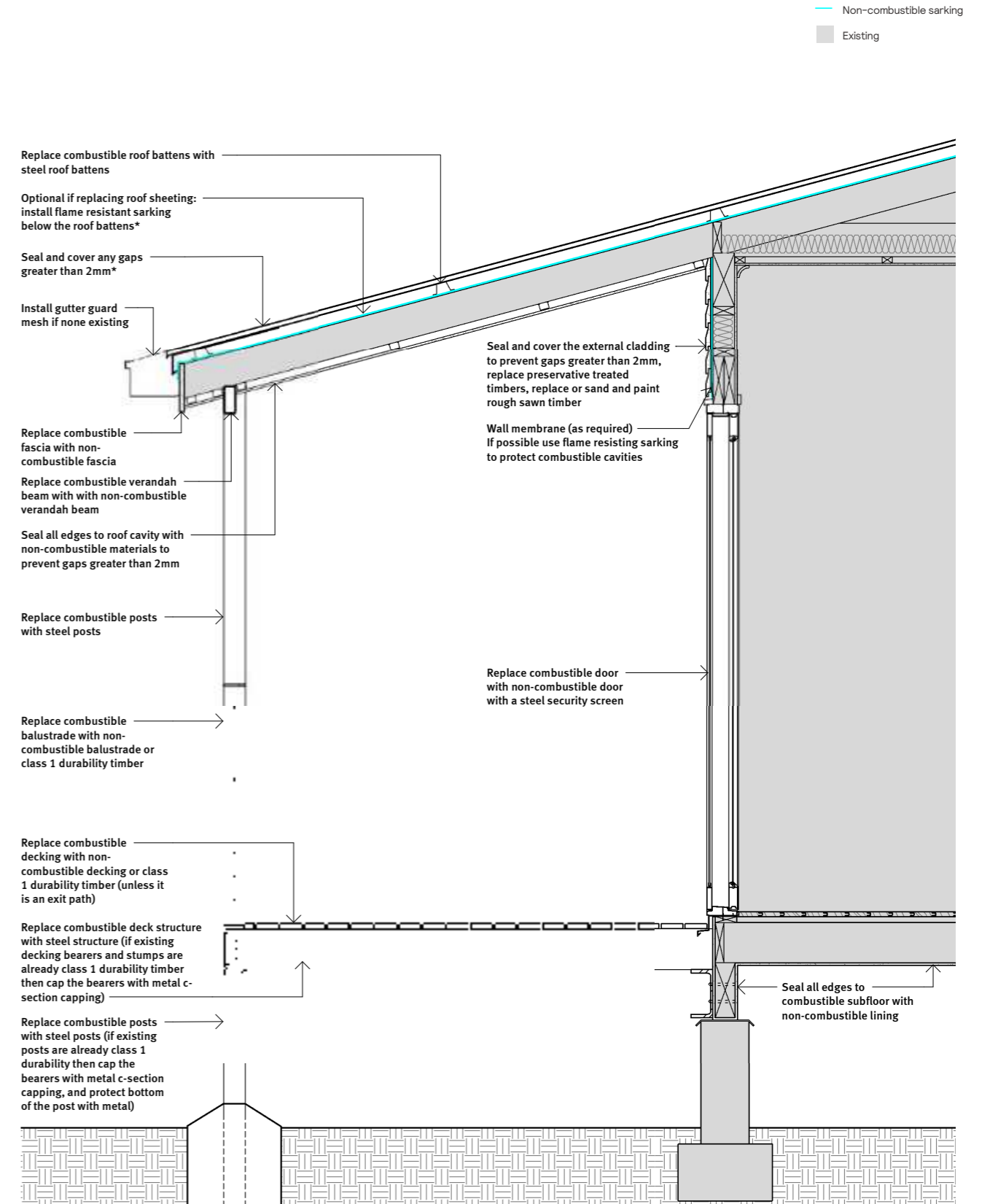
The following scenario explains how to create a deck adjoining a raised steel framed house to be resilient up to a level 2 exposure.



## Construction detail example 10

### Verandahs & decks - Adjoining a combustible frame - Level 1 Exposure

The following scenario explains how to create a deck adjoining a typical raised timber framed house to be resilient up to a Level 1 exposure.



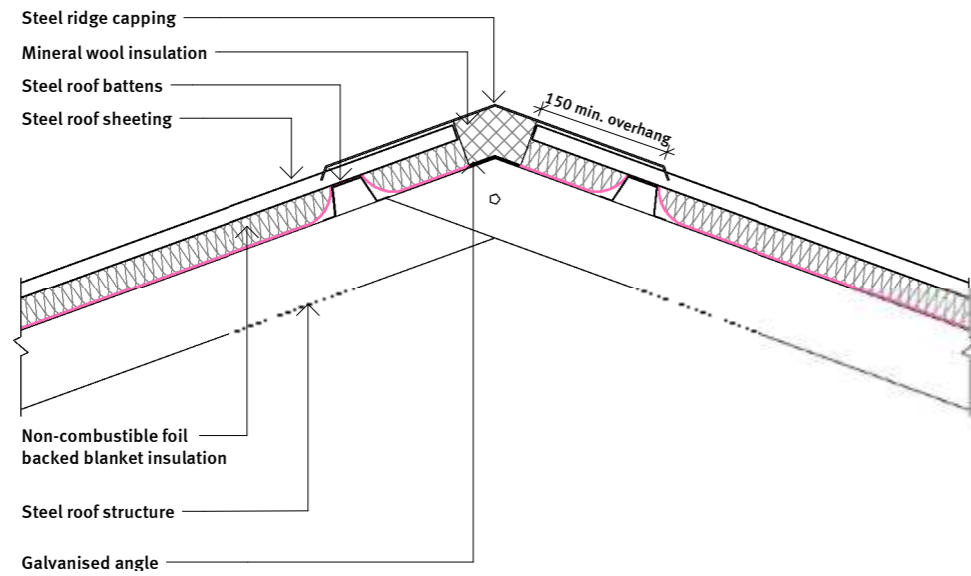
## Construction detail example 11

### Roof ridges

The following drawings show examples of steel and tile roof ridges resilient up to level 3.

- Non-combustible sarking
- Non-combustible foil backed insulation
- Existing

#### Steel Roof – Level 3 Exposure



From NASH Standards (2014)

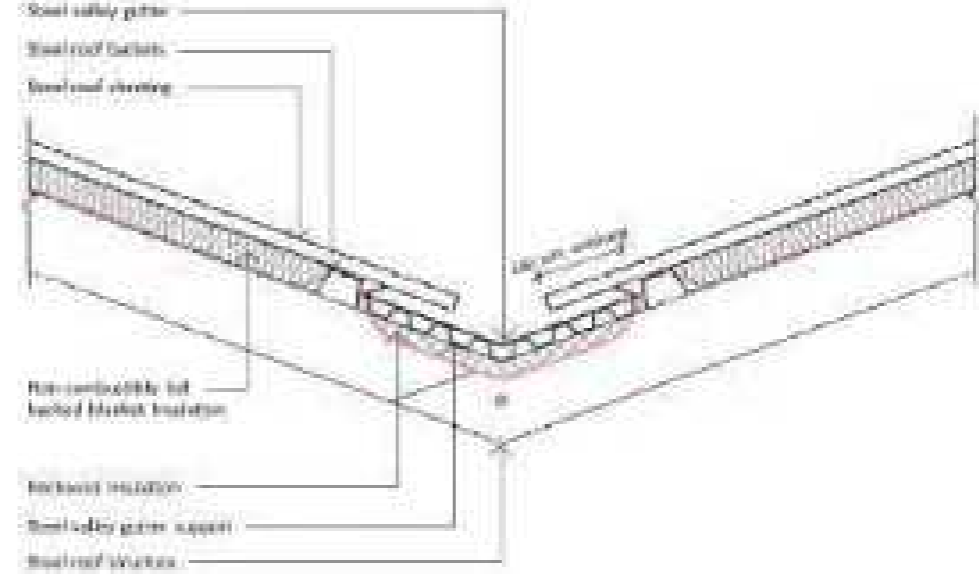
## Construction detail example 12

### Roof valleys

The following drawings show examples of steel and tile roof valleys resilient up to level 3

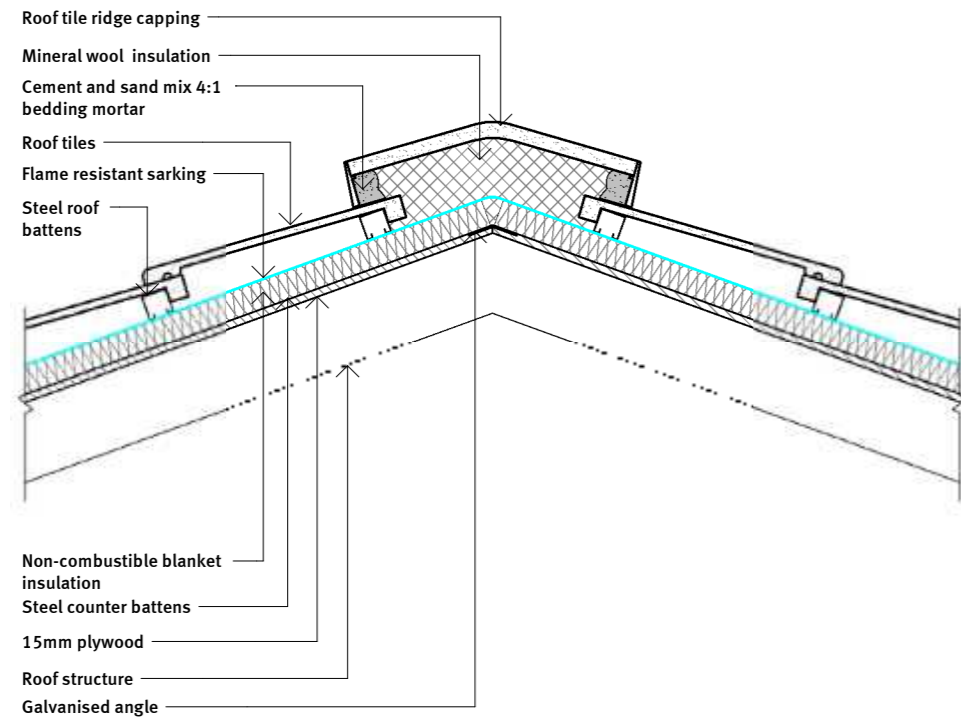
- Non-combustible sarking
- Non-combustible foil backed insulation
- Existing

#### Steel Roof – Level 3 Exposure



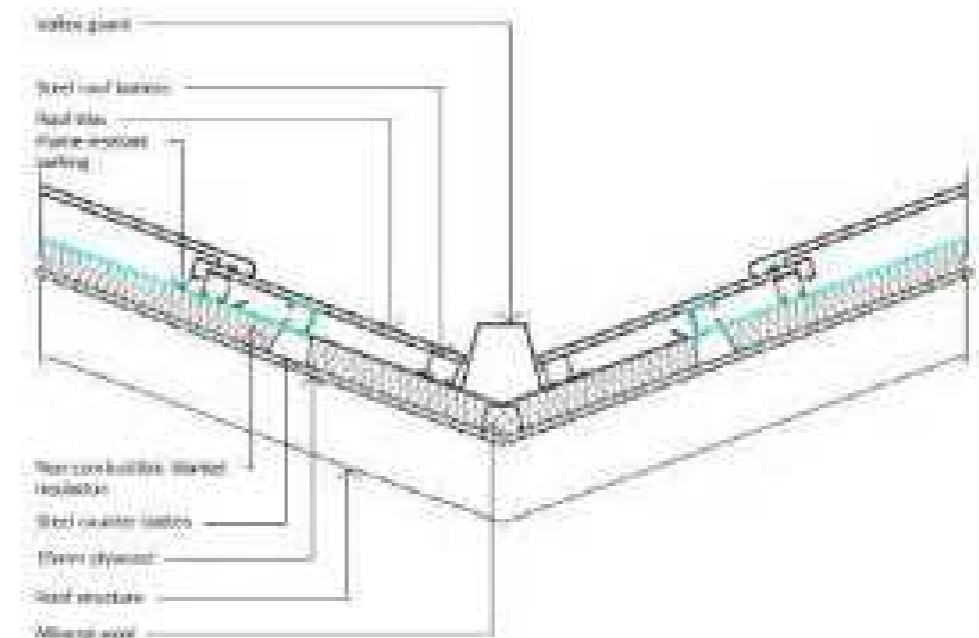
From NASH Standards (2014)

#### Tile Roof – Level 3 Exposure



From NASH Standard From AS3959 (2018)

#### Tile Roof – Level 3 Exposure



# Bushfire Resilient Materials

## Introduction to Bushfire resilient materials

This section describes the main materials used in common building types, including the advantages and disadvantages of the material to reduce ignition from embers, radiant heat and flame, and its resistance to damage by wind and objects carried by the wind. The material chosen should be considered in relation to other material used in the building (e.g. material used for cladding, material used for framing).

Concrete		
Including slab, concrete cast in situ, precast, tilt up panels, aerated concrete		
Uses and level of protection	Advantages	Disadvantages
<p>Used for ground slabs for all levels.</p> <p>Used for wall systems for all levels, and in some cases it may have a minimum thickness or joint requirements for level 3 and 4. The thickness requirements for the various materials or products can be provided by the suppliers or builder, to achieve either a 30-minute fire rating for level 3 or a 60-minute fire rating for level 4. If used for roofing, the same applies.</p>	<ul style="list-style-type: none"> <li>Strong non-combustible material resists all bushfire actions.</li> <li>Offers a reasonable degree of branch strike protection (depending on thickness).</li> <li>Dimensionally stable when heated.</li> <li>High thermal mass.</li> <li>Building fire rating test performance translates well to effective performance in bushfires.</li> <li>In many cases, it would only receive minor cosmetic damage in a bushfire.</li> </ul>	<ul style="list-style-type: none"> <li>No disadvantages from a bushfire exposure perspective, though in some cases it may be more expensive compared to lighter weight construction.</li> <li>If polymer insulation such as extruded polystyrene or insulation is used, toxic gas may be produced in the house and surrounds during a bushfire and should be avoided for levels 2, 3 and 4.</li> </ul>

### Choose designs and Materials carefully:

- Apply robust design principles by selecting systems that are durable, non-combustible and do not rely on manual operation or activation (e.g. non-combustible construction rather than combustible elements with water spray systems).
- Incorporate design redundancy so building performance does not depend on a single element. This may include metal window screens and fully non-combustible wall systems, including façades, framing, insulation, and window and door framing.
- Use simple, cost-effective design strategies that reduce bushfire risk, such as enclosing subfloors or building on a slab-on-ground, simplifying roof forms to avoid valleys and excessive ridges, and using simple building footprints that avoid re-entrant corners where debris can accumulate.
- Where possible, select solutions that work together by providing multiple benefits, such as window screens and shutters that also offer insect and solar protection.

### Masonry

Including: Brick veneer, double brick, concrete block, stones, mudbrick



Uses and level of protection	Advantages	Disadvantages
<p>Used for wall systems for all levels, and in some cases may have a minimum thickness or joint requirements for level 3 and 4.</p> <p>The thickness requirements for the various materials or products can be provided by the suppliers or builder, to achieve either a 30-minute fire rating for level 3, or a 60-minute fire rating for level 4.</p>	<ul style="list-style-type: none"> <li>Strong non-combustible material resists all bushfire actions.</li> <li>Offers a reasonable degree of branch strike protection (depending on thickness).</li> <li>Dimensionally stable when heated.</li> <li>High thermal mass.</li> <li>Building fire rating test performance translates well to effective performance in bushfires.</li> <li>In many cases would only receive minor cosmetic damage in a bushfire.</li> <li>Effective in protecting framing elements underneath from direct flame.</li> <li>Thick masonry has a high fire rating.</li> </ul>	<ul style="list-style-type: none"> <li>Vents and weepholes need to be carefully designed and maintained, especially when there are combustible framing elements in the cavity behind the masonry cladding system.</li> </ul>

### Render

Including: Heavy and acrylic renders



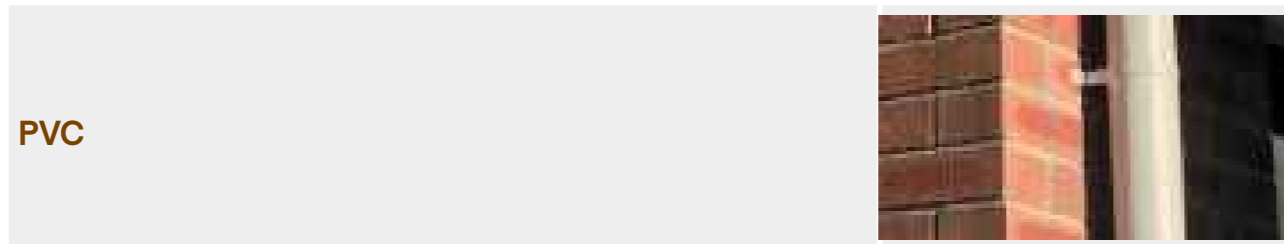
Heavy Masonry Render		
<p>Heavy masonry render can provide a level of protection similar to masonry cladding. The thickness requirements for the various materials or products can be provided by the suppliers or builder, to achieve either a 30-minute fire rating for level 3, or a 60-minute fire rating for level 4.</p> <p>Can be used to completely enclose and seal structural strawbale construction to create a bushfire resistant wall system.</p>	<ul style="list-style-type: none"> <li>Strong non-combustible material resists all bushfire actions.</li> <li>Offers a reasonable degree of branch strike protection (depending on thickness).</li> <li>Dimensionally stable when heated.</li> <li>High thermal mass.</li> <li>Building fire rating test performance translates well to effective performance in bushfires.</li> <li>In many cases would only receive minor cosmetic damage in a bushfire.</li> </ul>	<ul style="list-style-type: none"> <li>Requires a combination of good render formulation and skilled application to achieve uniformity and appropriate thickness and finish around building details.</li> </ul>

Acrylic Renders, Paints, Lacquers and Preservative Treatments		
Uses and level of protection	Advantages	Disadvantages
These renders are generally not recommended in bushfire circumstances. If chosen, then use as sparingly as possible as they can form a combustible surface or contribute to the combustibility of an existing substrate.	<ul style="list-style-type: none"> <li>Provides a cost-effective finishing solution and can reduce the rate of weathering of certain materials such as timber.</li> </ul>	<ul style="list-style-type: none"> <li>Could readily degrade and emit toxic fumes for levels 2 to 4, and for level 1 when adjacent to surfaces.</li> <li>Could increase the likelihood of ignition and fire spread over the surface. This initial spread could lead to house loss.</li> </ul>
<h3>Steel Wall and Roof Cladding</h3>		
Uses and level of protection	Advantages	Disadvantages
Steel wall and roof cladding are a durable non-combustible cladding system that is most effectively used over a non-combustible framing system. Is dimensionally stable for levels 1 and 2. Some distortion is possible for levels 3 and 4, requiring additional wall design details to account for possible cladding distortion.	<ul style="list-style-type: none"> <li>Cost effective non-combustible and dimensionally stable for levels 1 and 2.</li> <li>Cost effective replaceable cladding for levels 3 and 4.</li> <li>Common material used by conventional trades.</li> </ul>	<ul style="list-style-type: none"> <li>Cladding will suffer cosmetic impact and some distortion if subjected to direct flame contact. Its long-term durability may also be affected.</li> </ul>
<h3>Steel Framing</h3>		
Uses and level of protection	Advantages	Disadvantages
Steel framing is a durable, cost effective way to achieve light weight construction outcomes with wall and roof cavities that are non-combustible. Is dimensionally stable in the use cases described in the guide for all levels. Is dimensionally stable for steel temperatures up to 400 degrees Celsius, which are highly unlikely to be reached in the construction methods for housing.	<ul style="list-style-type: none"> <li>Cost effective non-combustible and dimensionally stable for levels 1 and 2.</li> <li>Cost effective replaceable cladding for levels 3 and 4.</li> <li>Common material used by conventional trades.</li> <li>Framing elements unlikely to exceed 400 degrees, therefore will be dimensionally stable and durable for future use.</li> </ul>	<ul style="list-style-type: none"> <li>Some builders have limited experience with steel framing.</li> </ul>

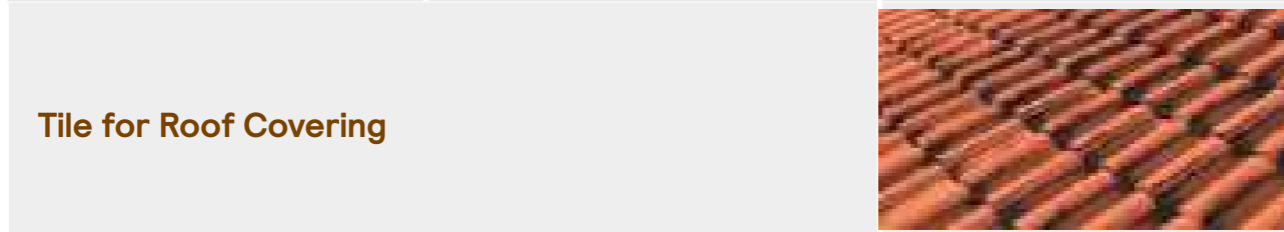
Can tolerate a reasonable degree of damage or modification to the wall system, as a breach of both outer cladding and inner wall plaster would be required to cause potential house ignition.		
<h3>Masonry</h3> <p>Including: Brick veneer, double brick, concrete block, stones, mudbrick</p>		
Uses and level of protection	Advantages	Disadvantages
Steel floor is a durable, cost effective support structure that is effective for levels 1 and 2 and requires shielding for levels 3 and 4 where direct flame contact over a significant duration may be possible.	<ul style="list-style-type: none"> <li>Cost effective non-combustible and dimensionally stable for levels 1 and 2.</li> <li>Cost effective replaceable cladding for level 3 and 4.</li> <li>Common material used by conventional trades.</li> <li>Framing elements unlikely to exceed 400 degrees and in these cases will be dimensionally stable and durable for future use.</li> </ul>	<ul style="list-style-type: none"> <li>Limited decking board fixing option.</li> </ul>
<h3>Render</h3> <p>Including: Heavy and acrylic renders</p>		
<h3>Class 1 (above ground) Durability Hardwoods Used as Timber Cladding (that have not been preservative treated)</h3>		
Is durable with a reasonable tolerance to ember attack and radiant heat appropriate to level 1. Timbers in this durability class tend to have higher resistance to ignition and lower tendency to support flame spread compared to lower durability timbers (compared at the same moisture content).  Will degrade (emitting significant smoke) at temperatures in excess of 150 degrees Celsius and be at risk of spontaneous ignition at temperatures above 200 degrees Celsius.	<ul style="list-style-type: none"> <li>High durability timber will last longer than other timber species as a cladding. Fortunately, timber durability is also a good predictor of bushfire performance compared to other timbers (a significantly better metric for bushfire performance compared to other generalised metrics like timber density class).</li> </ul>	<ul style="list-style-type: none"> <li>Dimensional stability is subject to moisture content.</li> <li>Can still ignite and support fire spread at low moisture content levels that are possible in some bushfire circumstances. Will ignite if exposed to high radiation levels or direct flame contact.</li> <li>Is commonly treated with oils or painted which is likely to increase its ignitability.</li> </ul>

Bushfire Resistant Timber (AS3959 Definition)		
Uses and level of protection	Advantages	Disadvantages
Consists of a mix of class 1 durability timbers, timbers treated with a fire-retardant system and some other timber species that are deemed to meet this definition according to the performance and testing regime.	<ul style="list-style-type: none"> <li>Is a better indicator of bushfire performance compared to other generalised metrics like timber density class.</li> <li>Offers a way to consider fire retardant coatings and impregnation treatments</li> </ul>	<ul style="list-style-type: none"> <li>Fire retardant system treatment systems may degrade over time when exposed to weathering.</li> </ul>
Preservative Treated Timber		
Uses and level of protection	Advantages	Disadvantages
Not recommended for use in bushfire prone areas due to its ignitability, which can be significantly higher than the same timber in its untreated state.	<ul style="list-style-type: none"> <li>Inexpensive, durable for the price point.</li> </ul>	<ul style="list-style-type: none"> <li>Dimensional stability is subject to moisture content.</li> <li>Low moisture content during bushfires can lead to ignition and sustained ignition can lead to house loss.</li> <li>The combustion process can release both toxic smoke and water-soluble metal salts, which can present a significant risk to people and the environment.</li> </ul>
Timber Framing		
Uses and level of protection	Advantages	Disadvantages
Is a common and cost-effective framing system suitable as framing material, provided appropriate measures are taken to prevent ember, radiation and flame access to the framing. There are suitable cladding options to achieve this in the guide. Care should be taken not to compromise the protective cladding, either during the initial build or through modification during the life of the building. Framing can degrade at temperatures more than 180 degrees Celsius, leading to a build-up of combustible smoke within the building cavity.	<ul style="list-style-type: none"> <li>Familiar framing approach with majority of current trades.</li> </ul>	<ul style="list-style-type: none"> <li>Provides a combustible element to the region below the cladding. This places a greater onus on the cladding to prevent ember contact and heat transfer to the framing elements immediately behind the cladding layer(s).</li> <li>Burning framing in roof and wall cavities can be difficult to detect by building occupants. As the fire develops, it can reach a point where it rapidly breaches the occupiable space, risking entrapment.</li> </ul>

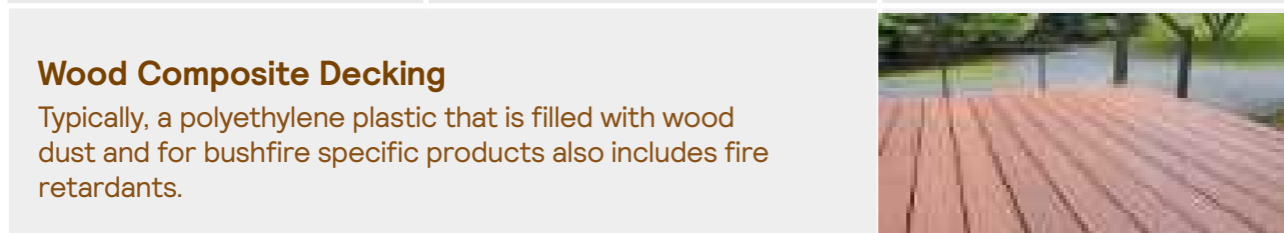
Other Cladding		
Uses and level of protection	Advantages	Disadvantages
Fibre Cement Sheet Cladding		
Uses and level of protection	Advantages	Disadvantages
Is a durable and effective cladding material over non-combustible framing systems. Is dimensionally stable for levels 1 and 2. Some distortion is possible for levels 3 and 4, requiring specific thickness requirements in combination with joint finishing methods.	<ul style="list-style-type: none"> <li>Inexpensive.</li> </ul>	<ul style="list-style-type: none"> <li>Is not as dimensionally stable as many other masonry claddings when exposed to flame.</li> </ul>
Aluminium Wall Cladding		
Uses and level of protection	Advantages	Disadvantages
Level 1 and 2 wall cladding.	<ul style="list-style-type: none"> <li>Non-combustible, low distortion when exposed to radiant heat (level 1 and 2).</li> </ul>	<ul style="list-style-type: none"> <li>May melt or fall away when exposed to direct flame, which is possible for construction exposed to levels 3 and 4.</li> </ul>
Render		
Including: Heavy and acrylic renders		
Uses and level of protection	Advantages	Disadvantages
Not used as a barrier at any level. Commonly used for light access in open pergolas and carports.  Not effective as a window or skylight glazing element that encloses a house.	<ul style="list-style-type: none"> <li>Does not support flame spread until heated to a molten state, so it tends to fall away from its installed location before it supports flame spread.</li> </ul>	<ul style="list-style-type: none"> <li>Does not offer a barrier to radiant heat or flame. Will melt and fall away from current location when heated. If it falls to the ground and continues to be heated by adjacent sources, it can form a molten puddle on the ground which can burn. May hamper exit path in this situation.</li> </ul>



PVC		
Uses and level of protection	Advantages	Disadvantages
For example, used for gutter and cladding.	<ul style="list-style-type: none"> <li>Like polycarbonate, it tends to melt and fall away before flaming begins.</li> </ul>	<ul style="list-style-type: none"> <li>If it falls to the ground and continues to be heated by adjacent sources, it can form a molten puddle on the ground which can burn. May hamper egress in this situation. Smoke from burning PVC can be very toxic.</li> </ul>

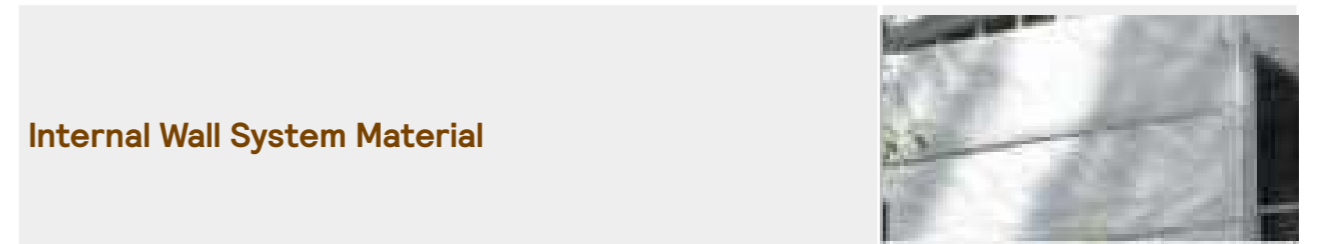


Tile for Roof Covering		
Uses and level of protection	Advantages	Disadvantages
Used as a roof covering for all levels as it provides a non-combustible roof finish	<ul style="list-style-type: none"> <li>Inexpensive, has thermal mass, dimensionally stable when heated.</li> <li>Can be part of a high-performing roof at all levels when it is combined with non-combustible framing and tile battens.</li> </ul>	<ul style="list-style-type: none"> <li>Difficult to form a tight-fitting roof with gaps less than 2 mm that will prevent ember entry and debris accumulation in the roof space.</li> <li>Typically used with timber tile battens, which may be susceptible to ember and debris attack.</li> </ul>



Wood Composite Decking Typically, a polyethylene plastic that is filled with wood dust and for bushfire specific products also includes fire retardants.		
Uses and level of protection	Advantages	Disadvantages
For decking for level 1 and 2 provided it has been tested under bushfire conditions.	<ul style="list-style-type: none"> <li>Durable. Some bushfire specific products perform well in bushfire events.</li> </ul>	<ul style="list-style-type: none"> <li>Not all wood composite decking performs well in bushfires. Look for evidence of product testing and use a reputable brand.</li> </ul>

37. AS1530.2 -1993 Methods for fire tests on building materials, components and structures Test for flammability of materials Sydney: Standards Australia



Internal Wall System Material		
Sarking (Unrated)		
Uses and level of protection	Advantages	Disadvantages
Not recommended for any circumstances in bushfire construction.	<ul style="list-style-type: none"> <li>Inexpensive, provides a moisture barrier in typical wall systems</li> </ul>	<ul style="list-style-type: none"> <li>Sarking is combustible and may spread flames through building cavities even if adjacent elements are non-combustible.</li> </ul>

Sarking with Level 5 Flammability (AS1530.2) <sup>27</sup>		
Uses and level of protection	Advantages	Disadvantages
Used as a moisture barrier where needed. This sarking offers little to no protection to underlying combustible elements from the flame and smouldering debris that has accumulated against the sarking.	<ul style="list-style-type: none"> <li>Has a low tendency to support the spread of flame beyond the active area in which the flame occurred.</li> </ul>	<ul style="list-style-type: none"> <li>Does not offer a barrier to flame, a flame or smouldering debris may burn a hole through the sarking.</li> </ul>

Sarking that is Flame Resistant		
Uses and level of protection	Advantages	Disadvantages
Used to limit the spread of flame to underlying building elements.	<ul style="list-style-type: none"> <li>Offers an option to protect the underlying framing from flame and ember contact in certain new building circumstances (refer to relevant construction details).</li> </ul>	<ul style="list-style-type: none"> <li>More expensive than conventional sarking.</li> <li>This category of sarking is not formally defined by a test method, but it is relatively easy to observe whether the sarking forms a hole when flame is applied to it.</li> </ul>

Insulation - Non-Combustible e.g. Glass Wool and Rockwool		
Uses and level of protection	Advantages	Disadvantages
Used as thermal insulation and in some cases as a barrier to the passage of heat and flame.	<ul style="list-style-type: none"> <li>Low cost, reasonable high temperature performance for glass wool.</li> <li>Excellent high temperature performance for rockwool.</li> </ul>	<ul style="list-style-type: none"> <li>Provides small amount of toxic gas if exposed to flame due to the binders used to hold the fibres together.</li> </ul>

Insulation - Combustible e.g. Polyester, Polyisocyanurate Foam, Expanded or Extruded Polystyrene		
Uses and level of protection	Advantages	Disadvantages
Not recommended in bushfire applications.	<ul style="list-style-type: none"> <li>Inexpensive with good insulation properties.</li> </ul>	<ul style="list-style-type: none"> <li>Breaks down at temperatures that are readily achieved in bushfire events. This breakdown may result in toxic gas emission flame spread.</li> </ul>

# Bushfire Resilient Landscaping

## Introduction to Bushfire resilient landscaping

The design and management of the area surrounding the home plays an important role in bushfire resilience. **Part 1, Bushfire essentials**, explained how most buildings destroyed by bushfire are ignited by wind-driven embers.

In many cases of house loss, embers were found to have ignited vegetation in the garden, which then spread fire to the home. Hence, bushfire resilience in the immediate vicinity of the home can be increased significantly through landscaping modifications that:

- plan a strategic garden layout
- minimise the use of combustible garden materials (such as combustible mulches and timber garden edging)
- choose appropriate plantings.

This section provides a comprehensive look at the most important landscaping principles that should be followed by people living in bushfire prone areas<sup>38</sup>.

In the past, the common approach to designing bushfire resilient gardens tended towards elimination rather than adaptation. Homeowners would clear all vegetation around the home and replace it with lawn or a non-combustible surface, such as gravel or pavers. While this approach can improve bushfire resilience, it also reduces a home's liveability. Gardens should be designed to be used all year around, not just during bushfire season. By adopting the following design principles, you can create a beautiful, family-friendly garden that is also resilient to bushfire.



The design and management of the landscape surrounding the home plays an important role in bushfire resilience.

### Landscape design

An increasing number of people desire to live in closer contact with their natural environment. This often translates to gardens that emulate native bushland. While this style of garden brings about a certain level of hazard, it can (when managed appropriately) also shield the home from an advancing fire. Gardens also offer the opportunity to create a micro-climate for the house and its immediate surroundings, offering both amenity and resilience to a bushfire.

Broadly, the principles outlined on the following pages involve reducing the amount and continuity of surface and near-surface fuels in order to disrupt an advancing fire front and prevent isolated fires from developing to a size that could threaten the house. It is also important to consider continuity in a vertical sense by providing a substantial distance between surface fuels and tree canopies.

Reducing fuel continuity around the house also aligns with landscaping principles that limit soil subsidence in areas with reactive soils (like clay soil) and associated house damages and cracks.<sup>39</sup>

Some key guiding principles are:

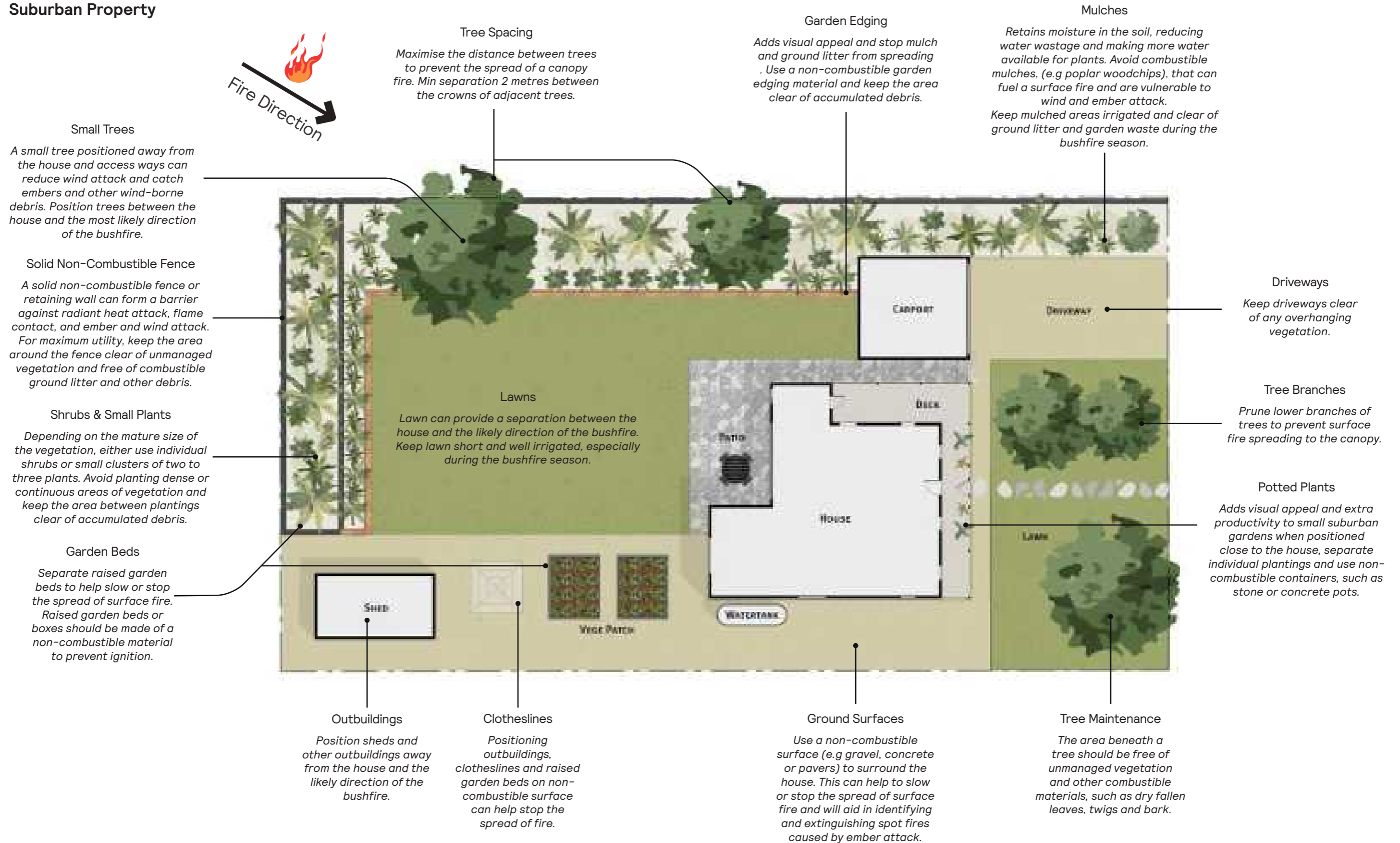
- Use landscaping solutions to shield the home from embers, heat, flame and wind.
- Use landscaping to improve the ease with which buildings can be defended during a bushfire.
- Use landscaping to provide safe and effective egress from the house to an alternative place of shelter by considering the layout of the garden and how people might navigate around the house.
- Consider the aesthetics of the garden and how to incorporate a bushfire resilient design without compromising the intended look, feel and function of the garden.

Landscaping should be thought of as a holistic process, where each design element impacts on the elements around it. A resilient landscape requires ongoing maintenance. Vegetation can quickly become overgrown, presenting an increasing bushfire hazard.

*Landscaping can play an important role in a building's bushfire resilience.*

## Landscape Design

### Suburban Property



**Landscape Design**  
**Rural Property**

**Sheds & Outbuildings**  
should be positioned away from the house. Positioning outbuildings within a gravelled area (or on a similar non-combustible surface) can help slow or stop the spread of fire.

**Irrigated Lawn**  
provide a separation between the house and the likely direction of the bushfire. Keep lawn short and well irrigated, especially during the bushfire season.

**Open Areas**  
A fuel-reduced area between the house and the direction of the bushfire can help stop fire spreading to the home and reduce the impacts of bushfire attacks.

**Water Bodies**  
A farm dam, pond or other large water feature between the house and direction of the bushfire can help slow or stop the spread of fire.



**Water Tanks**  
Non-combustible water tanks can help shelter the house from radiant heat and provide water for irrigation and for defending the house in the event of a bushfire. Keep the area around the water tank free of flammable vegetation and other combustible objects.

**Food Producing Plants**  
can be used to break the continuity of other, more flammable vegetation. They are less flammable to other types of vegetation. Plant in non-combustible raised garden beds and keep plants green and watered during hot, dry weather.

**Vegetation Around Driveways**  
Keep driveways clear of overhanging vegetation, debris and other obstacles. Providing ample space for vehicles to turn may aid evacuation.

**Exposed Parking**  
Position exposed parking spaces away from the house, other combustible objects and the direction of the bushfire



**Screening Plants**  
Moderately dense evergreen trees, orchards or hedges can be used as screening plants to filter embers and wind-borne debris from spreading to the house. They also shield the house and occupants from wind attack.

**Ground Surfaces**  
Use a non-combustible surface, (e.g gravel, concrete or pavers) to surround the house that can help to slow or stop the spread of surface fire and will aid in identifying and extinguishing spot fires caused by ember attack.

**Driveways**  
A driveway that provides access to a public road away from the likely direction of the bushfire is often ideal.

**Swimming Pools**  
can provide a water supply. Swimming pools, farm ponds and dams are not considered reliable sources of static water supply in New South Wales due to regular drought events.

## Garden layout

Garden layout describes the general arrangement of garden beds, trees, pathways and other features in the area surrounding the home.

Before proceeding, try to decide on the overall style of garden (e.g. an exotic garden, a modified Australian landscape or park-like garden)<sup>42</sup> rather than designing one element at a time.

This initial choice should consider the suitability of the garden in the given environment, its maintenance requirements, and how easy (or difficult) it will be to manage in terms of bushfire resilience.

It is also important to identify the hazards at both local and regional scales, and note any slopes, ridges or earthworks that may restrict access, promote the spread of fire or provide a barrier against bushfire attack. Think about how to incorporate existing elements into the design of the garden. If these elements represent a hazard, consider how to remove them or mitigate the risk.

Garden design and layout is often dictated by lot size. Large lots provide some great opportunities for developing highly resilient homes, while small lots may restrict the available options. In either case, consider how the available space (or lack thereof) will affect the occupant's ability to prepare for a bushfire. For example, small lots may limit opportunities to control for hazards in neighbouring properties. If this is the case, consider a cooperative approach that involves the owner of the neighbouring lot. If it is not possible to remove hazards in the adjoining land, consider installing a barrier to shield against attack, or using an area of open space as a buffer. Also, ensure the home is resilient to the risks that the hazard represents, such as increased ember attack.

- Provide easy access for firefighters and vehicles onto, or adjacent to the lot; prioritise access between buildings and the likely direction of the bushfire.
- Provide an area of open space around the building that reduces fire intensity and improves conditions for firefighting.
- Provide a buffer between the main building and the direction of the bushfire hazard; this buffer could be an area of open space, or a swimming pool, pond or other water feature.<sup>43</sup>
- Where possible, provide more than one accessway to the property that are clear of any overhanging or adjacent vegetation (excluding lawn).
- Accessways should provide adequate access onto the site and safe evacuation.
- Create gaps in vegetation (e.g. between trees, shrubs and garden beds) to slow down or stop the spread of fire towards buildings.
- Use options that minimise maintenance requirements.
- Consider the long-term needs of occupants; remember that gardens should be used all year round.
- Create a asset protection zone around the home.
- Position larger plantings (such as trees and shrubs) beyond flame contact distance from buildings and key access routes.
- Install water faucets on at least two sides of the house and ensure garden hoses can reach all areas of the garden.





### Open spaces and asset protection zones

Both open spaces and asset protection zones can be used to slow or stop the spread of fire. In addition to reducing fuel load, these areas provide a space where embers and burning debris can fall without the risk of fire spreading to other parts of the property. Asset protection zones can also provide a safe refuge to defend buildings or to shelter in-place during a bushfire.

A asset protection zone is an area of modified native vegetation or managed landscape that is partially cleared of fuel, while an open space is an area of open land with little or no vegetation, featuring an artificial or highly managed surface (e.g. lawns, paved areas, mown or grazed paddocks, sporting ovals, tennis courts or similar).

As a rule, buildings located in a BPA should incorporate an open space in the immediate vicinity of buildings, and if possible, an extended asset protection zone between buildings and the direction of the bushfire hazard. The desired size of the asset protection zone is largely dependent on the slope of the land, its aspect and the type of vegetation. The size and layout of the lot or subdivision may also dictate the size and position of fuel-reduced areas.

- If possible, create an open space around buildings using a non-combustible surface, such as concrete, gravel or pavers.
- Create a asset protection zone between the house and the likely direction of the bushfire. For more information, refer to the document on clearing for firebreaks and fire management lines.
- Use open spaces to separate trees, garden beds and areas of dense vegetation.
- Lawns and pathways are suitable for creating 'mini' breaks in the continuity of vegetation.
- An asset protection zone can be created by managing existing vegetation:
  - remove ground litter and undergrowth from around trees and shrubs either using
  - mechanical means or via controlled burning (do not do this without authorisation)
  - thin trees to break the continuity of canopy vegetation
  - remove dead limbs and branches from individual trees and shrubs
  - and remove low hanging branches from trees.
- Keep the area clear of ground litter and other combustible materials.

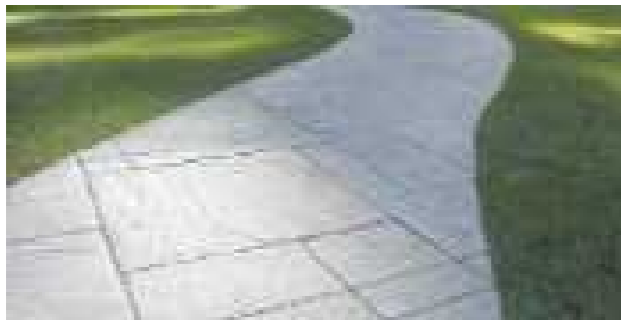
### Pathways

Pathways (like open spaces) play a critical role in bushfire resilience by improving the chances of buildings and occupants surviving a fire.

Pathways can be used to separate areas of vegetation to slow or stop the spread of fire.

They are also important in ensuring the safe movement of occupants and emergency responders during a bushfire.

As a rule, always keep pathways clear of trip hazards, overhanging vegetation and combustible materials. Moving around should be both practical and safe.



Keep pathways clear of trip hazards, overhanging vegetation and combustible debris.

- Use pathways to break the continuity of vegetation and to aid navigation.
- Consider how pathways can be integrated as part of the wider landscape system; pay attention to the interactions between pathways, garden beds, mulch, vegetation, open spaces, asset protection zones and other features.
- Pathways, especially key exit routes, should be created using non-slip, non-combustible surfaces such as concrete, gravel, stone or hardpacked earth.
- Keep pathways clear of overhanging vegetation.
- Position key access routes away from unmanaged vegetation.
- Avoid or minimise the use of edging near or along pathways; these are a trip hazard and can accumulate debris.
- Do not rely on a single pathway for access onto and off the property; it is important to plan for multiple solutions.
- Ensure that pathways are safe to navigate during bushfire conditions; be mindful of strong winds and poor visibility.
- Consider using artificial lighting and non-combustible handrails to aid navigation.
- If possible, shield key access routes using non-combustible retaining walls.

### Landforms and earthworks

Landforms and earthworks can be used to mitigate the hazards associated with bushfire. Landforms include naturally occurring features in the terrain, such as ridges, slopes and gullies, while earthworks are human-made, and include earth mounds, terraces and retaining walls. No matter the origin, earthworks and landforms can provide an effective barrier against all four bushfire attack mechanisms—embers, heat, flame and wind.

Consider how to use features in the terrain to block or deflect bushfire attack. Be aware that some landforms (particularly steep slopes and narrow ridges) can increase risk, so manage these appropriately.

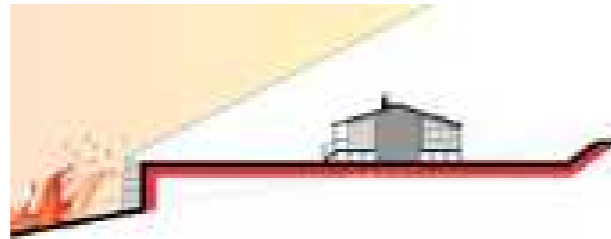


Figure 11 Terracing of sloping ground can block and deflect embers and radiant heat away from buildings (from Caird and Ramsay, 2003)

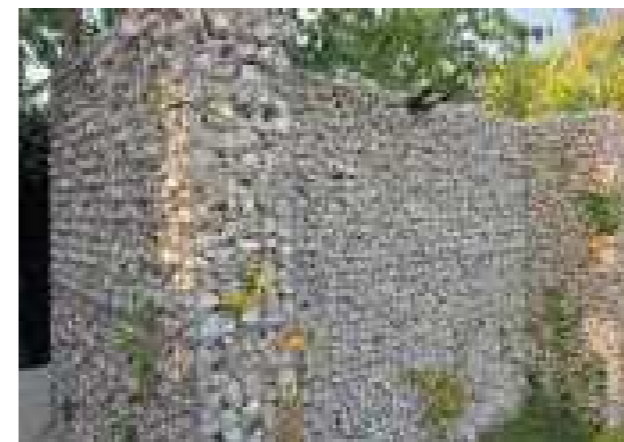
- Use earth mounds to block and deflect radiant heat, embers, flame and wind attack.
- Earth mounds need to be of an appropriate height and distance away from buildings to be effective.
- Be mindful of erosion and how newly established earthworks may interfere with natural surface drainage patterns. It may be necessary to create drainage ditches to divert the flow of run-off.
- While effective, earthworks can be expensive to construct and are likely to obstruct access, views and other activities, so weigh the costs and benefits carefully; it is often possible to obtain many of the same benefits using an appropriately designed fence, wall or row of screening plants.
- Manage the risks associated with building on existing landforms, such as hills and gullies.
- On sloping land, cut-and-fill or terrace the terrain in order to create a flat surface for buildings; if possible, create space for a flat, trafficable area around the building's perimeter.
- Cut-and-fill and terracing will likely result in

the formation of retaining walls and earth embankments, which can also act as effective

- barriers against the spread of fire burning uphill; use these features to your advantage.
- Ensure that pathways that extend along slopes or narrow ridges are safe and easy to navigate. Consider installing artificial lighting and handrails along key access routes.



Retaining wall.



Non-combustible garden walls can protect against all modes of bushfire attack.

### Fencing and garden walls

Fences and garden walls can be used as a barrier to block embers, flame, radiant heat and the spread of debris. They are also effective at ensuring the safe exit of occupants during a bushfire event, by shielding pathways and accessways.

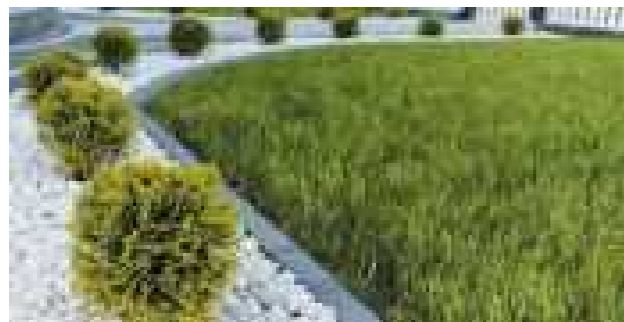
Consider installing a non-combustible fence or garden wall between buildings and the likely direction of the bushfire hazard. Once installed, make sure to keep the surrounding area clear of combustible materials.

- Use non-combustible materials, such as concrete, stone, brick or metal.
- Avoid combustible materials, such as timber, bamboo or brushwood, close to vulnerable building elements.
- Use non-combustible fences or garden walls as heat shields between bushfire hazards, buildings and key access routes.
- Do not install combustible fences or garden walls close to buildings.
- For smaller lots (or where neighbouring buildings are located close together), a solid, non-combustible wall can reduce radiant heat (depending on the situation).
- Non-combustible walls can be used to enclose vulnerable objects, such as gas cylinders, electricity generators, water pumps and piles of garden waste.
- Set walls and fences into the ground (using concrete or deep-set posts) so they can withstand wind attack.
- Avoid permeable fence styles such as horizontal or vertical slatted fences, etched metal screens, picket fences, lattices, and wire fences—these styles can be visually appealing, but they offer little protection against bushfire attack and may trap occupants or otherwise restrict movement during a bushfire.
- Ensure boundary walls and fences have appropriately located and designed gates and accessways; ensure these features are clear of vegetation and other combustible elements.

### Mulching

Mulching helps to retain moisture in the soil, meaning there is more water available for plants. Although they are important to plant health, mulches can be a significant fire hazard if used and managed incorrectly.

Ensure that mulched areas are clear of large amounts of combustible materials, such as ground litter. Non-combustible mulches, such as pebbles, shells and gravel, are the best option. These mulches will not burn, and many are heavy enough that they will not be scattered by the strong winds that accompany a bushfire.



*Non-combustible mulches are resistant to ember attack and can help slow or stop the spread of surface fire.*

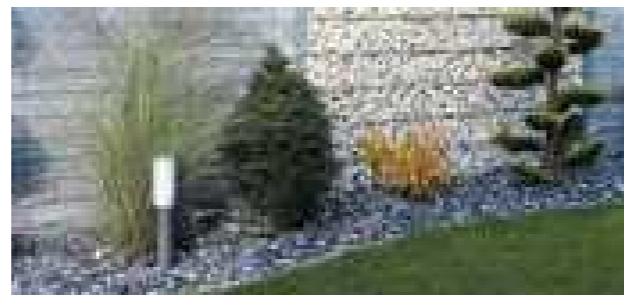
### Garden edging

Garden edging can add visual appeal to gardens and has the practical benefit of providing a barrier to stop mulch from straying onto lawns.

Edging also helps to protect plants from lawnmowers and edging tools. Despite its benefits, garden edging can be a fire hazard if used and managed inappropriately.

Try to minimise the use of garden edging around pathways, especially near to key access routes. Garden edging is a potential trip hazard, and this risk can be compounded by the low visibility conditions that accompany a bushfire.

- Garden edging can trap embers and other debris (debris will accumulate during a bushfire); therefore, it is important to use non-combustible edging materials.
- Use non-combustible materials, such as brick, stone, concrete or weathering steel.
- Avoid using timber garden edging; these materials can ignite and spread fire to other parts of the garden.
- Ensure that garden edging is kept in good condition and is clear of accumulated debris.



*Garden edging.*

## Plant Selection and management

This section describes how to manage existing vegetation and choose and use new plantings<sup>46</sup>. As a rule, plant selection and management should be aimed at reducing the opportunities for vegetation to ignite and slowing or stopping the spread of fire.

In the past, the advice on achieving bushfire resilience tended towards removing mature vegetation and replacing it with exotic species and foreign garden styles. Many contemporary approaches, however, opt for a nuanced solution that favours fuel reduction and intelligent design, over wholesale elimination and replacement.

For many, the imported garden approach can work, provided there is a suitable growing climate and an adequate water supply to sustain exotic species. Unfortunately, these requirements may be beyond the scope of some NSW homes. But in either case, we recommend using native plants whenever possible, supplemented by the strategic use of imported species.

Despite its reputation, native vegetation is not wholly bad when it comes to bushfires. Many native plants have low flammability characteristics, which makes them suitable for growing in bushfire prone areas. Native species also have the added benefit of supporting local bird and insect life, and are generally better suited to local growing conditions, meaning they may require less water than imported plant species.

Regardless of the choice of vegetation, landscapes require ongoing maintenance to remain resilient. Vegetation can quickly become overgrown, presenting an increasing bushfire hazard. In all cases, a proactive approach of regular maintenance and enhancement should be adopted—you never know when the next bushfire will strike, so be prepared.

For additional information on plant selection and landscaping in bushfire-prone areas, see NSW RFS guidance in **Planning for Bush Fire Protection 2019** and associated vegetation management advice from the **NSW Rural Fire Service**.

The following section illustrates a variety of strategies that are applicable to buildings, both historical and contemporary. Many of these strategies are specific to plant types, while others are more broadly relevant.

In general:

- Keep plants and garden beds clear of ground litter and other combustible debris.
- Remove dead or dry leaves, twigs and branches.
- Dead plants should be removed immediately during the bushfire season.
- Avoid vegetation that regularly dries out during the bushfire season.
- Remove leaves and branches which overhang buildings and pathways.
- Avoid planting large areas of dense vegetation (unless used as a barrier).
- Remove or thin areas of unmanaged vegetation.
- Separate large plantings using open spaces, pathways or non-combustible retaining walls.
- Do not plant anything against the house—it is very important to keep vegetation away from doors, vents and windows.
- Do not store large piles of garden waste next to buildings, trees, pathways or other vulnerable elements.
- Irrigate during periods of hot, dry weather.
- In the event of a bushfire, keep plants wet until after the fire front has passed; prioritise vegetation closest to and between buildings and the direction of the bushfire hazard.

46. You may need to check with your local government to determine if there are any specific requirements relating to landscaping and vegetation

**Plant selection 1: Lawns and grasses**

Lawns and grasses can be planted in strategic locations to break up areas of larger, more combustible vegetation. A well irrigated and maintained lawn can be used as an effective firebreak, especially when combined with non-combustible features, like a pathway, fence or stone wall.

Manage areas of lawn in a way that does not create an additional fire risk. For example, don't slash or mow during hot weather and do not store grass clippings in large exposed piles. Large, stacks of garden waste are extremely vulnerable to ember and flame attack and can promote the spread of fire.



**Plant selection 2: ground covers and creeping plants**

Ground covers and creeping plants should be used sparingly in bushfire prone areas. These plants can accumulate large amounts of fine fuels, and trap embers and other wind-driven debris.

All plants, including lush green creeping plants, can burn under the right conditions. Dry ground covers will burn almost instantaneously when in contact with an ignition source, and this fire can travel quickly along the ground. As a rule, aim to keep plants green and to a manageable size, and consider separating areas of vegetation with a non-combustible surface.



**Design strategy**

**Which selecting lawn and grass species:**

- Choose species that have favourable flammability characteristics.
- Avoid species that contain an abundance of oils, waxes or resins.
- Avoid species that produce a lot of dead plant material.
- Avoid tall grasses, especially species which have fine foliage—these plants can ignite and burn very quickly.
- Choose species that remain green throughout the summer.

**When planting lawns and grasses:**

- Plant in strategic locations to provide breaks in fuel continuity.
- Separate larger, dense plantings with lawn or short-cut grasses.
- Plant lawn or short-cut grasses in the area surrounding buildings.
- Use lawn and grasses in the design of defensible spaces.
- Consider planting lawn in the area between the main building and the direction of the fire hazard.

**When managing lawns and grasses:**

- Keep lawn and grasses short, irrigated and clear of debris—this is very important for grasses near trees, shrubs, buildings and other combustible elements.
- Grass clippings should be disposed of appropriately.
- Do not store garden waste in large exposed piles close to buildings.
- Lawn and short-cut grasses are relatively safe; however, all plants (even moist green lawn) can burn under extreme bushfire conditions.
- Minimise risk by keeping grasses short and clear of accumulated debris.

**Design strategy**

**When selecting ground cover and creeping plant species:**

- Select species with favourable flammability characteristics.
- Avoid species that contain an abundance of oils, waxes or resins.
- Avoid species that produce a lot of dead plant material.
- Choose species with lush, green foliage, and which remain green throughout the summer.

**When planting ground covers and creeping plants:**

- Avoid planting large, continuous areas of vegetation, especially near buildings (do not plant close to doors, windows or vents).
- Break up any large plantings with strategically placed pathways and open spaces.

**When managing ground covers and creeping plants:**

- Manage waste vegetation appropriately and do not store garden waste in large piles.
- Keep plants short, irrigated and clear of debris, especially during hot, dry weather.
- When under imminent threat of bushfire, keep any creeping plants wet until long after the fire front has passed.

**Plant selection 3: shrubs**

Shrubs may form a 'ladder fuel' that can spread fire along the ground to other parts of the garden. If this happens, the spreading fire may be difficult to control. To minimise this risk, ensure that plantings are positioned, maintained and irrigated appropriately



**Design strategy**

**When selecting shrub species:**

- Choose species with favourable flammability characteristics.
- Avoid species that produce a lot of ground litter.
- Choose low growing species that remain green throughout the summer—this is very important for vegetation near buildings and accessways.

**When planting shrubs:**

- Do not plant against walls or near windows, vents or doorways.
- Avoid large or dense plantings—use individual or small clusters of plants.
- Plant away from any pathways leading to the secondary place of shelter or along key access routes
- burning shrubs are a hazard to people trying to escape or defend against bushfire.
- Some larger species of shrub can be used as a bushfire barrier—these species can shield people and buildings from embers, wind and radiant heat.

**When managing shrubs:**

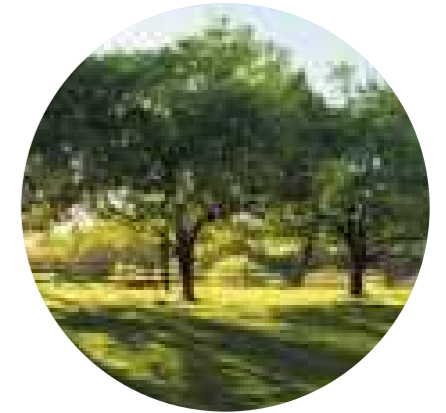
- Keep plants watered and clear of debris, especially during hot, dry weather.
- Regularly prune dead leaves and limbs and dispose of the waste appropriately.

**Plant selection 4: screening plants**

Screening plants include hedges and other windbreaking vegetation.

As well as providing privacy to occupants, appropriately selected and maintained screening plants can protect people and buildings from bushfire by:

- filtering out embers and wind-driven debris
- slowing the spread of fire
- protecting people and buildings from dangerous winds
- protecting people and buildings from radiant heat.



Windbreaks require a degree of permeability to prevent negative pressure on the house-facing side of the barrier. This negative pressure can cause dangerous turbulence during a bushfire.

The feasibility of using screening plants to improve bushfire resilience will depend on the size of the subdivision. Large land parcels in rural areas are generally more suited to this form of protection.

**Design strategy**

**When selecting screening plant species:**

- Choose species that have good barrier-forming characteristics.
- Avoid highly flammable species—plants that produce a lot of dead vegetation or which contain an abundance of an oils, waxes or resins in the leaves and stems should be avoided.
- Species that produce lush, fleshy foliage are the best option.

**When planting screening plants:**

- Screen plantings should consist of rows of closely packed shrubs or trees, either trimmed as a hedge or untrimmed as tightly grouped plantings. Include breaks in hedges to reduce vegetation continuity that could spread fire.
- Screen plantings should be placed in strategic locations to catch embers and other debris, and to shield against wind attack.
- If sited correctly, screening plants can filter out a large proportion of the burning debris that is carried by the wind during a bushfire.
- Screening plants should be positioned between the home and the most likely direction of a bushfire attack. A recommendation is that the planting should be located between 1.5 times the height of the tree and 5 times the height of the tree from the building.
- Plan for the possibility that screening plants will ignite during the bushfire. Minimise risks associated with this burning by creating a separation distance of 10 metres between the home and the plantings.

**When managing screening plants:**

- Keep plants to a manageable size, noting that overgrown vegetation is more vulnerable to bushfire.
- Keep the area around the plants free of ground litter and other combustible materials.
- Keep vegetation green and moist, especially during hot weather.

**Plant selection 5: ornamental and food-producing plants**

Ornamentals and food-producing plants provide variety and colour to the garden and are generally less flammable when compared to other types of vegetation. It is important to maintain ornamental and food-producing plants by clearing ground litter from around the plant and regularly pruning dead or dry leaves and limbs.

All plants, no matter how green or succulent, will burn if the fire is intense enough.



**Design strategy**

**When selecting ornamental and food-producing plant species:**

- Most ornamentals and food-producing plants are safe to use.
- Lush green plants are best because of their high moisture content.
- Most ornamental and food-producing plants are seasonal, so consider what this means for the design of your garden and its bushfire resilient properties.

**When planting ornamental and food-producing plants:**

- Larger species, such as orchard or flowering trees, can be used as screening plants (see section opposite).
- Plant smaller ornamental and food-producing plants in non-combustible tubs, pots or raised garden beds—separate individual garden beds using open spaces, retaining walls or pathways.
- Keep plants away from walls, windows, vents and doorways.
- Do not store on window ledges or in window-mounted pots.
- Lush green ornamental and food producing-plants can be used to break the continuity of other, more flammable vegetation.
- Prune regularly during the bushfire season to remove dead or dry plant material.

**When managing ornamental and food-producing plants:**

- Keep plants and garden beds clear of garden waste and other debris.
- Keep plants green and watered during hot, dry weather.
- In the event of a bushfire, keep plants wet until long after the fire front has passed.

**Plant selection 6: trees**

Trees have something of a dual nature when it comes to bushfires. Trees provide fuel for bushfires to burn, but when used strategically, trees can protect people and buildings from wind and radiant heat exposure and can filter out embers and other flying debris. Trees are useful in the design of a bushfire resilient home, provided they are carefully selected, maintained and positioned at a safe distance from buildings.

For existing trees, make sure to be aware of how they might affect movement around the house during a bushfire. If a tree is likely to impact people’s ability to move around safely, then it is recommended that the tree is removed or lopped. Be mindful of trees located close to buildings, roads and powerlines.



**Design strategy**

**When selecting tree species:**

- Avoid species that produce excessive amounts of leaf litter, fallen bark or woody debris.
- Avoid species that shed debris (e.g. leaves, bark) during bushfire season.
- Avoid species with loose, flaky, stringy or ribbon-like bark—these barks can spread fire to the canopy, and when dropped are a dangerous source of fine fuel.
- Select species with thick or reflective bark.
- Choose species that retain green leaves during bushfire season.

**When planting trees:**

- Keep trees away from buildings, water supplies, powerlines, accessways, exit routes and defensible spaces—trees and tree limbs are vulnerable to strong winds.
- Trees should be at least 1.5 times their mature height away from buildings and other vulnerable elements, such as pathways and secondary places of shelter.
- Separate large trees to minimise the spread of fire (especially canopy-to-canopy fires).
- When building near established vegetation, fell individual trees (if possible) to create gaps between plantings to help slow or stop the spread of fire.

**When managing trees:**

- Remove low hanging and damaged branches—these are vulnerable to ‘laddering’ and wind damage.
- Remove loose bark, dead leaves, twigs and branches from the lower reaches of the tree.
- Keep the area under trees clear of ground litter and other combustible materials.
- Remove leaves, bark and other flammable materials from gutters, rooftops and around other parts of the house.
- Dispose of garden waste appropriately.

## Ongoing Maintenance

### Building maintenance

Buildings are dynamic systems that constantly change, meaning there is an ever present need to maintain their bushfire resilient properties.

Even appropriately designed buildings can be compromised through a lack of routine maintenance. Remember that buildings follow a weakest link principle, where a single flaw in the design or management of the building can compromise the entire structure.

This section provides general guidance for the management of all new and existing buildings. The information below is intended to supplement the materials provided in **Part 2** and **Part 3, bushfire resilient design and construction**.

#### General management

Care should be taken to ensure the bushfire resilience of a building is maintained and reflects the changing nature of the landscape. Be aware that new hazards may develop which warrant additional design or construction responses. For example, vegetation in an adjacent property may become overgrown through the passage of time, creating a bushfire hazard not present when the building was initially designed.

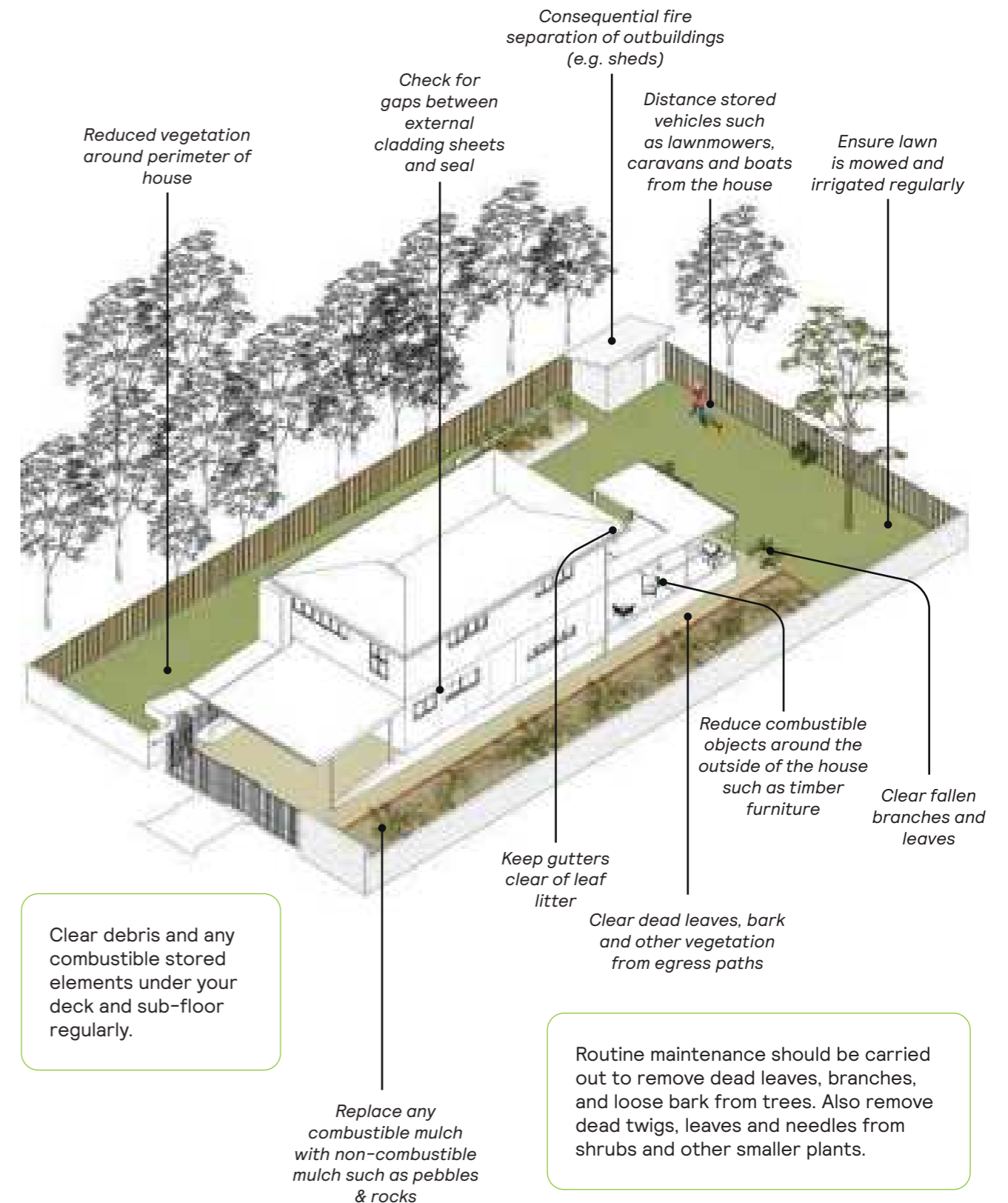
General management actions include:

- Continue to update and refine your bushfire survival plan. Note and adjust for any changes in the building's condition, local bushfire hazards, road closures, accessibility (onto, through and adjacent to the property), access to water and equipment, and the health and mobility of occupants.
- Routinely check for any damage to vulnerable building elements. Pay close attention to the condition of doors, windows, vents, roof systems, building facades, stairs and steps.
- Routine maintenance should be carried out

to remove dead leaves, twigs, bark, and other organic matter from around buildings, parking spaces and accessways. As a rule, aim to keep the area within 10 meters of the main building clear of loose, combustible materials. The frequency with which this maintenance is carried out will depend on your situation, for instance, more heavily vegetated gardens will require more frequent management.

- Routinely check that driveways are kept in good condition and are free from fire and trip hazards, or other obstacles which may prevent or obstruct access.
- Regularly check for disruptions to local water services.
- Ensure that home water pumps and water supplies (including hoses and fittings) are available and in good working condition. We recommend routine testing of all hoses, pumps and fire suppression systems before and during the bushfire season.

### Property maintenance in a bushfire prone area



### Walls and Cladding

The integrity of wall systems must be maintained in order to retain their effectiveness as a barrier to radiant heat, wind, smoke, and ember attack.

Regular maintenance actions include:

- Damaged or missing panels, sheeting, and cladding must be repaired or replaced as soon as possible.
- Monitor external walls for cracks, gaps, and holes. Damaged surfaces should be repaired as soon as possible.
- Closely monitor the condition of any exposed timber surfaces. Decaying timber is vulnerable to bushfire attack, as embers may become lodged within gaps. Gaps in the timber should be sealed and any fire-retardant treatments or coatings need to be reapplied.
- Monitor painted surfaces for damage. Flaking, cracked, or chipped surfaces need to be repainted and any fire-retardant treatments need to be reapplied. Loose, flaking paint can readily ignite and create fine fuels which may also spread as embers.
- When under imminent threat of bushfire, do not wet masonry or concrete walls. These surfaces perform better when dry.

### Floors and underfloor spaces

Care should be taken to manage the integrity of floors and underfloor spaces – poorly managed underfloor spaces are vulnerable to bushfire attack. The following guidance on the maintenance of floor systems will help to retain their bushfire resilient properties:

- Where underfloor spaces are enclosed, cladding should be regularly checked for holes, gaps, or cracks. Any damage should be repaired.
- Routine maintenance should be carried out to clear vents and weepholes of debris.
- Avoid storing combustible materials in underfloor spaces.
- Floor surfaces should be kept in good condition. Repair or replace any damaged surfaces.
- When under imminent threat of bushfire, store any combustible rugs or mats in cupboards and ensure that walkways are clear of trip hazards.

### Roofs and roof cavities

Damaged or poorly managed roof systems are vulnerable to all forms of bushfire attack: wind, heat, flame, and embers. As a rule, care should be taken to maintain watertight seals on all exposed surfaces to prevent embers from gaining entry to the roof cavity.

Regular management actions include:

- Regular management actions include:
- Routine maintenance should be carried out to remove leaves, twigs, bark, and other combustible materials from rooftops and gutters.
- Routinely check the integrity of gutters and gutter shielding. Damaged materials should be repaired or replaced.
- Check tiles and roof lines for broken or dislodged roofing materials.
- Maintain the integrity of sarking materials.
- Damaged materials should be repaired or replaced.
- Clear vents of debris.
- Maintain the seal between the roof and wall junctions. Damage should be repaired, and any gaps should be sealed.
- Avoid storing combustible materials in roof cavities.



*Regularly clean debris from your gutters.*

### Windows and doors

Windows and doors can create problems in a bushfire, especially when under attack from embers and other burning debris. Most building losses can be attributed to failures in these systems, with faulty windows, doors, and vents providing a means of entry for embers or surface fire to ignite combustible materials inside the house or within wall, floor, or roof cavities.

Consider the following guidance:

- Maintain the integrity of door and window frames. Routinely check the materials for damage. Split, cracked, or broken frames should be repaired or replaced. Pay close attention to timber frames as they are particularly vulnerable to bushfire attack.
- Check for gaps in window and door systems (e.g. between the door and doorframe). Gaps should be minimised using draught seals or close-fitting construction methods.
- Cracked or broken glazing should be repaired as soon as possible.
- Routinely check doors for damage and excessive wear and tear. Damaged surfaces should be repaired and repainted, and any fire-retardant treatments should be reapplied.



*Damaged or decaying timber frames are vulnerable to ember attack.*

- Ensure that screens on windows and doors are kept in good condition. Tears or holes in screens need to be repaired.
- Where window shutters are installed, routinely check that they function as intended. Non-combustible shutters can enhance the bushfire resilience of buildings, so ensure shutters
- are properly maintained in order to retain their bushfire resilient properties. As a rule, shutters should be closed when the building is unattended, in case a bushfire occurs when occupants are away from home.
- If timber window shutters are installed, ensure that fire-retardant treatments or coatings are reapplied at regular intervals as specified by the manufacturer.
- Keep the area around doors and windows clear of vegetation and other combustible elements, such as free-standing timber structures, piles of garden waste, and outdoor furniture.
- Regularly check the condition of door mats. Damaged mats should be removed or replaced as they can create a trip hazard. Ensure that mats are made of a non-combustible material to minimise the chances of them igniting and spreading fire.

### Verandahs and decks

Poorly managed verandahs and decks can ignite and spread fire to buildings or other parts of the property. We recommend using solid, non-combustible decking to partially 'design-out' this risk.



*Damaged deck is vulnerable to ember attack.*  
Source: CSIRO



*Example of deck well maintained, clear of clutter.*  
Source: Andrew Halsall

Regardless of the construction materials, attention should be paid to the following:

- Routine maintenance should be carried out to remove debris which may have accumulated around decks and its supporting elements.
- Monitor all materials for damage or excessive wear and tear. Pay close attention to holes, cracks or gaps in surface materials which may provide a point of entry for ember attack. Repair or replace materials as required.
- Check timber decking and support columns for damage. Cracks or gaps in the timber should be sealed, repainted or replaced. Fire-retardant treatments should also be reapplied on a regular basis as recommended by the manufacturer.
- Maintain artificial lighting or navigation aids for use during low visibility conditions. Be mindful of slip and fall hazards around the perimeter of decks and verandahs.
- Minimise the number of plants stored on decks and verandahs. Ensure that any plants are well-maintained and are potted in fire-resilient containers (such as ceramic or concrete pots). Plants should be positioned away from doors, windows, vents and stairs.
- Keep decks and verandahs clear of excessive clutter. Maintain clear, open spaces, especially near to doors, steps, and stairways where clutter may form a trip hazard. Clear debris accumulating in corner and close to combustible elements.
- Minimise the number of plants stored on decks and verandahs. Ensure that any plants are well-maintained and are potted in fire-resilient containers (such as ceramic or concrete pots). Plants should be positioned away from doors, windows, vents and stairs.
- Keep decks and verandahs clear of excessive clutter. Maintain clear, open spaces, especially near to doors, steps, and stairways where clutter may form a trip hazard.

## Landscape and garden maintenance

### Managing garden waste

Garden waste includes any dead plant material or organic plant matter. This includes lawn clippings, pruned leaves and branches, weeds, compost and whole plants that have been removed from the soil.

- Garden waste, is a significant fire hazard.
- Inappropriately managed waste can ignite and spread fire and embers.
- inappropriately managed garden waste is a significant hazard. Light waste is vulnerable to being spread by winds that accompany a bushfire.
- This wind-driven debris may then accumulate on rooftops or in and around other vulnerable elements of buildings. When ignited, this debris can threaten buildings and the safe escape of occupants.

Regular management actions include:

- Do not store garden waste in exposed piles. Dispose waste using the green waste bins provided by your local council.
- Store garden waste in tubs or cover with a non-flammable material.
- Keep all compost and piles of garden waste moist, especially during hot weather. Dry garden waste is a bushfire hazard.
- Store garden waste well away from buildings, never store compost or piles of garden waste near to doors, windows, vents or key access and exit routes.
- Routine maintenance should be carried out to remove garden waste from around the garden.
- Routinely remove any organic material that might accumulate around buildings.



### Vegetation management

We recommend incorporating vegetation management into your bushfire survival plan. Areas of unmanaged vegetation can drastically increase the impacts of a bushfire and will reduce the chances of people and buildings surviving the event.

Regular management actions include:

- Maintain a clear understorey around trees and shrubs.
- Routine maintenance should be carried out.
- Prune excess foliage (especially dead or dry foliage) from trees, shrubs and other woody plants.
- Remove the lower branches of trees. Keep all lawn and grasses short
- Retain the moisture content of plants by watering them regularly.
- Be mindful of the influence of seasonal weather patterns and how the garden will perform in summer when bushfires are most prevalent.
- Trees and other vegetation in the vicinity of powerlines must be managed.
- Woodpiles and other combustible materials should be stored downslope (if possible) and well away from buildings.
- Replacement plantings will need to be considered as older plants die or the needs of the occupants change.

## Appendix A–Acronyms and Abbreviations

<b>APZ</b>	Asset Protection Zone
<b>AS</b>	Australian Standards
<b>BAL</b>	Bushfire Attack Level
<b>BCA</b>	Building Code of Australia
<b>BPA</b>	Bushfire Prone Area
<b>CSIRO</b>	Commonwealth Scientific and Industrial Research Organisation
<b>FDI</b>	Fire Danger Index
<b>FDR</b>	Fire Danger Rating
<b>NASH</b>	National Association of Steel-framed Housing
<b>NCC</b>	National Construction Code

## Appendix B–Glossary

**Access (and ingress and egress):** to enter (ingress) or exit (egress) a site or location. This may include stairs, steps, walkways, traversable open spaces, driveways, and public and private roads.

**Active (and passive) protection systems:** in the context of bushfires, active protection systems (such as automatic sprinkler systems, fire extinguishers and smoke alarms) act in order to suppress, extinguish, or alert people to the presence of a fire. These systems require some amount of energy, action or motion to take effect. Passive protection systems (such as non-combustible retaining walls or breaks in the continuity of vegetation) are static building or landscaping features and are generally aimed at stopping or slowing the spread of fire or preventing an initial ignition.

**AS 3959:** regulatory construction standards applicable to residential developments in bushfire prone areas within Australia.

**Aspect (of slopes):** the compass direction that a slope faces. In the context of bushfires, aspect influences the amount of sunlight or solar radiation that a fuel source (vegetation growing on the slope) receives. This will also influence the moisture content of the fuel, making it easier (or more difficult) to ignite.

**Asset protection zone (APZ):** also referred to as a fire protection zone, an APZ is a fuel-reduced area surrounding a house or other asset of value. This can include any residential, commercial, industrial or heritage-listed building. Fuel-reduced means an active reduction in the available vegetation, which is sufficient to reduce the impacts of bushfire on the asset.

**Bushfire:** an unplanned fire burning in forest, woodland, grassland or scrub. Bushfires are a defining feature of many of Australia’s ecosystems and play an important role in shaping the landscape and the biodiversity within it.

**Bushfire attack:** the method or mechanism by which a bushfire can damage, injure, kill or destroy. There are four main types of bushfire attack (embers, radiant heat, flame, wind), and each presents specific risks and may require specific measures to address.

**Bushfire Attack Level (BAL):** a means of measuring the severity of a building’s potential exposure to bushfire attack. BAL is used as the basis for establishing the requirements for construction to improve protection of building elements in AS 3959.

**Bushfire event:** any occurrence of a significant, uncontrolled bushfire that threatens life or property.

**Bushfire front (also called a fire front):** the part of the bushfire within which continuous smouldering or flaming combustion is taking place. The bushfire front is the leading edge of the bushfire’s perimeter.

**Bushfire hazard:** an event or natural phenomenon that may lead to or contribute to the loss of life, injury, infrastructure damage, or socio-economic or environmental disruption. Bushfire hazards include embers, radiant heat, flame, smoke, toxic gases and particles, winds, and the vegetation or other fuels that support bushfires.

**Bushfire prone area (BPA):** an area of land that can support a bushfire or is particularly vulnerable to bushfire attack. A statewide map that identifies areas at very high risk of bushfire. Properties that fall within an area identified by the Bushfire Prone Area require measures to protect against bushfire attack mechanisms.

**Bushfire resilient design:** the use of materials, construction methods and design principles that can withstand substantial bushfire attack by actively mitigating hazards and reducing or eliminating vulnerabilities.

**Bushfire risk:** the combination of one or more related hazards and exposure to these hazards. Includes an object’s, person’s or system’s vulnerability to these hazards.

**Bushfire survival plan:** a bushfire survival plan outlines all the decisions that households must make when threatened by a bushfire, including whether to leave early or stay and defend the property, as well as plans for escape and defence, and many other important and potentially life-saving details. A bushfire survival plan should be completed well in advance of the bushfire season.

**Canopy (or crown) fire:** a fire burning in the upper foliage of a tree.

## Appendix B–Glossary

**Combustion:** a chemical process where a material (a fuel source) reacts rapidly with oxygen and produces heat.

**Consequential fire:** defined as any fire supported by the burning of combustible elements surrounding a house, such as fences, wood heaps, cars and sheds.

**Cut-and-fill:** the process of moving earth from one place to another to make an area of land level for the construction of a new building. The 'cut' is performed when earth is removed from above the desired ground level and the 'fill' is performed when earth is used to fill in a depression up to the desired height.

**Debris:** fine bushfire fuels, such as dry leaves, bark, twigs, scattered mulch, grass clippings, paper and other light weight combustible materials. Debris can support surface fires and can form embers when spread by winds.

**Embers (also called burning debris):** any burning twigs, leaves, bark and other debris that are carried by the wind. Embers can land well ahead or away from the main bushfire front, and as such they represent an especially unpredictable hazard. Ember attack is the most common way that buildings catch fire during bushfires.

**Exposure:** the state of experiencing or being subjected to a hazard. In the context of bushfire resilience, the goal should be to limit or eliminate exposure to the harmful or damaging effects of bushfires.

**Fire:** chemical reaction that occurs when flammable objects combust and produce heat. Three components are necessary to ignite and sustain a fire: fuel to burn, heat to ignite the fuel and oxygen to sustain the chemical reaction.

**Fire danger index (FDI):** an index of relative fire danger, developed by CSIRO scientist AG McArthur, for Australian forests and grasslands. FDI is calculated as a function of a location's air temperature, relative humidity, wind speed and fuel-based moisture content on a given day. The higher the FDI, the greater the danger should a bushfire occur on a given day.

**Fire danger rating (FDR):** a descriptive indicator of relative fire danger based on the FDI. The FDR provides a six category (low-moderate, high, very high, severe, extreme, catastrophic) assessment of a fire's behaviour and its potential impacts on the community, should a bushfire occur on a given day.

**Fire front:** see bushfire front

**Fire fuel:** small pieces of vegetation or garden waste under six millimetres in diameter (e.g. twigs, leaves, wood chips and grass clippings). Fine fuels are easily ignited, burn quickly and can form embers, which may spread fire to new locations.

**Fuel:** a source of fuel is required to sustain and spread bushfires. The most common bushfire fuels include fallen bark, leaf litter, dry grasses and unmanaged vegetation (such as overgrown trees and shrubs).

**Fuel load:** describes the amount of fuel in a landscape. Generally, the greater the fuel load, the hotter and more intense the bushfire.

**Asset Protection Zone:** An area of managed vegetation surrounding a building where fuels are reduced or modified to lower bushfire intensity and provide defensible space between the building and surrounding vegetation.

**Hazard:** see definition for bushfire hazard.

**Hazard assessment:** the process of hazard identification, analysis and evaluation.

**Ignition:** the process by which a fuel catches fire. In the context of bushfire resilience, the goal should be to reduce the chances of building and landscaping elements igniting.

**Laddering:** the process by which fire spreads from the ground layer to the crown of a tree, by burning along the surface of the trees' bark, up nearby shrubs, or up climbing plants.

**Landforms (and earthworks):** Landforms and earthworks can be used to mitigate the hazards associated with bushfire. Landforms are naturally occurring features in the terrain, such as ridges, slopes and gullies, while earthworks are human-made and include earth mounds, terraces and retaining walls.

## Appendix B–Glossary

**Managed vegetation:** vegetation that has been modified or planned in such a way to reduce the opportunities for it to ignite and spread fire.

**Mitigation (also called hazard reduction):** actions taken to eliminate a hazard or reduce its harmful effects.

**NASH Standard:** the NASH Standard for Steel Framed Construction in Bushfire Areas, which provides construction standards and guidance for new buildings located in bushfire affected regions. The standard provides two separate solutions, one covering lower BALs (BAL-12.5 to BAL-40) and another for BAL-FZ (buildings located in a flame zone).

**Open space:** an area of open land with little or no vegetation, featuring an artificial or highly managed surface (e.g. lawns, paved areas, mown or grazed paddocks, sporting ovals, tennis courts and other similar spaces).

**Radiation (radiant heat):** the heat produced from combustion, or the burning of a fuel source.

**Re-entrant corner:** the internal angle (or corner) formed at the junction of two vertical surfaces of a building.

**Resilience:** the ability of a building, environments or community to withstand and recover from the negative impacts of a hazard.

**Sarking:** a sheeting of waterproof material used beneath roofing materials or behind wall cladding.

**Sarking (fire resistant):** non-combustible sheeting.

**Secondary place of shelter (secondary shelter):** an alternative refuge where a person may shelter during the passage of a bushfire with some level of safety.

**Site assessment:** the process of hazard identification, analysis and evaluation at a site – usually at the location of a new build.

**Site layout:** the general arrangement of garden beds, trees, pathways and other features in the area surrounding the main building.

**Site slope:** the average slope (also called gradient or incline) of the ground between the building or proposed building site and the edge of the nearest bushfire hazard (e.g. an area of unmanaged vegetation).

**Siting:** the process of positioning a home and other fixed structures on a property in order to mitigate the risks or impacts of bushfires and any other potential hazards.

**Surface fire:** low to high intensity fire that burns horizontally along the ground, consuming low-lying vegetation, ground litter and other debris.

**Temperature (ambient):** the temperature of the air in an environment or in the space surrounding an object or structure.

**Terracing:** the process of grading or cultivating a slope into a series of level spaces (called benches or steps).

**Topography:** (also called terrain), describes the shape, arrangement or layout of the earth's surface.

**Tree strike:** the process by which a damaged tree or branch falls and causes damage to property or causes injuries or loss of life. Tree strike can occur at any time, as a result of prolonged or sudden damage from winds, disease, insect infestation or dry rot from drought. It is also a common occurrence during and preceding a bushfire as significant fire and wind damage can weaken trunks and branches, which may lead to them falling.

**Unmanaged vegetation:** vegetation that results in a substantial bushfire hazard when ignited.

**Vulnerability:** the characteristic or property of a community, system or object that makes it susceptible to the damaging effects of a specific hazard.

**Wind direction:** the direction a wind is blowing from. For example, a north-westerly wind will be blowing from the north-west and will generally be pushing the fire front in a south-easterly direction.

## Appendix C–References and Resources

### References

Arena, A., Opie, K., Warren, G., Bianchi, R., Leonard, J. & Newnham, G. (2018). Tathra Fire, NSW, 18 March 2018: Preliminary findings on regulated buildings affected by the fire. Melbourne: CSIRO confidential report.

AS 3959 (2018). Construction of buildings in bushfire-prone areas. Standards Australia, Sydney.

AS 5414 (2012). Bushfire water spray systems. Standards Australia, Sydney.

AS/NZS 1530.8.1 (2018). Methods for fire tests on building materials, components and structures – Tests on elements of construction for buildings exposed to simulated bushfire attack – Radiant heat and small flaming sources. Standards Australia/Standards New Zealand, Sydney.

AS/NZS 1530.8.2 (2018). Methods for fire tests on building materials, components and structures – Tests on elements of construction for buildings exposed to simulated bushfire attack – Large flaming sources. Standards Australia/Standards New Zealand, Sydney.

Barrow, G.J. (1945). Survey of houses affected in the Beaumaris fire, January 14, 1944. Journal of the Council for Scientific and Industrial Research, 18(1).

Bianchi, R. & Leonard, J. (2008). Property safety: judging structural safety. In: Handmer, J. & Haynes, K. (eds.), Community Bushfire Safety, pp. 77–85.

Bowditch, P. (2006). House fire spread, an investigation – Gulgong NSW. CSIRO Manufacturing and Infrastructure Technology report to Bushfire CRC.

Cohen, J.D. (2000). Preventing disaster. Journal of Forestry, 98(3), pp. 15. Available from: <http://proquest.umi.com/qdweb?did=55322153&sid=1&Fmt=1&clientId=82754&RQT=309&VName=PQD>.

Gold Coast City Council (2020). Bushfire Resilient Design Guidelines. Gold Coast, QLD. Available from: <https://www.goldcoast.qld.gov.au/files/sharedassets/public/v/2/pdfs/brochures-amp-factsheets/bushfire-resilient-design-guideline.pdf>

Leonard, J. (2019). Decks, Porches, and Patios. In: Manzello, S.L. (ed.), Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires. Cham: Springer International Publishing, pp. 1–8. Available from: [https://doi.org/10.1007/978-3-319-51727-8\\_108-1](https://doi.org/10.1007/978-3-319-51727-8_108-1).

Leonard, J., Bianchi, R., Bicknell, A.D., Sargeant, A.J., Reisen, F., White, N. & Cheng, M. (2006). Research and investigation into the performance of residential boundary fencing systems in bushfires. CSIRO Manufacturing & Infrastructure Technology.

Leonard, J., Bianchi, R., Leicester, R., Lipkin, F., Newnham, G., Siggins, A., Opie, K., Culvenor, B., Cechet, B., Corby, N., Thomas, C., Habili, N., Jakab, M., Coghlan, R., Lorenzin, G., Campbell, D. & Barwick, M. (2009). Building and land use planning research after the 7th February 2009 Victorian bushfires: Preliminary findings.

## Appendix C–References and Resources

Melbourne: Bushfire CRC. Available from: <http://www.bushfirecrc.com/managed/resource/bushfire-crc-victorian-fires-research-taskforce-final-report.pdf>

Leonard, J.E., Bianchi, R., White, N., Bicknell, A., Sargeant, A. & Andersson, S. (2005). Research into the performance of water tanks in bushfire. CSIRO Manufacturing & Infrastructure Technology report for Bushfire CRC.

Leonard, J.E., Opie, K., Bianchi, R., Newnham, G. & Holland, M. (2016). Wye River/Separation Creek post-bushfire building survey findings. Available from: <http://wyeseconnect.info/wp-content/uploads/2016/05/Wye-River-Separation-Creek-final-V1-1.pdf>.

Manzello, S.L., Cleary, T.G., Shields, J.R. & Yang, J.C. (2006). Ignition of mulch and grasses by firebrands in wildland-urban interface fires. International Journal of Wildland Fire, 15(3), pp. 427–431. Available from: <http://www.publish.csiro.au/paper/WF06031>.

Manzello, S.L., Park, S.-H. & Cleary, T.G. (2009). Investigation on the ability of glowing firebrands deposited within crevices to ignite common building materials. Fire Safety Journal, 44(6), pp. 894–900. Available from: <http://www.sciencedirect.com/science/article/B6V37-4WH0JRY-2/2/c93bb86ccb5fc7607bd857e767b0fb45>

Mell, W., Maranghides, A., McDermott, R. & Manzello, S.L. (2009). Numerical simulation and experiments of burning Douglas fir trees. Combustion and Flame, 156(10), pp. 2023–2041.

NASH Standard (2014). Steel Framed Construction in Bushfire Areas. Melbourne, Australia.

Queensland Reconstruction Authority (2024). Bushfire Resilient Building Guidance. Available from: [https://www.qra.qld.gov.au/sites/default/files/2024-02/0873\\_QRA%20CSIRO%20Bushfire%20Guideline%20%28updated%20February%202024%29.pdf](https://www.qra.qld.gov.au/sites/default/files/2024-02/0873_QRA%20CSIRO%20Bushfire%20Guideline%20%28updated%20February%202024%29.pdf)

Ramsay, G.C., McArthur, N.A. & Dowling, V.P. (1996). Building in a fire-prone environment: research on building survival in two major bushfires. Proceedings of the Linnean Society of NSW, 116, pp. 133–140.

Ramsay, G.C. & Rudolph, L.S. (2003). Landscape and building design for bushfire areas. Melbourne: CSIRO Publishing.

Standards Australia (2018). AS3959 – Construction of buildings in bushfire prone areas. Sydney: Standards Australia. References

### Resources – General

- CSIRO – [Bushfire Best Practice Guide](https://research.csiro.au/bushfire/) (<https://research.csiro.au/bushfire/>)
- [Home – Bushfire Resilience Inc](https://bushfireresilience.org.au/) (<https://bushfireresilience.org.au/>)

### NSW Specific

- [Check if you're in bush fire prone land – NSW Rural Fire Service](#)
- [Planning for Bushfire Protection | NEMA](#)
- [AFDRS Community Resources](#)

## Appendix D–Bushfire Attack Level Calculator

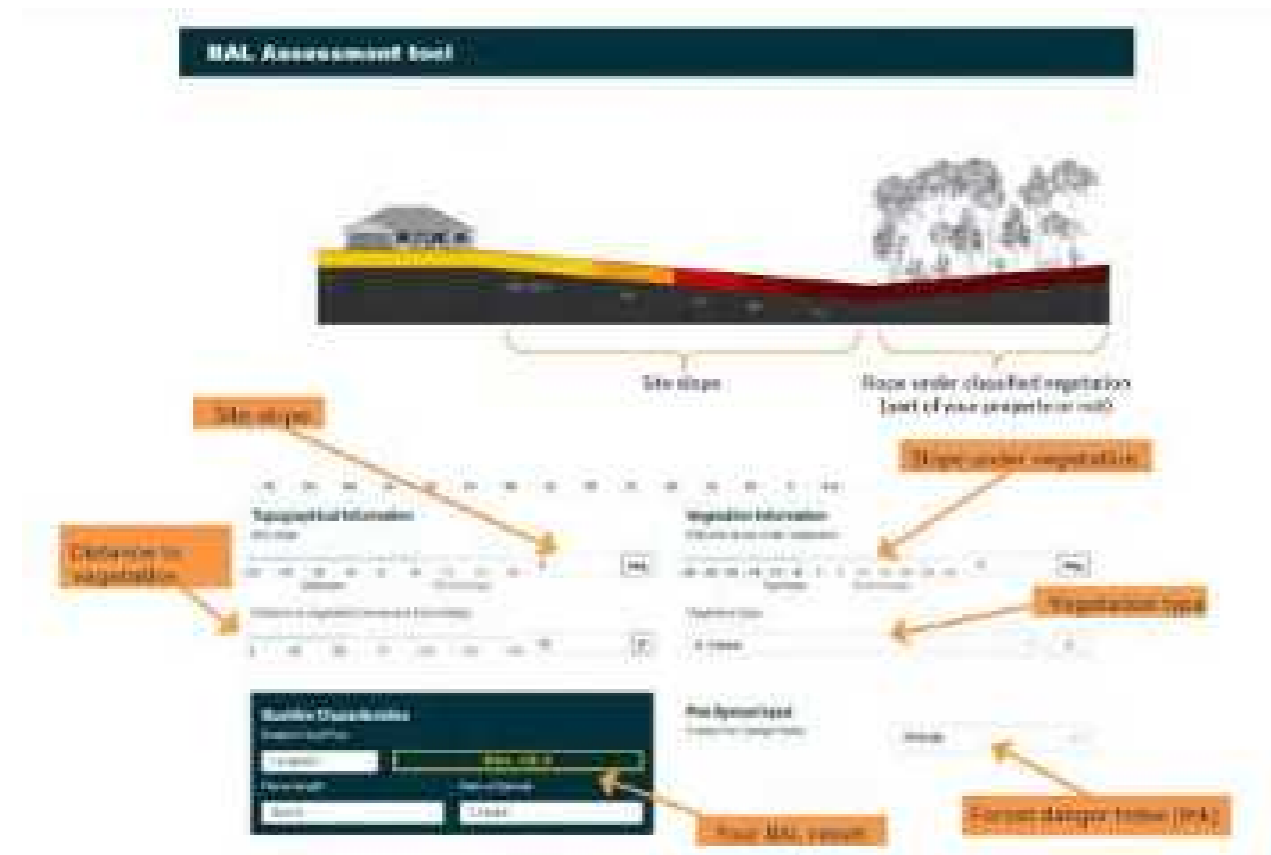
Bushfire Attack Level (BAL) contours (i.e. estimates of the bushfire attack level in the direction of any surrounding classified vegetation) form the basis of most planning and building regulations. Where different building controls are required for different BALs, BAL contours can aid in siting the house in order to reduce the impacts of bushfire and mitigate the surrounding hazards.

BAL contours can be determined using the CSIRO interactive BAL assessment tool and calculator, available at [best-practices-assessment-tool.herokuapp.com/#calculator](https://best-practices-assessment-tool.herokuapp.com/#calculator).

The BAL calculator requires the following inputs for each contour:

- an estimate of the location's fire danger index
- the majority classified vegetation type or types in the direction of the given BAL contour
- the average distance to the classified vegetation
- an estimate of the effective slope underneath the classified vegetation
- an estimate of the site slope (the average slope between the site and the classified vegetation).

Guidance on how to estimate these inputs is available in AS 3959.



Please note that this Guide is general guidance on bushfire resilience design practice and strategies that may be suitable for your home. The identification of strategies is for information purposes and should not be taken or construed as advice.

We recommend this Guide is shared with building professionals or other suitable consultants (such as a licenced builder, building designer, architect or engineer) for advice to determine whether the options or strategies contained in this Guide are suitable for your home and circumstances.

