Fire Risk Assessment Study
North West Corner - Officer Precinct Structure Plan

Draft for discussion

Report Commissioned by Cardinia Shire Council

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Fire Risk Assessment Study: North West Corner – Officer Precinct Structure Plan

Report prepared by Terramatrix on behalf of Cardinia Shire Council, February 2011

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0.1	20 January 2011	Report outline	JB, NE, CS
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1 Introduction

Terramatrix Pty Ltd was commissioned by the Cardinia Shire Council to conduct an assessment of the wildfire risk posed to the northwest corner of the Officer Precinct Structure Plan.

Risk to the proposed residential development is assessed using three criteria:

1. The deemed to satisfy provisions of the Wildfire Management Overlay (WMO);
2. A WMO option 3-style alternative solution using site-specific data; and
3. The simple site assessment procedure of *AS:3959-2009 Construction of Buildings in Bushfire Prone Areas* (Standards Australia, 2009a).

This report presents an analysis of the wildfire risk to the study area and suggests planning approaches to enable safe residential development. The report:

- Describes potential bushfire scenarios on a landscape scale;
- Classifies vegetation within the study area pursuant to the WMO and AS:3959-2009;
- Predicts potential fire behaviour within each vegetation type using site specific and WMO-default inputs for a number of vegetation management scenarios;
- Calculates the requisite buffer distances for each scenario and each fire impact model; and
- Suggests guiding principles to be applied to ensure appropriate subdivision and development design in response to the significant vegetation and fire management.

The detailed requirements of the study were provided in Cardinia Shire Council (2010) *Quote Required for Fire Risk Assessment Study North West Corner – Officer Precinct Structure Plan: Consultancy Brief*. The specific research questions are listed in Appendix 1.

2 Methodology

In this section a summary of the methodology is provided. A detailed methodology is provided as Appendix 2.

The approach taken in this investigation is consistent with the risk management standard (ISO:31000 – Standards Australia, 2009b) and utilises the standard site assessment methodologies for assessing bushfire risk to new development in Victoria. It includes the following steps:

1. Set the context for the risk analysis;
2. Determine the fire management objectives based on the Victorian Planning Provisions and Cardinia Shire Council Municipal Fire Prevention Plan;
3. Identify and assess the elements of hazard, exposure and vulnerability that contribute to bushfire risk to the proposed use of the site;
4. Survey the site including mapping of current fire management works, defining fire behaviour zones for subsequent modelling, and assessing topography, vegetation structure and fuel hazard;
5. Model the potential fire behaviour across the study area for specified weather conditions;
6. Model the impact of the test fires on the proposed development within the site using three standard site tools:
    a. The deemed to satisfy provisions of the Wildfire Management Overlay (WMO);
    b. A WMO option 3-style alternative solution using site-specific data; and
    c. The simple site assessment procedure of *AS:3959-2009 Construction of Buildings in Bushfire Prone Areas*; and

7. Suggest design principles to mitigate the risk to the proposed development.

3 Context of the risk analysis and fire management objectives

3.1 Context

The context of this risk analysis is the impact that a major bushfire may have on the safety of future residential development, and hence residents, within the study area. Analysis considers the impact of both a fire starting within the study area and an established fire burning into the Precinct.

Potential mitigation of the impact of such a fire is considered in the context of:

1. Our current understanding of building and life safety during major bushfires;
2. The existing suite of bushfire safety controls regulating development in Victoria;
3. Cardinia Shire Council land use planning and bushfire safety policy positions; and
4. The findings of the 2009 Victorian Bushfires Royal Commission (VBRC, 2010).

A summary of this contextual information is provided in Appendix 3.

3.2 Safety objective and risk criteria

The safety objective set for this study of bushfire risk in the northwest corner of the Officer Precinct Structure Plan is that future development should be able to withstand the level of bushfire attack credible for the site during a major bushfire under Code Red weather conditions.

The performance requirement for this objective is that there is no flame contact or radiant heat ignition of future buildings and that the risk of ember ignition is minimised.

The criteria against which the risk is assessed is that future residential development is able to meet the requirements of the WMO and AS:3959-2009.

4 Study site description

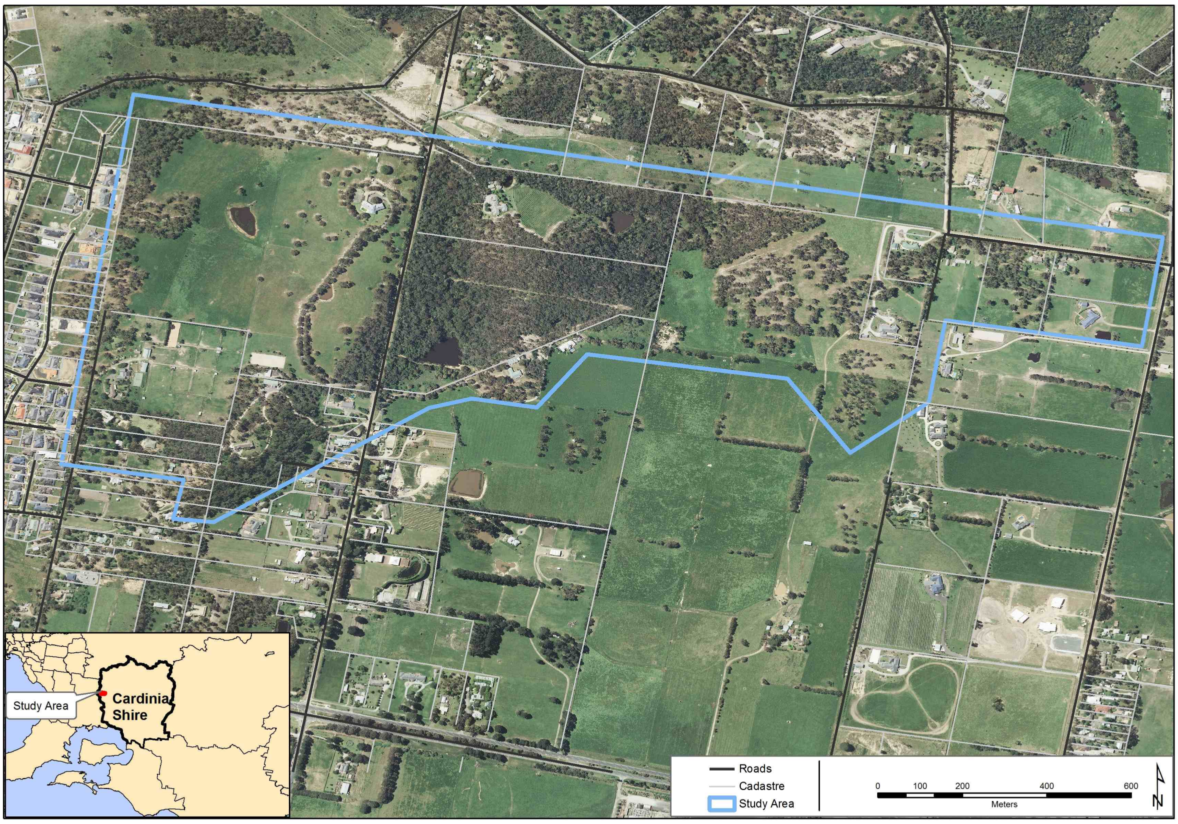
This section describes the study area in terms of its location, physical environment and planning context.

4.1 General information

Location:	Northwest corner of Officer Precinct Structure Plan
Municipality:	Cardinia
Directory reference:	Melway 214 E1
Assessment date:	12 January & 19 January 2011

The study area is located on the northern edge of the Officer township, immediately south of the electricity transmission line easement (see Map 1). The study area runs from the east side of May Road to the west side of Bayview Road.

An inspection of the study area was conducted by Jon Boura, Duncan Maughan, Nancy Easton and Catherine Stephenson on the 12th of January 2011 with field data collection by Jon Boura and Catherine Stephenson on the 19th of January 2011.

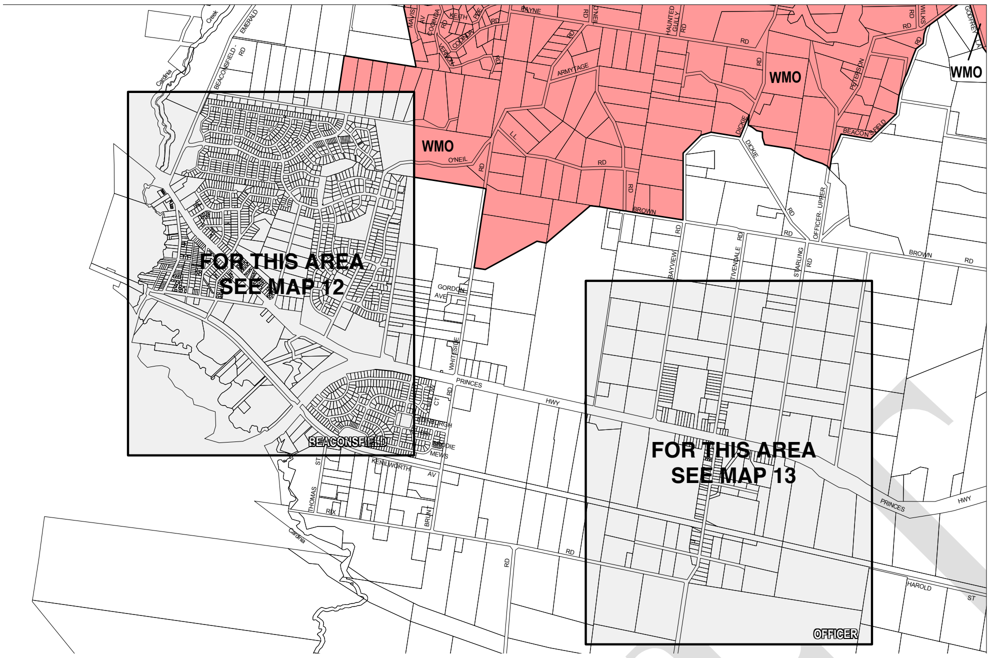


Map 1 – Study area in the north west of the Officer Precinct Structure Plan.

4.2 Planning context

Zone:	Urban Growth Zone (UGZ)
Overlays:	Wildfire Management Overlay (WMO) Environmental Significance Overlay (ESO) Environmental Significance Overlay – Schedule 1 (ESO1)

Wildfire Management Overlay
The existing WMO covers a small section in the north of the study area immediately east of Whiteside Road comprising the two northernmost blocks in Whiteside Road and a small parcel of trees in the northwest corner of 325 Old Princes Highway (see Map 2). The area to the north of the study area is also covered by the WMO.



Map 2 – Extent of the WMO in the vicinity of the Officer Precinct.

The purpose of the WMO is 'to identify areas where the intensity of wildfire is significant and likely to pose a threat to life and property.

To ensure that development which is likely to increase the number of people in the overlay area:

- Satisfies the specified fire protection objectives.
- Does not significantly increase the threat to life and surrounding property from wildfire.
- To detail the minimum fire protection outcomes that will assist to protect life and property from the threat of wildfire.'

(Victorian Planning Provisions Clause 44.06)

This purpose is achieved by designating areas of potentially high fire intensity as WMO areas and requiring a planning permit for construction and use within those overlay areas. In addition a set of objectives relating to water supply, access, construction standards and vegetation management are specified in order to achieve a satisfactory level of fire protection.

Environmental Significance Overlay

The purpose of the Environmental Significance Overlay is to identify where the development of land may be affected by environmental constraints and to ensure that development is compatible with identified environmental values.

Schedule 1 to the Environmental Significance Overlay highlights areas in the northern part of the municipality (north of the Princes Highway) as an area with significant landscape and environmental values. The area is characterised by a geology of Devonian Granitic and Sulrian Sediment origin, moderate to steep slopes, and areas of remnant vegetation. These characteristics are significant factors for environmental hazards including erosion and bushfire.

The objectives of the schedule are to ensure that siting and design of buildings and works do not adversely impact on environmental values including the diverse and interesting landscape, areas of remnant vegetation, habitat of botanical and zoological significance and water quality. Consideration should also be given to hazards such as slope, erosion and fire risk.

4.3 Physical environment

4.3.1 Overview

The study area is situated in the Urban Growth Corridor between the Beaconsfield-Nar Nar Goon Road (old Princes Highway) and the electricity transmission line. The study area will be part of the planned residential expansion of Officer and will comprise new residential subdivisions, existing larger bushland residential blocks, and public open space.

The study area marks the transition from the flat grasslands of Officer to the forested foothills leading up to Mount Misery, Upper Beaconsfield and Pakenham Upper.

4.3.2 Topography

The southern part of the study area is essentially flat.

The ground rises to the north and northwest as a series of gentle spurs extend south from the uplands to the north. The steepest slopes are on the spur sides (predominantly easterly or westerly aspects) and average around 15° with small sections up to 20°. The steepest section is on the western side of Whiteside Road.

The land rises gently through the centre of the study area to the top of Whiteside Road (see Figure 1) with southerly and southeasterly aspects and an average slope of approximately 5°; and more steeply up to the ridge line near the western end of Brown Road (see Figure 2) averaging 10° over 200 metres with a maximum of 15° over a 20 metre section.

Figure 1 – Land rising to the northwest (southeasterly aspect) towards the top of Whiteside Road.

Figure 2 – Land rising to the northeast (southwesterly aspect) south of Brown Road.

Beyond the study area the land slopes up from the northwest with the steepest slopes under the Woodland parallel to O'Neil Road (8° with a westerly aspect) and parallel to the transmission line immediately north of Whiteside Road (8° averaged over 200 metres with one section of 15° over 20 metres and with a northwesterly aspect).

4.3.3 Vegetation and fuel

The study area is situated within the Highland Southern Fall bioregion. The predominant EVCs in the vicinity of the site are *Grassy Woodland* (175) and *Riparian Scrub/Swampy Riparian Woodland Complex* (126).

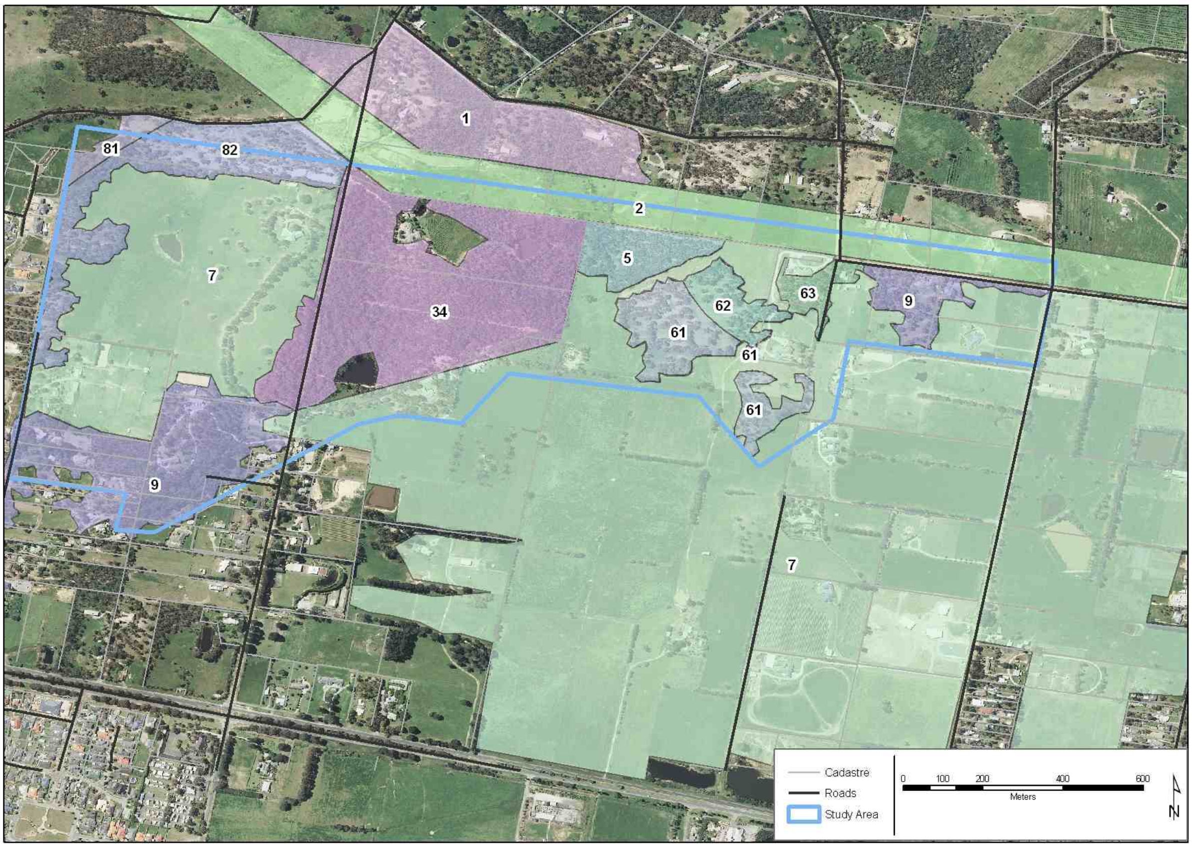
The *Riparian Scrub/Swampy Riparian Woodland Complex* occupies some of the drainage lines but appears heavily modified in many places. The remainder of the study area is classified as Grassy Forest.

Broad areas of vegetation were identified and classified according to the *WMO Applicant's Workbook* and AS:3959-2009 (see Table 1). These areas include the specific areas identified by Cardinia Shire Council for analysis.

Zones (see Map 3) were defined as:

- Zone 1 – representing the generic urban-forest interface to the north of the study area and through which a major bushfire would approach.
- Zone 2 – the 100 metre wide grassed easement for the transmission lines which is currently grazed.
- Zone 3 – those areas of the medium forest area to the east of Whiteside Road that have significant northerly, westerly or southerly aspects, i.e. where the test fire would be running up the hill.
- Zone 4 – those areas of the medium forest area to the east of Whiteside Road that have significant easterly aspects, i.e. where the test fire would be running down the hill.
- Zone 5 – an area of dense eucalypts with a forest canopy structure but a grassy understorey.
- Zone 6 (61,62,63) – areas of eucalypts planned to be retained and that currently have a grassy woodland structure. This includes the red hatched area referred to in the Scope of Works.
- Zone 7 – open grassland with scattered trees and currently grazed.

- Zone 8 (81, 82) - areas of eucalypts along the western edge of the study area that currently have a grassy woodland structure.
- Zone 9 – existing dwellings and associated gardens and paddocks. This includes the area outlined in black referred to in the Scope of Works.

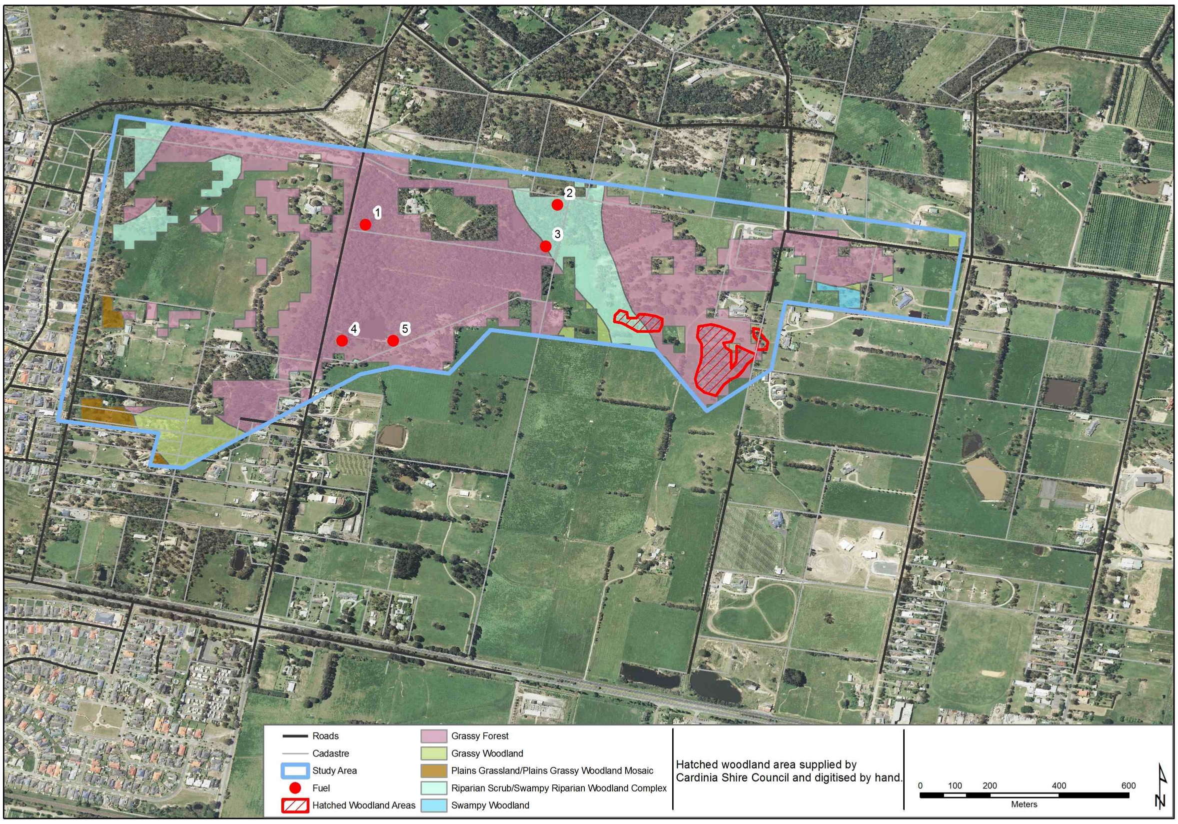


Map 3 – Vegetation zones

Zone	WMO Vegetation Type	AS:3959-2009 Vegetation Type
1	Medium Forest	Forest – open (A)
2	Grassland	Grassland (G)
3	Medium Forest	Forest – open (A)
4	Medium Forest	Forest – open (A)
5	Medium Forest	Forest – open (A)
6	Woodland	Woodland (B)
7	Grassland	Grassland (G)
8	Woodland	Woodland (B)
9	Cultivated garden	Ornamental garden (not classified)

Table 1 – Vegetation classification.

A fuel hazard assessment was conducted in Zones 3 and 4 using the Overall Fuel Hazard Guide (Hines *et al*., 2010) and comprised 5 sample points (see Map 4). Fuel data are presented in Table 2.



Map 4 – Location of fuel sample points.

Sample number	Vegetation structural type	Canopy height (m) Base/Top	Bark hazard rating	Bark fuel load (t/ha)	Elevated fuel hazard rating	Elevated fuel load (t/ha)	Elevated fuel height (m)	Near-surface fuel hazard rating	Near-surface fuel load (t/ha)	Mean litter depth (mm)	Surface fuel hazard rating	Surface fuel load (t/ha)	Combined near-surface & surface fuel hazard rating	Overall fuel hazard rating	Overall fuel load (t/ha)
1	Medium forest	12/24	High	2	High	2-3	4	High	3-4	22	Moderate	4-10 (10)	High	HIGH	11-19
2	Medium forest	10/16	Moderate	1	High	2-3	3	Extreme	6-8	12	Moderate	4-10 (5)	Extreme	VERY HIGH	13-22
3	Medium forest	Unknown	Moderate	1	Very High	3-5	4	Very High	4-6	12	Low	2-4 (4)	High	VERY HIGH	10-16
4	Medium forest	15/23	High	2	Very High	3-5	4	Moderate	2-3	18	Moderate	4-10 (8)	Moderate	VERY HIGH	11-20
5	Medium forest	15/24	High	2	Very High	3-5	3	High	3-4	10	Low	2-4 (3)	Moderate	VERY HIGH	10-15

Table 2 – Fuel hazard data for forest to the east of Whiteside Road, Officer.

Overall fuel hazard was Very High. There was some variation in the combined near-surface and surface fuel hazard rating, ranging from Moderate at two points to Extreme in one sample. In all cases the litter layer was Low to Moderate and the higher rating at some sample points was due to the presence of a thick grass layer that gave Very High or Extreme near-surface fuel ratings (see Figure 3).

Figure 3 – Fuel sample points in the Grassy Forest showing the variation in surface and near-surface fuels between points.

Bark hazard was Moderate to High at all sample points. The High ratings were due to Eucalypts with coarsely fibrous or stringybark. It is possible that the fuel hazard rating of the stringybark species could increase further over time.

Elevated fuel hazard was High to Very High and comprised a variety of shrub species up to 4 metres in height (see Figure 3).

The equivalent fine fuel load for this section of the study area was calculated to be between 11 and 18 t ha^{-1}. A total of 20 t ha^{-1} was used for fire behaviour modelling.

5 Discussion

5.1 General impressions regarding bushfire risk

There is potential for a large established bushfire to impact the northwest corner of the Officer Precinct. This fire could start to the north or northwest of the Officer Precinct in the hilly forested terrain of the Dandenong Ranges, Narre Warren East or Upper Beaconsfield (see Figure 4).

Figure 4 – Credible severe bushfire scenario for Officer Precinct study area.

The most likely scenario for a large bushfire is an event similar to the Belgrave Heights-Upper Beaconsfield fire of Ash Wednesday, 16th February 1983. Even a relatively small fire (i.e. < 1000 ha) can impact rapidly and do extreme damage within the urban-forest interface.

The Belgrave Heights-Upper Beaconsfield fire of 1983 started in Courtney Road, Belgrave Heights around 3.20 pm under conditions of extreme fire danger (FDI > 100 i.e. Code Red). The fire established quickly and houses were being lost on Courtney's Road within 4 minutes of the fire being reported to CFA (Silberbauer, 2006). The combination of extreme fire weather conditions, steep slopes and forest vegetation caused rapid fire escalation with crown fire and considerable short and long distance (> 10km) spotting (CFA, 1983; Milligan, 1992). Spot fires established along the Cardinia Creek, around Holm Park Road, Pink Hill and in the grasslands south of the Princes Highway at Officer about 4.45 pm (Milligan, 1992). The southwards run of the fire was contained in eaten out drought stricken pasture south of the Princes Highway after traveling approximately 16 km with a width of between 1 and 2 km (Milligan, 1992). A violent southwesterly wind change reached the fire area at approximately 9 pm (CFA, 1983). Fire behaviour worsened and the long eastern flank of the fire became the head of the fire and burnt through the Upper Beaconsfield township claiming 21 lives and nearly 200 homes. The fire had reached as far as Mount Eirene south of Gembrook before conditions moderated and it was contained. The final area burnt was approximately 9,200 ha (CFA, 1983).

Whilst there has been significant residential development in the area to the north and north west of the Officer Precinct since 1983 this area is still best classified as Interface Living according to the CFA precinct definitions (Kennedy *et al.*, 2008) and would support intense bushfire behaviour under extreme fire weather conditions.

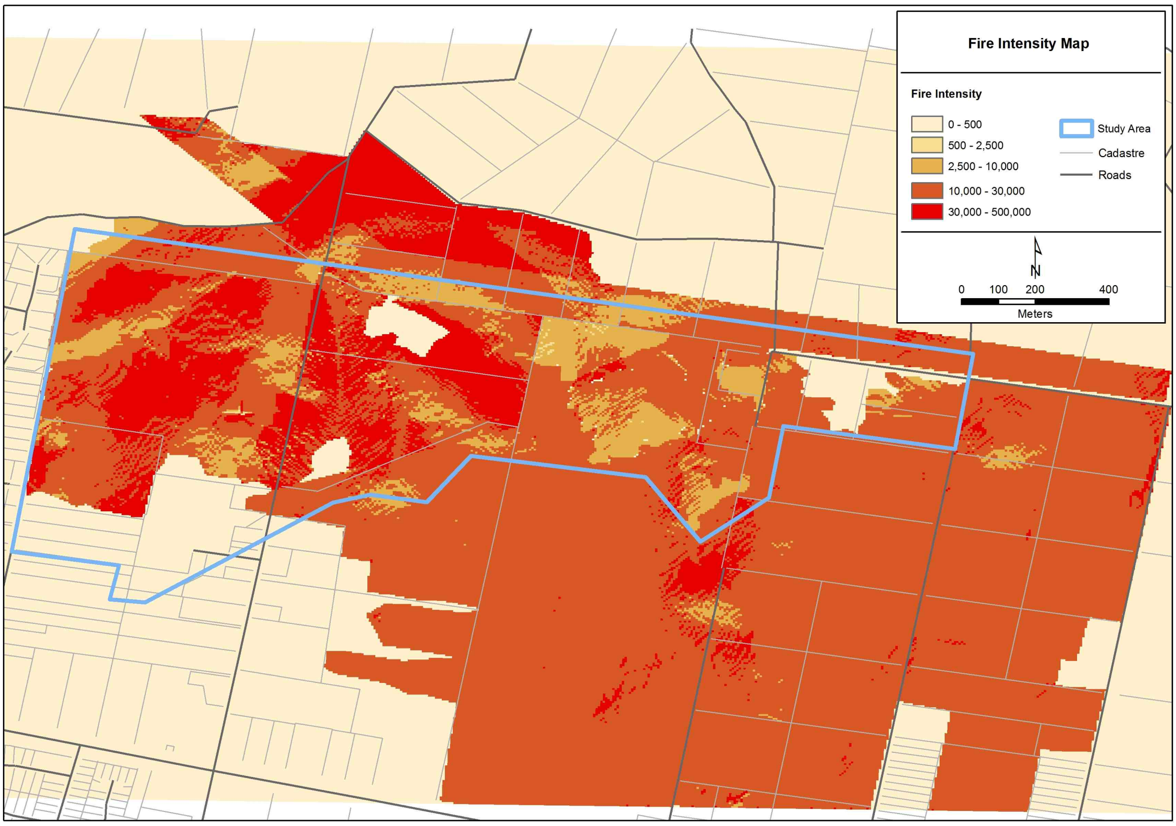
This threat is recognised in the *Cardinia Municipal Fire Prevention Plan* (Cardinia Shire Council, 2007) and the *Municipal Wildfire Preparedness Plan* (Cardinia Shire Council, no date) lists localities to the north and northwest of the Officer Precinct as being at risk from bushfire. These include areas along the Cardina Creek (e.g. Brennan Estate (UB1), High Street (UB2), Foott Road (UB3) and Alber Road (UB8)) and the southerly slopes immediately north of Officer (e.g. Mount Misery (BE1), O'Neil Road (BE2), Dickie Road (OF1) and Carpenter Road (UB12)).

There is limited potential for severe bushfire to impact the study area from a direction other than the north or northwest. The built up area of Beaconsfield, which now extends south to the Princes Freeway, provides a buffer against fire spread from the west and southwest. Whilst there is farming and bushland to the east, extreme fire weather is rarely associated with an easterly wind and so any fire from this direction will be much milder than that assumed by the planning and building controls.

It is possible for a local ignition to burn into or within the study area. A local ignition, however, would have limited opportunity for growth in terms of head fire width or length of run particularly in the fragmented vegetation of the proposed residential area.

Thus the high fire risk is the impact of an established bushfire burning into the Precinct from the north or north west of the study area. Map 5 shows predicted fire intensity across the study area with existing vegetation and fuel loads.

After the Precinct has been developed as a residential area this impact could see the main fire front or a significant spot fire impacting upon the northern edge of the study area, and significant ember attack through out the study area.



Map 5 – Predicted fire intensity across the study area for existing vegetation and fuels.

5.2 Potential fire behaviour in hatched area in Attachment 3 (Zone 6)

5.2.1 Theoretical fire behaviour in forest vs woodland in the context of the WMO

The WMO defines forest as trees of any height but with a canopy cover of at least 30% (CFA, 2010). Forest is divided into three sub-classifications:

- Low Forest where trees are 10 metres or less in height;
- Medium Forest with trees 10-30 metres in height; and
- Tall Forest with trees more than 30 metres in height.

The average tree height in Zone 6 was 20-25 metres, which would equate to Medium Forest.

Medium Forest is considered higher risk (Category 2) vegetation under the WMO (CFA, 2010). It is assumed that there will be a well-established litter layer and a shrubby or grassy understorey. The WMO applies a default overall fine fuel load of 35 t ha^{-1} of which 25 t ha^{-1} is surface or near-surface fuel.

The WMO assumes that the fire will be a crown fire under the FDI 120 conditions used in the model, and it incorporates the effect of crowning on the flame length by adding half the tree height to the flame lengths calculated for the surface fire.

The WMO defines Woodland as trees of any height but with a canopy cover of less than 30% (CFA, 2010). The WMO treats Woodland as a lower risk vegetation type (Category 1) containing low levels of fuel (CFA, 2010). It assumes that there will be little elevated fuel and that the surface fuel (litter layer) will be limited due to the sparseness of the trees. The predominant fuel layer is likely to be the near-surface fuel (i.e. grass). The WMO applies a default overall fine fuel load of 15 t ha^{-1}.

It is also implied in this lower risk rating that the low fuel load, paucity of ladder fuels (e.g. shrubs, bark) and large gaps in the tree canopy will prevent crown fire.

Fire behaviour in Woodland with a grassy understorey is similar to that of a grass fire but with the rate of spread generally about half of that in open grassland as the trees reduce the speed of the wind reaching the flames (Cheney and Sullivan, 2009). This means that fire will spread more quickly in Woodland than Medium Forest but with lower intensity.

5.2.2 Vegetation type in Zone 6

Current

The current vegetation structure is best described as Woodland under the WMO classification schema and as Woodland (B) under AS:3959-2009 (Standards Australia, 2009a).

It should be noted, however, that this structure appears to be the result of long-standing vegetation management practices; that is the grazing of livestock beneath the trees. This practice is likely to have significantly reduced recruitment of both the eucalypt overstorey and shrubby understorey species, whilst maintaining the grass in a grazed condition.

Potential changes

It is understood that this area will become part of a bushland reserve within the Precinct.

If grazing were to cease there would be changes to the fuel/vegetation structure. In the short term the grass would grow taller and pose a greater fire risk. The height of grass has a profound effect on the rate of spread of a grass fire and on flame lengths.

In the medium term the *Acacia paradoxa* that is already establishing in areas of the paddock (see Figure 5) would become denser and may result in an elevated fuel layer comparable to that on the private property to the west (elevated fuel hazard of High – Very High).

Natural regeneration of the understory, such as the wattles, peas and *Cassinia* species may take a long time in the event cattle were simply removed from the area. Many understory plants found in woodlands such as these store their seed in the soil and wait for a trigger to break their dormancy and initiate germination (Florence, 1996). The seeds of some species, including wattles, may lie dormant in the soil for decades. A fire in this landscape is likely to favour regeneration of the shrubby understorey species by breaking seed dormancy (Florence, 1996; Gill, 1981).

Figure 5 – Two instances of *A. paradoxa* establishing within the grazed woodland.

In the longer term recruitment of the Long Leaf Box (*Eucalyptus goniocalyx)* could see a gradual thickening of the canopy and transition to a Medium Forest structure. As with many eucalypts, the Long Leaf Box can regenerate via a number of methods depending on the environmental conditions at the time. Regeneration may be via:

- A lignotuber, which is a woody growth at the base of the stem (either below ground or at surface level) that contains numerous latent buds (Carr *et al*., 1982). In the event of seedling/tree defoliation from grazing or fire, the buds from the lignotuber grow to replace the parent plant. There was evidence of seedlings growing from lignotubers during the site inspection in Zone 6.
- Epicormic shoots located under the bark that grow in times of stress, such as defoliation from fire or insect attack (Ashton and Spalding, 2001; DPI, 2008).
- Seed germination. This can occur after a fire from seeds falling onto a nutrient-rich ash bed (Gill, 1981), or between fire periods if the conditions are suitable, such as after heavy rains (Ashton and Spalding, 2001).

Several studies have tested the potential for eucalypt regeneration from seeds in an agricultural landscape, with two being of particular interest in relation to the Long Leaf Box. Dorrough and Moxham (2005) found that grazing was a primary factor limiting regeneration in central Victoria. Natural regeneration was recorded on 16% of privately owned (farmed) sites. On these sites, almost no regeneration was found under regular grazing. Conversely, 91% of sites on public land adjacent to these private properties showed evidence of natural regeneration.

Dorrough and Moxham (2005) found that the history of cultivation, percentage of exotic annual cover (e.g. grasses) and distance to mature trees all influenced the probability of natural regeneration via seeds. Weinberg *et. al*. (2011) reported very similar results in terms of the proportions of natural regeneration on private and public land, and grazing being the primary limiting factor.

It is credible therefore that, if left unmanaged or actively re-vegetated, this area may eventually become a weedier version of the vegetation on the properties to the west. The impact of grazing on the vegetation structure is shown in Figure 6 with grazing excluded from the property on the left. This marks the boundary between Zones 3 & 4 and Zone 6.

Figure 6 – Change in vegetation structure between grazed and ungrazed properties.

Figure 7 shows an area identified as potentially suitable for *Riparian Scrub/Swampy Riparian Woodland Complex*. This again indicates the potential for the fuel structure to change considerably in the future.

Figure 7 – Grazed area identified as potentially suitable for *Riparian Scrub/Swampy Riparian Woodland Complex.*

5.3 Analysis of the anticipated fire behaviour if all vegetation is categorised as grassy forest

The EVC name *Grassy Forest* belies the High to Very High elevated fuel hazard found in the forested triangle east of Whiteside Road.

Potential fire behaviour was modelled using the equations of the McArthur MkV Forest Fire Danger Meter (Noble *et al.*, 1980).

The input data was a FFDI of 120, the maximum down slope (i.e. northerly or westerly aspect) assessed within each zone and the fuel load measured on site (20 t ha^{-1}).

It was assumed that an established fire burning on a broad front could enter the northern part of the study area and that the fire would be at steady-state rate of spread. It was further assumed that the fire would crown when running up hill within the forest.

If the Zones 5 and 6 were to become forest with a fuel hazard comparable to that in the forest adjacent to Whiteside Road, fire behaviour would be extreme under the FDI 120 weather conditions. The most severe fire behaviour can be expected on up hill runs in the eastern parts of Zone 6. Predicted intensities on these slopes with 20 t ha^{-1} are predicted to be in the vicinity of 60,000 kW m^{-1} and flame lengths nearly 25 metres (see Table 3). Crown fire is likely if the wind is pushing the fire up the hill.

Site characteristics					Modelling assumptions		Fire behaviour outputs		
Zone	Vegetation type	Slope (º)	Tree height (m)	Fuel load (t ha^{-1})	Crown fire?	Steady-state rate of spread?	Steady-state rate of spread (km h^{-1})	Intensity (kW m^{-1})	Flame length (m)
3 & 4	Forest	-5	25	20	On	Yes	2.0	21,148	20.1
5	Forest	0	25	20	On	Yes	2.9	29,861	21.4
61	Forest	-10	25	20	On	Yes	1.4	14,977	19.0
62	Forest	10	25	20	On	Yes	5.7	59,534	24.7
63	Forest	10	25	20	On	Yes	5.7	59,534	24.7

Table 3 – Input data and outputs of fire behaviour modeling for *Grassy Forest* using the McArthur MkV Forest Fire Danger Meter.

Some short distance spotting and ember attack is likely to be significant given the High bark hazard.

5.4 Analysis of anticipated fire behaviour if vegetation within the hatched area (Zone 6) is categorised as Woodland

Potential fire behaviour was modelled using the equations of the CSIRO Grassland Fire Spread Meter (Cheney *et al.*, 1998) with the rate of spread modified to reflect impact of the Woodland canopy on the strength of the wind reaching the flame front (after Cheney and Sullivan, 1997).

The input data were Ash Wednesday-like grassland conditions (temperature 41ºC, wind speed 45 km h^{-1}, relative humidity 5.5%, grass curing 100% and pasture condition grazed) and the maximum down slope (i.e. northerly or westerly aspect) and up slope (i.e. easterly aspect) assessed within Zone 6.

It was assumed that an established fire burning on a broad front could enter the northern part of the study area and that the fire would be at steady-state rate of spread. It was assumed that the fire would not be crowning within the woodland due to the discontinuous canopy and lack of ladder fuels.

The rate of spread in the woodland scenario is greater due to the fire being essentially a grass fire with some of the impact of the wind blocked by the scattered eucalypts. Intensity, and hence flame length are, however, considerably less due to the lower fuel load. These peak at around 20,000 kW m^{-1} and 7.4 m (see Table 4), or about 30% of the level predicted for forest.

Site characteristics					Modelling assumptions		Fire behaviour outputs		
Zone	Vegetation type	Slope (°)	Tree height (m)	Fuel load (t ha^{-1})	Crown fire?	Steady-state rate of spread?	Steady-state rate of spread (km h^{-1})	Intensity (kW m^{-1})	Flame length (m)
5	Forest (grassy understorey)	0	25	3	Off	Yes	3.9	6,129	4.3
61	Woodland	-10	25	3	Off	Yes	3.3	5,124	3.9
62	Woodland	10	25	3	Off	Yes	13.1	20,366	7.4
63	Woodland	10	25	3	Off	Yes	13.1	20,366	7.4

Table 4 – Input data and outputs of fire behaviour modeling for woodland using the CSIRO Grassland Fire Spread Meter corrected for the impact of the woodland canopy on rate of spread.

Short distance spotting and ember attack is likely to be significant given the High bark hazard, however this would be less than in the medium forest scenario due to the lower density of trees.

When compared to the fire intensity predicted for forest in Zones 5 and 6, it can be seen that potential fire behaviour in the study area would be significantly reduced if the current surface/near-surface fuel arrangement was maintained.

5.5 Consideration of the surrounding environment including electricity transmission line easement

The built up area of Beaconsfield, which extends south to the Princes Freeway, provides a buffer against fire spread from the west and southwest. Whilst there is farming and bushland to the east, extreme fire weather is rarely associated with an easterly wind.

This means the only likely direction of approach of an established high intensity bushfire is from the north or northwest.

The electricity transmission line easement runs east - west along the northern boundary of the study area and is approximately 100 metres wide. It is on private land but SP-AusNet have the responsibility of ensuring that vegetation on the easement is managed to reduce the likelihood of the infrastructure starting fires, and also have an interest in reducing potential fire intensity in order to protect their infrastructure.

At the time of inspection the easement was grassland with the occasional short tree (see Figure 8). Where it dissected the forested zone in the north west of the study area, it appeared to be grazed by horses and other livestock. In considering its influence on fire behaviour it is assumed that this management regime will continue.

Figure 8 – Transmission line easement north of Whiteside Road.

It is generally accepted that fuel breaks alone will not prevent fire spread in a forest except under mild conditions (DSE, 2008; DSE & CFA, 2008; Wilson, 1998), and certainly not under the FDI 120 assumed by the WMO model. Rather, their value is in providing access and a control line for direct or in-direct (e.g. back burning) attack on the fire and to reduce fire intensity in the vicinity of assets such as residential areas (DSE, 2008).

Under the WMO model weather conditions breach of the transmission line fuel break is almost certain through spotting and/or flame spread across the cured grass even if heavily grazed. The predicted rate of spread for this area (Zone 2) is approximately 13 km h^{-1} which would see the fire front cross the 100 metre easement in less than 30 seconds. Whilst it is considered unlikely that a bushfire approaching the transmission lines from the north would be crowning, the 100 metre break in the canopy would ensure that the fire dropped out of the crown.

The use of the transmission line as a control line for fire suppression operations is considered unlikely unless the transmission line had been de-energised. Electrical discharge to ground through smoke and ionized air makes the vicinity of high voltage power lines hazardous during bushfires.

The easement would, however, have value as a buffer to residential development to the south of it. If grazed it would meet WMO outer zone vegetation management standards and could be incorporated as an Asset Protection Zone within the Officer Precinct Structure Plan. In particular it provides some level of protection to existing homes at the end of Whiteside Road.

It should be stressed, however, that the easement would not prevent fire spread, which could occur via ember attack starting multiple spot fires on and around the dwellings. Within the residential area low intensity fire will spread along 'wicks' of available fuel, such as bushland reserves, dry creek lines and vacant blocks. Even low intensity fire burning across dry lawns and in garden beds can destroy undefended houses through direct flame contact. Burning bark and leaves from trees and shrubs in gardens and road reserves can supplement longer distance ember attack from the forest to the north.

5.6 Does the vegetation outlined in black in Attachment 3 (Zone 9) need a buffer at all?

The area outlined in black in Attachment 3 (shown as Zone 9 on Map 3) is considered low risk vegetation.

Using the WMO classification schema it is cultivated garden around the buildings and woodland or grassland with scattered trees elsewhere in the zone. All of these are Category 1 lower risk vegetation types.

Brown Road and the transmission line easement provide some separation from the forest to the north.

If the vegetation in Zone 9 is to remain in its current condition no buffer is considered necessary.

5.7 Recommended buffer distances for each vegetation type

Fuel managed buffer zones reduce the likelihood of ignition of buildings due to flame contact and radiant heat by reducing fire intensity in the lead up to buildings. That is, they put a physical space between the long, tall flames in the unmanaged forest and the buildings. As radiant heat decreases rapidly with distance (the inverse square law) this can be an effective way of reducing the level of bushfire attack.

The width of the buffer zone for each vegetation type was calculated for a number of combinations of fuel management regime and acceptable radiant heat flux, and using different fire impact models (see Table 5). The contentious Zones 5 and 6 were also mapped as woodland and as medium forest (see Map 6).

Site characteristics			Setback distances (m)		
Zone	Vegetation managed as…	Slope (°) within 100 m of future dwellings	WMO 'alternative solution'	WMO 'deemed to satisfy'	AS:3959-2009 (to allow BAL-29 construction)
2	Grassland - grazed	0	18	30	0
3 & 4	Forest – shrubby understorey	-5	31	60	25
5	Forest - grazed	0	7	60	25
5	Forest – shrubby understorey	0	36	60	25
61	Woodland - grazed	-10	7	30	16
61	Forest – shrubby understorey	-10	27	60	25
62	Woodland - grazed	10	18	30	26
62	Forest – shrubby understorey	10	55	90	39
7	Grassland - grazed	0	18	30	0
8	Woodland - grazed	10	18	30	26
9	Cultivated garden	various	N/A	N/A	N/A

Table 5 – Buffer distances calculated for each vegetation type using WMO 'deemed to satisfy', WMO 'alternate solution' and AS:3959-2009 impact models.

Map 6 – Buffer distances for Zones 5 and 6 by each model and for woodland and medium forest.

The recommendation of buffer zones requires a number of decisions to be made:

1. What is the most appropriate vegetation classification given potential regeneration of currently grazed areas?
2. Which is the better fire impact model to use?
3. What BAL should new dwellings in new communities on the urban-forest fringe be built to withstand?

In making bushfire management decisions it is prudent to err on the side of safety. In cases where it is credible for a higher risk scenario to come to pass then planning should be undertaken on the assumption that it will. Life safety should be the overriding consideration.

We recommend that planning for the entire area of vegetation nominated for retention be done on the basis that it could become Medium Forest (*Grassy Forest*). Planning on the basis of it remaining woodland would require certainty that the surface/near-surface and elevated fuels will not increase over time. This seems problematic if it is to form a bushland reserve.

We have also considered the future planning implications of each option, assuming that a bushfire planning or building control may cover the area. The WMO 'deemed to satisfy' is the most conservative approach. Using it as the basis of decision making in the Precinct Structure Plan would increase the likelihood that future subdivision and dwelling proposals are also able to meet the 'deemed to satisfy' provisions. Particularly if the buffer zone was retained in Council hands and becomes independent of the development of individual allotments adjacent to the forest.

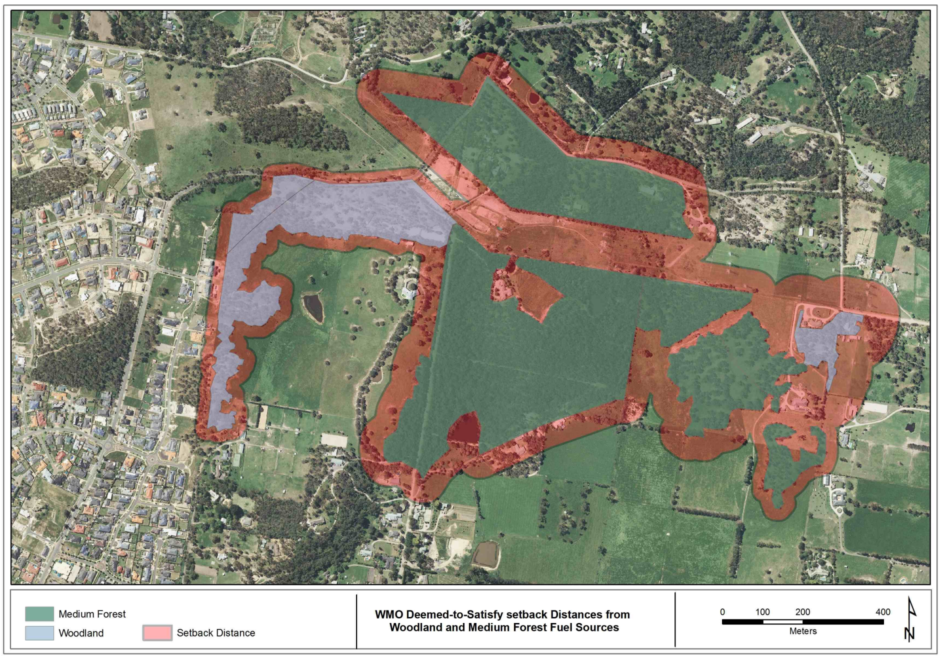
We believe that the WMO 'alternate solution' modeling we have conducted is valid and robust. However, any variation from the WMO assumptions and default inputs will be judged on its merits by CFA. In this case the use of a lesser fuel load may be contested; whilst we are told that Zones 3 and 4 have been largely undisturbed since they were burnt in 1983 it is possible that the fuel load measured on site could increase through further infestation of woody weeds.

If the WMO 'alternate solution' is to be used it is possible that future subdivision and dwelling applications may each have to argue alternative solutions, which may or may not be accepted.

It is unclear at this stage what reforms to the existing planning and building controls will occur in the next few years. There is a stated intent by key players such as CFA, Building Commission and the Department of Planning and Community Development to develop a single site assessment process for the bushfire planning and building controls. Presumably this would also deliver a single set of deemed to satisfy vegetation management and building construction options. We understand that the intent is to use the WMO test fire (FDI 120) and the AS:3959-2009 radiant heat model. It is possible that this will produce buffer distances somewhere between the current WMO deemed to satisfy and AS:3959-2009. As this revised methodology has not been approved or released it is not possible to say with certainty what future requirements may be.

The final factor to consider in choosing a buffer distance is what construction level future dwellings should be constructed to. Our experience with 'green field' subdivisions is that CFA require BAL-29 construction. On this basis we have only calculated the buffers required to reduce radiant heat below 29 kW m^{-2}. It is possible to reduce buffer distances by building to a higher construction level, e.g. BAL-40. This seems unnecessary given the ability to provide adequate buffer zones.

The recommended buffer distances are shown on Map 7 and have been mapped from the edge of the treed area.



Map 7 – Recommended WMO 'deemed to satisfy' buffer distances across the study area.

5.8 Guiding principles to ensure appropriate subdivision and development design

5.8.1 Objectives

The VBRC stated the role that land use planning can play in reducing the bushfire risk to people as:

- Restricting development in high risk areas;
- Increasing the survivability of developments;
- Assisting fire fighter access to properties;
- Ensuring properties have a (static) water supply for firefighting; and
- Creating safe evacuation routes (VBRC, 2010).

These roles are used as a framework for considering appropriate design principles.

5.8.2 Restricting development in high risk areas

Locating residential areas in the landscape so as to reduce potential fire intensity (and hence flame length and radiant heat impact) is the foundation of bushfire safe planning (P&E, 1990; CFA, 2010; Ramsay and Dawkins, 1993; Ramsay and Rudolf, 2003). Avoiding areas of steep slope exposed to fire winds, such as north or westerly aspects, and heavy fuel loads typically associated with native forests and plantations is considered preferable to locating dwellings in these higher risk areas and creating a requirement for ongoing vegetation management.

The Officer Precinct complies with these principles. It is located on predominantly flat ground to the south of the Upper Beaconsfield uplands. New subdivisions within the precinct will occupy land that has been used for grazing and is cleared of forest.

Where housing is to be located near areas of heavy fuel load, adequate defendable space is required (CFA, 1991; CFA, 2010). The defendable space takes the form of a fuel reduced buffer with the width of the buffer determined by the potential fire behaviour, which in turn depends upon the vegetation structure and its fuel load, and topography within 100 metres of the exposed asset. The fire behaviour and impact modeling contained in the Fire Risk Assessment Study indicates that adequate buffers can be provided for the Precinct.

5.8.3 Increasing the survivability of developments

Width of buffer zones

The vegetation type, and the slope and aspect of the land under that vegetation determine the width of the recommended buffers in the northwest corner of the Officer Precinct (see Table 6 and Map 9).

We are informed that CFA are considering changes to the WMO (Andreou *pers. comm.*) that <u>may</u> result in an increased inner zone but decreased outer zone . The implications of this on requisite buffer zone distances in the future are uncertain.

Fuel hazard of buffer zones

The buffers need to comply with the CFA WMO vegetation management standards as a <u>minimum</u>. These are an intensively managed inner zone 10 metres in width supported by a broader outer zone whose width is determined by the vegetation type and slope within 100 metres of the exposed asset.

The outer zone is designed to prevent direct flame or radiant heat ignition of the dwelling from the forest. It is also intended to reduce a crown fire to a surface fire.

The inner zone is designed to minimise the chance of dwelling ignition from fuel burning in the outer zone.

We understand that the intent of the vegetation management prescription for the outer zone was to reduce the overall fuel hazard to Moderate (after the DSE Overall Fuel Hazard Guide 3rd Edition – McCarthy *et al*. 1999). This requirement was presented in layman's terms in the various WMO applicants' resources (see Table 7 from CFA, 2010).

Zone	Vegetation management
Inner	• Grass must be no more than 100mm in height; • Leaf litter must be less than 10mm deep; • There must be no elevated fuel on at least 50 per cent of the area. On the remaining 50 per cent, the elevated fuel must be at most sparse, with very little dead material; • Dry shrubs must be isolated in small clumps more than 10 m from the dwelling; and • Trees must not overhang the roofline of the dwelling.
Outer	• Grass will be no more than 100mm in height; • Leaf litter will be no more than 20mm deep; • There will be no elevated fuel on at least 50% of the outer zone; and • Clumps of dry shrubs will be isolated from one another by at least 10m

Table 7 – Vegetation management prescription for inner and outer zones under the WMO.

A notable absence from the vegetation management requirements of the WMO is consideration of bark fuel hazard. Bark hazard is important for a number of reasons; it can add up to 7 t ha^{-1} at Extreme bark hazard ratings (Hines *et al.*, 2010), it is the main source of fire brand material for spotting and ember attack, and it acts as a ladder fuel increasing flame height and promoting crown fire initiation.

The bark hazard of the forested and woodland parts of the study area was assessed as High (see Figure 9). Given the 27 years since the area was last burnt it is considered unlikely that the bark hazard will increase significantly in the future unless there is an increase in the proportion of stringybarks which can develop an Extreme bark hazard.

Figure 9 – High bark fuel hazard on eucalypts in the woodland in the western part of the study area.

If the objective is to have an overall fuel hazard of Moderate, and it is accepted that bark hazard will be High, then elevated fuel needs to be restricted to Moderate and surface/near-surface fuel maintained as Moderate. This will require significant and ongoing management of the forest vegetation. The surface/near-surface fuels are currently High-Extreme and elevated fuel High-Very High.

As the buffer zones are going to be located on land currently used for grazing, the main implication is not on the impact this will have on existing vegetation but rather its impact on any planned re-vegetation. If the inner and outer zone concept was to be used it will be important that any natural or enhanced re-vegetation in the outer zone does not exceed the Moderate overall fuel hazard. This would require careful planning and ongoing fuel management.

From a bushfire safety perspective it would be preferable, and may be easier from a management perspective, to maintain the vegetation in its current state (i.e. all at inner zone standard) by slashing beneath the mature eucalypts and/or developing as minimal fuel public open space such as roadway, play ground etc..

We are informed that CFA are considering changes to the WMO (Andreou *pers. comm.*) that may result in an increased inner zone but decreased outer zone . The implications of this on requisite vegetation management within the buffer zone are uncertain.

Land tenure of buffer zones
The buffer zone could be incorporated into private allotments or pass into Council hands.

If incorporated into private allotments it would be necessary for each allotment to be large enough to allow a building envelope to be sited beyond the buffer zone. Ongoing management of the buffer zone to the specified standard in perpetuity would need to be mandated via the planning controls. As the VBRC noted, ongoing compliance is problematic and difficult to monitor and enforce.

It may be preferable to retain the buffer zone in public ownership, i.e. managed as a Council reserve and/or incorporated into subdivision infrastructure such as a road. If this was to occur it is important that the purpose of the reserve to provide a buffer zone retains primacy and management of ensures it remains fit for this purpose. It may be easier to maintain the vegetation in its current state (i.e. at inner zone standard) by slashing beneath the mature eucalypts or developing as minimal fuel public open space such as a roadway, play ground etc..

Council management of the buffer would ensure that it was in place regardless of the timing of the development of individual allotments.

Size and shape of allotments if buffer zone is to be incorporated into private property
If incorporated into private allotments it would be necessary for each allotment to be large enough to allow a building envelope to be sited beyond the buffer zone.

The WMO deemed to satisfy provisions require the entire buffer distance to be contained on each allotment and to extend anticlockwise from the northeast to the south (see Figure 10a).

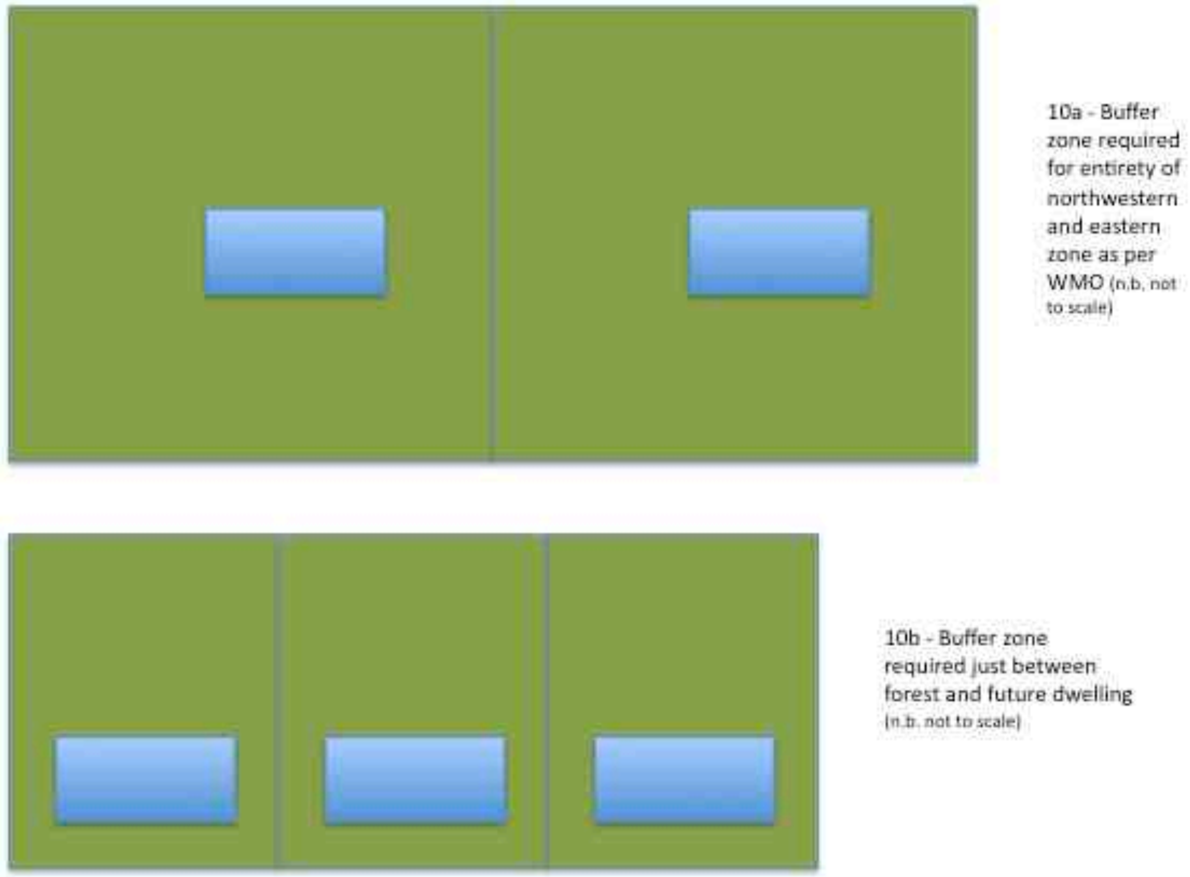


Figure 10 – Size and shape of allotments to incorporate buffer zone.

As the forest area to be retained forms a sharp boundary with the area to become residential subdivision, it seems reasonable that the need for defendable space be restricted to the area between the forest and the residences, rather than each allotment having to provide defendable space in all directions from the building envelope. This would allow smaller long, thin allotments containing the requisite buffer distance to the north or northwest, and relying on their neighbours to contribute defendable space in the form of cultivated gardens on the other sides (see Figure 10b). A statutory mechanism may be needed to ensure that vacant blocks are appropriately managed until developed (this could be included in an Outline Development Plan, via s.173 agreements, or through the issuing of Fire Prevention Notices pursuant to s.41 of the *Country Fire Authority Act*, 1958).

Building-to-building fire spread

Spread of fire from one burning building to an adjacent building has been documented in several major bushfires (Blanchi and Leonard, 2005). A building ignited by a bushfire will burn for a long period of time and emit large amounts of radiant heat which will pre-heat surrounding objects. If the buildings are close enough together ignition by direct flame contact is possible.

Ensuring adequate distances between adjacent houses can mitigate this risk, although the literature is silent on what is an adequate distance. AS:3959-2009 stipulates that adjacent structures (such as garages, sheds etc.) more than 6 metres from the dwelling do not need to be constructed to the BAL level of the dwelling (Standards Australia, 2009a). This could be interpreted as implying that at this distance if they did burn they would not pose a direct threat to the dwelling. In our opinion this distance is likely to be insufficient in the context of adjacent homes and which, if well within the subdivision, are likely to have been built to lower BAL levels.

Another strategy is to locate dwellings at different depths on the block to break up the potential 'domino effect' of a long line of buildings (Blanchi and Leonard, 2005).

Fuel within the residential area

Whilst the focus of this analysis has been on the boundary between the proposed residential area and the forest to the north, it is appropriate to consider the impact of vegetation within the residential area on the level of bushfire risk.

Creation or retention of native forest as a bushland reserve or linear park can bring fire into the residential area. It would increase the length of interface and may increase the need for buffers. Even if the nature of the reserve was such that any fire would be of relatively low intensity, i.e. small or narrow reserve such as the strip of woodland on the western boundary of the study area (Zone 8), it is likely to provide a source of embers close to houses and would increase the likelihood of house loss, particularly if undefended. It is advisable to maintain a low surface/near surface and elevated fuel hazard in such areas (as is currently the case – see Figure 11).

Extension of fire into the residential area is also likely to complicate any movement of people away from the approaching fire.

Figure 11 – Two views of the strip of woodland along the western boundary of the study area (Zone 8).

Similarly there is a risk of fire spread through undeveloped allotments (see Figure 11). Thirteen homes were lost on the western outskirts of Melton in January 1985 when a grass fire penetrated a partially developed residential subdivision (Maynes and Garvey, 1985). Fuel on undeveloped private blocks is commonly managed by issuing Fire Prevention Notices from the Municipal Fire Prevention Officer. A more strategic approach might be to stipulate an appropriate grass-cutting regime and have it agreed by major developers as part of any development plan.

Figure 12 – Urban bushland reserve and grassy undeveloped allotments in the O'Neil Road estate immediately to the west of the study area.

5.8.4 Assisting firefighter access to properties

Provision of 'two ways in and out' is a long-standing design principle in bushfire prone areas (P&E, 1990) both to facilitate fire service access and resident egress.

Access and egress can be facilitated by design of the road network so that there are multiple north – south access/egress routes, and that these are linked by east-west roads to enable lateral movement onto another egress route in case of one becoming blocked.

Road construction within the residential areas of the Officer Precinct should meet the requirements of CFA as specified in *Requirements for Water Supplies and Access for Subdivisions in Residential 1 and 2 and Township Zones* (CFA, 2006).

Restricted dry weather access for the fire service along the buffer zones, if under Council management, would be desirable. This would require gated or bollarded access from the north-south egress roads onto the buffer zone.

Whilst the Officer Precinct is not covered by the WMO it is recommended that dwellings to be constructed within 100 metres of the retained grassy forest/woodland be required to comply with the WMO access requirements for driveways.

These are:

- Access to the dwelling will be designed to allow emergency vehicle access. The following minimum design requirements will be met:
  - Curves in driveway will have a minimum inner radius of 10 metres;
  - The average grade will be no more than 1 in 7 (14.4%) (8.1°) with a maximum of no more than 1 in 5 (20%) (11.3°) for no more than 50 metres; and
  - Dips will have no more than a 1 in 8 (12.5%) (7.1°) entry and exit angle.

- If the driveway from the road to the dwelling and water supply, including gates, bridges and culverts, is greater than 30 m long, the driveway:
  - Will be designed, constructed and maintained for a limit of at least 15 tonnes, be of all weather construction; and
  - Will provide a minimum trafficable width of 3.5 metres, and be clear of encroachments 4 metres vertically.

- If the driveway is longer than 100 metres, a turning area for fire fighting vehicles close to the dwelling will be provided, by either:
  - A turning circle with a minimum radius of 8 metres; or
  - The driveway encircling the house; or
  - A T head or Y head with a minimum formed surface of each leg being 8 metres in length measured from the centre point of the head, and 4 metres trafficable width as per Figure 12, page 13 of the CFA WMO Applicant's Kit.

- If the length of the driveway is greater than 200 metres, passing bays will be provided that are 20 metres long and provided every 200 metres, with a trafficable width of 6 metres.

5.8.5 Creating safe evacuation routes

Provision of 'two ways in and out' is a long-standing design principle in bushfire prone areas (P&E, 1990). Consideration should be given to the likelihood of large numbers of people choosing to leave the study area in advance of a bushfire.

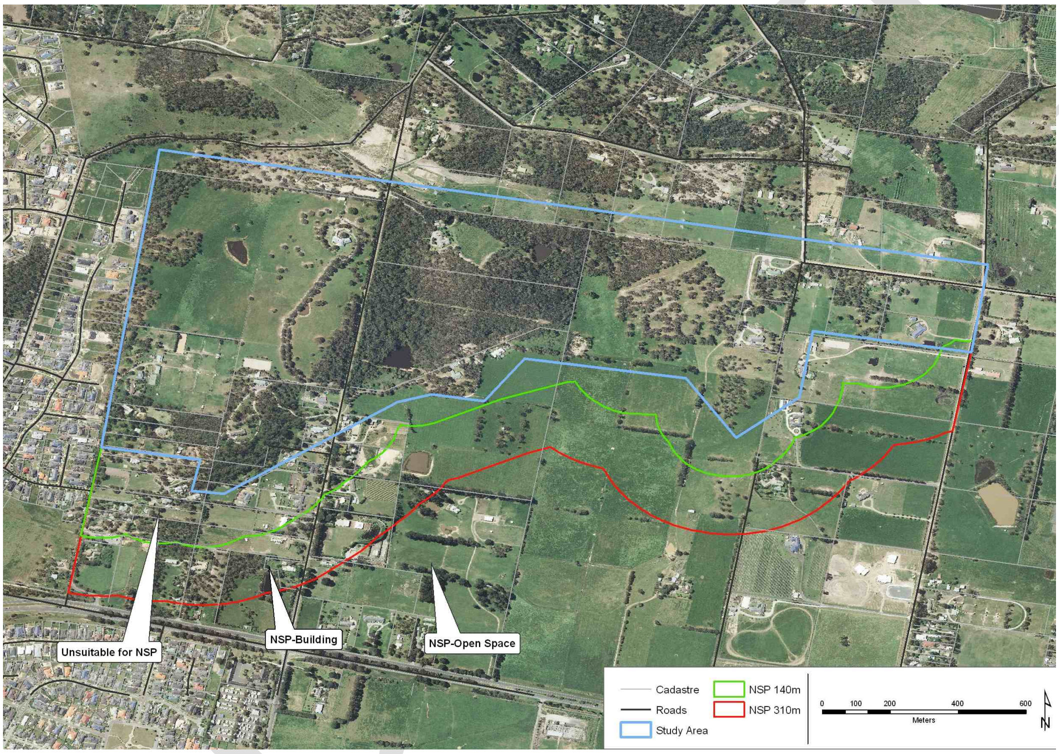
This movement of residents can be facilitated by design of the road network so that there are multiple north – south egress routes (the existing May Road, Whiteside Road and Tivendale Road may suffice), and that these are linked by east-west roads to enable lateral movement onto another egress route in case of one becoming blocked.

Road construction within the residential areas of the Officer Precinct should meet the requirements of CFA as specified in *Requirements for Water Supplies and Access for Subdivisions in Residential 1 and 2 and Township Zones* (CFA, 2006).

Consideration could be given to the use of a public building constructed within the Officer Precinct north of the Old Princes Highway as a Community Refuge or Neighbourhood Safer Place. If such a use was contemplated the public building should be located well within the residential area so that both the buffer zone and residential streets protect it. It should be constructed to the appropriate construction standard.

The CFA guidelines for the designation of Neighbourhood Safer Places specify that if the Neighbourhood Safer Place is to be a building it should be a minimum of 140 metres from the fire hazard (i.e. the Grassy Forest or Woodland). If an open space it should be more than 310 metres from the vegetation (CFA, 2009). Map 8 shows areas within the study area potentially suitable for a Neighbourhood Safer Place.

Alternatively the existing urban development on the Old Princes Highway at Officer or Beaconsfield may include suitable locations. Both locations are less than 2 km distant from the northern parts of the study area, and are well buffered by residential areas.



Map 8 – Areas potentially suitable for location of a Neighbourhood Safer Place of either a building or an open space.

5.8.6 Ensuring properties have a (static) water supply for firefighting

It is understood that the residential area of the Officer Precinct will be reticulated. Hydrants should meet the requirements of CFA as specified in *Requirements for Water Supplies and Access for Subdivisions in Residential 1 and 2 and Township Zones* (CFA, 2006).

Whilst the Officer Precinct is not covered by the WMO it is recommended that dwellings to be constructed within 100 metres of the retained grassy forest/woodland be required to comply with the WMO static water supply requirements.

These are:

- A static water supply, in the form of a tank will be provided that:
    - Provides a minimum storage of 10,000 litres on-site that is maintained solely for fire fighting;
    - Is located within 60 m of the dwelling;
    - Fire brigade vehicles are able to get to within 4 m of the water supply outlet; and
    - The water supply will be readily identifiable from the building, or signage as per Figure 9, page 18 of the *WMO Applicant's Workbook* will point to the water supply.

- All below-ground water pipelines will be installed to the following depths:
    - Subject to vehicle traffic: 300 mm;
    - Under houses or concrete slabs: 75 mm; and
    - All other localities: 225 mm.

- All fixed above-ground water pipelines and fittings, including water supply, will be constructed of non-corrosive and non-combustible materials, or protected from the effects of radiant heat and flame.

- If the static water supply is above ground, the following additional standards will be met:
    - All above-ground static water supplies will provide at least one 64 mm, 3 thread/25 mm x 50 mm nominal bore British Standard Pipe (BSP), round male coupling;
    - All pipe work and valving between the water supply and the outlet will be no less than 50 mm nominal bore; and
    - If less than 20 m from the building, each outlet will face away from the building to allow access during emergencies.

- These actions will be completed prior to occupancy.

- The minimum 10,000 litres of water will be maintained solely for fire fighting purposes.

Consideration should also be given to the provision of strategic static water supplies for use in asset protection along the precinct boundary, acknowledging that reticulated water supply has often failed during major bushfires due to excessive demand or fire damage to water distribution infrastructure. A strategic static supply could be created through retaining existing dams on private property, incorporating one or more of these dams into public open space, or providing emergency water tanks at strategic locations such as where the north-south roads intersect the buffer zone.

5.9 Diagrams and plans which illustrate the design principles

An atlas of maps and diagrams including those contained in the body of this report but formatted for A3 printing is also available.

6 Conclusion

An assessment was conducted of the wildfire risk posed to the northwest corner of the Officer Precinct Structure Plan.

Risk to the proposed residential development was assessed using three criteria:

1. The deemed to satisfy provisions of the Wildfire Management Overlay (WMO);
2. A WMO option 3-style alternative solution using site-specific data; and
3. The simple site assessment procedure of *AS:3959-2009 Construction of Buildings in Bushfire Prone Areas* (Standards Australia, 2009a).

There is potential for the Officer Precinct to be impacted by a large established bushfire burning from the hilly areas to the north and northwest. Under extreme fire weather conditions fire behaviour on the precinct boundary could be severe, there is likely to be considerable ember attack into the residential areas of the Precinct and the likelihood of spot fires.

Requisite buffers (setback distances of dwellings from the unmanaged forest) have been recommended that would reduce radiant heat on the dwellings to below 29 kW m^{-2}.

It is considered prudent to assume that the current Woodland areas will develop into Medium Forest if left unmanaged or actively managed for flora conservation. Maintaining the current slashed/grazed grass beneath the canopy would reduce buffer requirements.

It is recommended that this buffer be taken into Council management and maintained as minimal fuel public open space. Provision of emergency access along the buffer zone and strategic static water supplies are considered desirable. Alternatively the buffer zone could be incorporated into private property with ongoing vegetation management prescribed and enforced via the appropriate planning control.

Buildings within 100 metres of the forest would need to be constructed to BAL-29. It is recommended that, due to the likelihood of ember attack into the residential areas, that all dwellings are constructed to the relevant BAL under AS:3959-2009. Dwellings should also comply with WMO 'deemed to satisfy' access and water supply requirements.

The design of future subdivisions will be important in reducing the potential for fire spread into and within the residential area.

Provision of multiple north-south access/egress routes is important. The existing road network provides this. These need, however, to be linked at several places by east-west roads in case an egress route becomes blocked during a major bushfire.

A Community Refuge or Neighbourhood Safer Place could be considered for the Precinct, however, we believe relocation to the urban areas of Beaconsfield or Officer may be a viable alternative.

A mechanism should be established to monitor and regulate fuel load on vacant blocks during the development of the Precinct.

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Appendix 1 – Research questions from Cardinia Shire Council

The request for tender from Cardinia Shire Council (Cardinia Shire Council, 2010) required that the study and report include:

- Analysis of the vegetation within the study area and its fire risk rating including, whether the hatched area in Attachment 3 would be considered to have a 'forest' structure both now and in the longer term;
- Analysis of the anticipated fire behaviour if all vegetation within the study area is categorized as grassy forest;
- Analysis of the anticipated fire behaviour if vegetation within the hatched area (Attachment 3) is categorized as woodland;
- Consideration of the surrounding environment (including the electricity transmission line easement) and the implications it has on the fire management controls/buffers;
- Drafting of the guiding principles to be applied to ensure appropriate subdivision and development design in response to the significant vegetation and fire management;
- Advice on how best to alleviate the threat of bushfire including:
  - Recommended buffer for grassy forest vegetation;
  - Recommended buffer for woodland vegetation; and
  - Recommendations regarding ways to reduce buffer distances for urban development (dwellings);
- Advice on whether or not vegetation outlined in black (Attachment 3) requires a fire buffer at all and if so, advise the recommended fire buffer distance; and
- Diagrams and plans that specifically illustrate the design guidelines to be adopted for future subdivision and development where appropriate.

Appendix 2 – Methodology

Set context

The context refers to the policy and regulatory environment within which the bushfire risk management for the Officer Precinct Structure Plan needs to be considered.

It includes Victorian State Government policy, the Victorian Planning Provisions and Building Code of Australia, local policy positions of the Cardinia Shire Council, and approaches to bushfire risk assessment currently in use by key stakeholders such as CFA.

The context also includes the deliberations and findings of the 2009 Victorian Bushfires Royal Commission applicable to development in bushfire prone areas.

This contextual information was used to select the risk assessment methods, to guide interpretation of results and making of recommendations.

Determine the fire management objectives

A management objective was developed based on a review of the relevant documents described above.

Understand risk factors

Sources of risk that might have an impact on the fire management objective were identified. Scenarios in which these risks might occur were described to allow detailed fire behaviour and impact modeling.

Risk information was considered as describing:

- Hazard (about the physical nature of the fire);
- Exposure (about what assets or values are present in the area being assessed); or
- Vulnerability (about how susceptible these assets are given the hazard scenario).

Understanding how these factors interact in and around the Officer Precinct allows likelihood and consequence to be considered.

Wildfire site assessment

The wildfire risk was assessed using three separate methodologies:

- the standard WMO site assessment process as described in the WMO Applicant's Workbook (CFA, 2010);
- a more detailed assessment using site-specific data within the approved WMO methodology (Maughan and Krusel, 1999); and
- the 'simple' site assessment procedure of *AS:3959-2009 Construction of Buildings in Bushfire Prone Areas*.

The major differences between the methods are summarized under in the Model fire behaviour section below.

Identify fuel zones

Fuel zone analysis was conducted to assess and map areas of similar fuel. Fuel zones are based on the underlying vegetation, represented by the Ecological Vegetation Classes (EVCs), the vegetation classification according to the CFA's *Wildfire Management Overlay Applicant's Workbook* (2010) and the past disturbance history.

Assess fuel

Indicative fuel sampling was conducted within each fuel zone at a frequency sufficient to provide an overall fuel hazard assessment (Hines, 2010) accurate enough to use in the fire behaviour modeling.

The degree of curing of annual grasses (Garvey and Millie, 2000) was assumed to reach 100% during the driest period of the year.

Assess topography

Slope and aspect were measured using contour data provided by Cardinia Shire Council. Multiple transects were established to identify average slope over 200 metres and maximum slope over 20 metres.

A digital elevation model of the study area and surrounds was created from the contour data.

Local slope and aspect were confirmed using a compass and clinometer. Any other topographic features likely to affect fire behaviour were also recorded.

Model fire behaviour

Local input data and the WMO test fire weather conditions were used to define credible wildfire scenarios. Fire behaviour modelling determined the potential behaviour in terms of intensity, flame length, radiant heat and ember generation. Figure A2.1 illustrates the inputs and outputs of fire behaviour modelling.

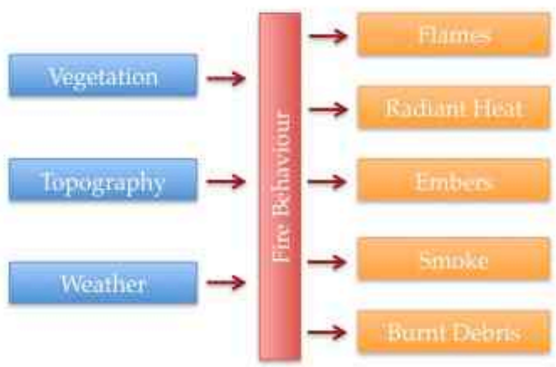


Figure A2.1 - Inputs and outputs of fire modeling.

The values for topography and fuel used in the model were:

1. relevant default values assumed by the WMO to determine the 'deemed to satisfy' provisions of the Applicant's Workbook;

2. site-specific data collected according to the assessment techniques described above; and
3. relevant default values assumed by AS:3959-2009 to determine the Bushfire Attack Level (BAL) in the 'simple' procedure.

Test fires generated from the detailed WMO alternative solution modeling were classified according to their intensity and presumed level of impact. The general assumption is that the higher the fire intensity the greater the potential impact. The descriptors are shown in Table 2.

Intensity descriptor	Intensity range ($kW\ m^{-1}$)	Fire description
Low	< 500	Easily suppressed fires e.g. fuel reduction burns.
Moderate	500 – 2,500	Fires may cause damage but are controllable. Upper values near limit of suppression capability in forest.
High	2,500 – 10,000	Fires are uncontrollable by direct attack in forest, suppression ability limited in grasslands at higher intensities.
Very High	10,000 – 30,000	Large fires that may cause significant damage e.g. Dandenong Ranges fires 1997.
Extreme	> 30,000	Very large uncontrollable fires for example Ash Wednesday and Black Saturday fires at upper limits (> 120,000 $kW\ m^{-1}$).

Table A2.1 – Fire intensity classification.

WMO model

The weather conditions are based on those that occurred during the 'Ash Wednesday' bushfires of 16th February 1983. This is consistent with the weather conditions used to by the CFA to set benchmark conditions for building survivability (Maughan and Krusel, 1999). These weather conditions consisted of high temperature, dry air, an extended drought and strong northerly winds with a possible shift in wind direction to the south-west and are shown in Table A2.2. An event of this magnitude is generally considered to occur once in fifty years.

Temperature (°C)	Relative Humidity (%)	Wind Speed ($km\ h^{-1}$)	Forest Fire Danger Index (FFDI)
41	5	45	>120

Table A2.2 - Weather conditions used in the WMO fire behaviour model based on 1500 hour readings for Melbourne Airport on 16th February 1983

Rate of spread was calculated using the published fire behaviour equation applicable to the vegetation type of the zone:

- Grasslands (Cheney *et al.*, 1998);
- Shrub and heath (Catchpole *et al.*, 1998);
- Forest (Noble *et al.*, 1980); or
- Woodland (grassland with modified wind function) (Cheney *et al.*, 1998; Cheney and Sullivan, 1997).

Fire intensity was calculated using Byram's fire line intensity equation (Alexander, 1982).

Radiant heat flux was calculated using the Leicester equation (Leicester, 1987) and measured from the tip of the flame.

AS:3959-2009 model

AS:3959-2009 models rate of spread and fire intensity using the same published equations as the WMO. It assumes an FDI of 100 (as opposed to 120 for the WMO), and has different default fuel loads for some vegetation types.

It uses, however, a different radiant heat model, known as the View Factor Model (Tan *et al.* 2005) to determine the distance required for radiant heat flux to fall below predetermined levels. Radiant heat is measured from the mid-point of the flame.

The radiant heat thresholds align to the Bushfire Attack Levels (BALs) in the construction standard.

Model impacts

Impacts from the three site assessment processes were mapped and compared.

Output from the WMO detailed modeling for flame length and radiant heat flux were overlaid on the site map, allowing the radiant heat level at specific points on the site to be identified. To represent the radiant heat flux in a meaningful way, the radiant heat levels were banded to correspond with the Bushfire Attack Levels (BALs) defined in AS:3959-2009 (see Table A2.3).

Output from the WMO *Applicant's Workbook* model is the 'deemed to satisfy' vegetation management zone distance, designed to allow BAL-29 construction.

Output from the AS:3959-2009 is expressed as the minimum distance from the classified vegetation required for each BAL.

Bushfire Attack Level (BAL)	Risk Factor	Construction elements are expected to be exposed to…
BAL-Low	There is insufficient risk to warrant any specific construction requirements but there is still some risk	Not applicable.
BAL-12.5	There is risk of ember attack	A radiant heat flux of not greater than 12.5 kWm^{-2}.
BAL-19	There is a risk of ember attack and a likelihood of exposure to radiant heat.	A radiant heat flux of not greater than 19 kWm^{-2}.
BAL-29	There is an increased risk of ember attack and a likelihood of exposure to increased levels of radiant heat.	A radiant heat flux of not greater than 29 kWm^{-2}.
BAL-40	There is a much increased risk of ember attack and a likelihood of direct exposure to flames from the fire front.	A radiant heat flux of not greater than 40 kWm^{-2}.
BAL-FZ	There is an extremely high risk of ember attack and a	A radiant heat flux greater than 40 kWm^{-2}.

	likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front.	

Table A2.3 – AS:3959-2009 BAL Levels and associated risk factors (Standards Australia, 2009).

Appendix 3 – Context of the risk analysis

The context of this risk analysis is the impact that a major bushfire may have on the safety of future residential development, and hence residents, within the study area. Analysis considers the impact of both a fire starting within the study area and an established fire burning into the Precinct.

Potential mitigation of the impact of such a fire is considered in the context of:

- Our current understanding of building and life safety during major bushfires;
- The existing suite of bushfire safety controls regulating development in Victoria;
- Cardinia Shire Council land use planning and bushfire safety policy positions; and
- The findings of the 2009 Victorian Bushfires Royal Commission (VBRC, 2010).

Buildings and life safety in bushfires

The 'prepare, stay and defend or leave early' policy as set out by the Australasian Fire Authorities Council in the *Position Paper on Bushfires and Community Safety* (2005) was well supported by historical evidence (Tibbits *et al.*, 2008) and research into building survivability (Blanchi and Leonard, 2008).

It was reviewed following the 2009 Victorian Bushfires Royal Commission Final Report and a number of significant changes were made. Whilst the underlying principles remain (AFAC, 2010), much greater emphasis is put on people leaving before a bushfire impacts upon an area, either as personal choice or as an organized evacuation.

Research indicates that most people will not routinely re-locate on days of extreme fire danger and the AFAC position explicitly recognises that many people will leave later than is considered ideal. Thus residential areas should be designed and constructed to minimise the spread of bushfire into the residential area and limit its impact on the housing stock; and to facilitate evacuation and a variety of shelter in place options (AFAC, 2010).

In Victoria, legislation upholds the right of residents to decide whether to stay and defend and there is no legal provision for forced evacuation (Tibbits *et al.*, 2008). A significant portion of fire-affected populations over many fires have been found to have relied upon their house, to a greater or lesser extent, as part of their bushfire safety strategy.

The mechanisms of bushfire attack on a dwelling are well understood (Wilson and Ferguson, 1986; Ramsay and Dawkins, 1993; Ramsay and Rudolph, 2003; Blanchi and Leonard, 2005, 2008) and comprise a combination of sparks and embers, direct flame contact and radiant heat. Extremely strong winds may cause structural damage to the building making ignition by embers easier and compromising its ability to effectively shelter occupants.

Ember attack is statistically the most common mechanism of house ignition during bushfire. Its impact extends much further from the unmanaged fuel than flame contact and radiant heat, and it continues to pose a risk many hours after the fire front has passed. Embers start small fires on or near the structure that gradually get larger, and in the absence of effective suppression, will spread to eventually destroy the building.

Arguably, however, it is flame contact and radiant heat ignition that pose the greatest threat to human survival. These mechanisms can result in rapid involvement of the entire dwelling, and by definition cause the house to ignite during the passage of the fire front when in most cases there is no option for people present other than to shelter within the dwelling.

Ramsay and Dawkins (1993) state that it is desirable to have a fuel reduced area to eliminate where possible attack by radiant heat or flame contact. Siting a building or managing vegetation to reduce fire intensity such that the building is unlikely to be ignited by direct flame contact or radiant heat is a corner stone of CFA's community safety policy as articulated through the Wildfire Management Overlay (Maughan and Krusel, 1999; CFA, 2010) and various public education programs.

The rationale for this position is that the dwelling is the primary protection from radiant heat for people within a fire area, and thus needs to survive the passage of the fire front during which period conditions in the open may be lethal. After the fire front has passed it would be relatively safe for people to come out of the house and extinguish ember ignitions or even take refuge on burnt ground if the building fire is unable to be extinguished.

This strategy will fail if the house ignites and becomes untenable at the same time as conditions outside the house are lethal, or if people fail to leave the house before it becomes untenable. This could happen because:

- The house is ignited by direct flame contact or radiant heat during the passage of the fire front; and/or
- The house is ignited by embers in advance of the fire front and is unable to be extinguished and becomes untenable during the passage of the fire front; and/or
- The house is significantly damaged by wind allowing mass entry of embers that overwhelm active defence and results in rapid fire spread through the building; and/or
- People shelter-in-place but do not actively defend and fail to leave the burning building.

If dwellings are to have a role in bushfire safety, then the purpose of development controls must be to promote the dwelling surviving the passage of the fire front. This can be done by:

- Reducing the severity of the hazard by siting and/or managing vegetation; and/or
- Reducing the vulnerability of the dwelling by design and construction; and/or
- Facilitating active defence of the dwelling through provision of water, access, firefighting equipment and training etc..

The Victorian land use planning/building control regime actively addresses these three components in a reasonably integrated manner by aligning the WMO and BPA/AS:3959-2009 controls (and linking to knowledge transfer and behaviour change through community education). This regulatory regime and the VBRC's critique of it area described below.

Current bushfire safety controls for new development

State Policy Framework

The context for the assessment of bushfire risk to future development in Victoria is outlined in the Victorian Planning Provisions. The State Planning Policy Framework has an objective "To assist the minimisation of risk to life, property, the natural environment and community infrastructure from wildfire" (clause 13.05-1), and provides three strategies, to:

- Identify wildfire risk environments in planning schemes in consultation with relevant fire authorities;
- Consider fire hazards in wildfire risk environments to avoid intensifying the risk of wildfire through inappropriately located or designed uses or developments; and

- Seek advice of the relevant fire authority if compliance with the policy guidelines is not likely or additional measures are believed necessary.

Municipal Strategic Statement

The Cardinia Shire Municipal Strategic Statement also addresses wildfire management (clause 21.09-5) and has the objective "To recognise that areas in the municipality are prone to wildfires and to minimise the potential risk to life and property". It provides a number of strategies to:

- Ensure that the siting and design of houses in fire prone areas minimises the potential risk from fire;
- Minimise the development of land in areas of high fire intensity;
- In consultation with the Country Fire Authority, investigate the inclusion of areas in a Wildfire Management Overlay;
- Give consideration to "Planning Conditions and Guidelines for Subdivisions" (1991) for any proposed subdivision;
- Support the ongoing development and implementation of the Municipal Fire Prevention Plan;
- Encourage the formation and ongoing development of Community Fireguard groups; and
- Encourage the use of controlled burning to reduce ground fuel levels and to help maintain healthy and diverse forests and woodlands.

Wildfire Management Overlay

The Wildfire Management Overlay (clause 44.06) contains a number of objectives and outcomes that must be met by new subdivisions in high bushfire risk areas (see Table A3.1).

Element	Objective	Outcomes
Protective features	To ensure that the level of protection from fire in terms of the level of fire risk and potential loss of life is reduced by the design, siting and layout of the subdivision.	Topographical features must be utilized to best advantage to prevent the spread of wildfire both into the subdivision and within the subdivision. The subdivision must be designed so that the building protection zone is separated from the hazard by a fuel modified buffer zone. A building protection zone must be maintained by planning the subdivision to allow for the setback of buildings within the building envelope.
Access	To ensure that both public and private access is designed to provide safe access for emergency and other vehicles at all times.	Access to and within the subdivision must take into account: • The type and density of development • The type and source of fire hazard • The requirements of emergency vehicles • The need to provide for simultaneous evacuation. The road network should provide at least two access options.
Water requirements	To ensure adequate quantities of water are available to landholders or emergency services to enable	**Reticulated areas** If the subdivision has provision for a reticulated water supply, the minimum water flow rate measured at any hydrant must not be less than 270

	life and property to be defended from fire.	litres/minute. If the building envelope is more than 130 metres from the nearest hydrant, a supply of static water on site or an additional street hydrant or hydrant must be supplied. **Non-reticulated areas** A supply of water solely for fire-fighting purposes must be maintained in an accessible location at all times.
Public open space	To provide a fuel managed buffer between a potential or existing fire hazard and subdivision.	Areas of public open space should be used as a fuel modification buffer zone where appropriate.
Vegetation	To ensure that the subdivision is designed to recognise the effect of vegetation on the level of fire intensity.	The design of the subdivision must consider: • The location of vegetation in relation to existing and potential building envelopes and its potential to increase the fire risk to property. • The ability of vegetation to be used as a windbreak to protect buildings from radiant heat and windblown debris.

Table A3.1 – Objectives and outcomes for subdivisions in the Wildfire Management Overlay.

AS:3959-2009 Construction of Buildings in Bushfire Prone Areas

On March 11th 2009 Victoria became the first state in Australia to adopt *AS:3959–2009 Construction of Buildings in Bushfire Prone Areas*.

The Standard provides explicit performance standards, i.e. six (6) Bushfire Attack Levels defined by the level of radiant heat flux the construction is designed to withstand, and in more general terms the degree of ember attack. The articulation of clear performance standards is an improvement from AS:3959-1999 which did not relate level of construction to radiant heat flux (Standards Australia, 1999) and it was unclear what level of radiant heat flux Level 1, 2 or 3 construction was able to withstand.

AS:3959-2009 is currently employed independently across Victoria in areas not covered by the WMO including most of the Officer Precinct. Whilst broadly comparable to the WMO in approach and intent, it uses a different site assessment process to the WMO, classifies vegetation type differently, employs a different radiant heat model and slightly different test fire specifications one of the most important being a lower Fire Danger Index of 100 compared with 120 in the WMO.

In areas covered by the WMO, AS:3959-2009 is used in conjunction with it. The WMO site assessment process is used to quantify the level of bushfire attack on the dwelling, and the impact of the vegetation management prescribed on the planning permit is taken into account in working out the radiant heat flux that would impact upon the dwelling. The appropriate construction level from AS:3959-2009 is then applied.

Municipal Fire Prevention Plan

The Cardinia Shire Municipal Fire Prevention Plan (Cardinia Shire Council, 2007) recognises the impact of bushfire on the residential environment as a High risk. It does not, however, set any safety objective in relation to residential development or provide criteria against which the level of risk to buildings or people should be assessed.

Findings of the 2009 Victorian Bushfires Royal Commission

This section examines the *2009 Victorian Bushfire Royal Commission Final Report* with regard to the possible implications for planning and building in bushfire prone areas. We provide a summary of the topics in the *Final Report* relating to local government's role in fire management, with particular focus on planning and building, and a broad overview of other findings that may be applicable to Cardinia Shire Council in the design and development of the Officer Precinct. We do not provide a detailed assessment of Cardinia Shire's current policies and procedures against the findings and recommendations of the VBRC *Final Report*.

The *Final Report* of the VBRC was released on July 31 2010. It came with 67 recommendations relating to community safety, land-use planning and building, emergency management structures, arson, electricity causes fires, land management, and research.

The VBRC was an iterative process. Witness statements and submissions were invited on the fires overall and on particular topics from laypeople, responsible agencies and expert witnesses. These were summarized in the submissions of Counsel Assisting and draft recommendations produced. Key stakeholders then had an opportunity to respond to Counsel Assisting's submissions. On the basis of all this information the VBRC determined their position and made recommendations as documented in the *Final Report*.

Planning and building

This chapter of the VBRC *Final Report* considers how planning and building policies and controls could be modified to ensure increases in bushfire safety of both existing and future development.

To address the complex issue of land-use planning, the VBRC engaged an expert panel each of whom prepared an individual report on a series of questions, which was tendered in evidence. The experts then attended a private facilitated conference, preparing a joint written statement of the discussion, also tendered as evidence. The panel then appeared together before the Commission, responding to questions from Counsel Assisting, counsel for the parties with leave to appear, and the Commissioners.

The VBRC consider that the protection of human life should be the overriding objective in implementing bushfire mitigation measures, including the regulation of planning and building. The report makes reference to the 2004 report of the National Inquiry on Bushfire Mitigation and Management (COAG, 2004), which cited land-use planning as the 'single most important mitigation measure in preventing future disaster losses in areas of new development'.

The role planning can play in reducing the bushfire risk to people includes:

- Restricting development in high risk areas;
- Increasing the survivability of developments;
- Assisting fire fighter access to properties;
- Ensuring properties have a (static) water supply for firefighting; and
- Creating safe evacuation routes.

The report suggests that bushfire risk management should start when State and local governments are planning and zoning new settlements. Precinct structure plans should include a bushfire risk management plan developed in consultation with the CFA. This includes Melbourne's growth areas and development around regional centres.

At the State level, land use planning is regulated under the *Planning and Environment Act* (1987). The VBRC saw the role of the Act as ensuring land-use planning decisions are determined by what is best for the community, rather than individual properties. Currently this is mainly dictated under the Victorian Planning Previsions (VPP) as a prescribed set of Zones and Overlays. Most 'rural' zones contain basic bushfire safety requirements. The relevant overlay for bushfire is the Wildfire Management Overlay (WMO) that, where applied, sets out requirements for siting, vegetation management, water, access and construction.

The VBRC considered the framework to be weak and insufficient to adequately address bushfire risk. The VBRC identify two key areas in which the Victorian Planning Scheme can strengthen its role in bushfire mitigation. These are:

1. Restrict development in areas which pose an unacceptably high bushfire risk; and
2. Ensure risk mitigation measures and construction standards are related to the degree of risk.

Further, the VBRC heard (and agreed) that the application of the VPP across the State by local councils had been inconsistent and ad-hoc. There were many reasons cited for this including, lack of political will, the regulations being complex and confused, and often including conflicting and contradictory priorities. The VBRC assessed the VPP as lacking the specific detail or guidance to help councils discharge their obligations to minimise bushfire risk when making planning decisions.

The VBRC identified a number of solutions to the key shortcomings of the VPP. These included:

- Identifying an acceptable level of risk;
- Providing clearer guidance on how to prioritise objectives (with protecting human life the top priority);
- Disallowing development in areas of high conservation value with a high bushfire risk;
- Enabling landholders to undertake 'reasonable' steps to reduce bushfire risk; and
- Taking into account the effects of climate change on bushfire risk.

These high level policies developed at a State level then need to be interpreted and applied to the local context within the municipal planning policy framework. The VBRC considered improved local policy as vital to supplementing the State policies and that all councils in bushfire risk areas should have a bushfire policy within their local policy planning framework.

The regulation preventing building in high bushfire prone areas was considered weak. The VBRC concluded that insufficient importance was given to the risk of bushfire and the potential threat it poses to life and property. The strongest tool available is the WMO, however this is limited to influencing aspects of development, such as siting and vegetation management. Prior to the 2009 fires, the WMO had led to few refusals for planning permission for the construction of a dwelling. Further, the WMO as it existed in February 2009, was flawed due to the lack of accurate identification and mapping of high risk areas and the lack of adoption by many local councils. Less than 50% of the area burnt on 7th February 2009 was covered by the WMO.

Recommendations regarding changes to the WMO included:

- Changing the term wildfire to bushfire, as the more common word used in the Victorian vernacular;
- Improved mapping of bushfire prone areas;

- Providing a more streamlined process for councils to implement the WMO; and
- Including all types of vegetation that pose a bushfire risk, such as grasslands.

The VBRC also made recommendations regarding the compliance and enforcement of planning and building permit conditions. Although the local council is responsible for the enforcement of permit conditions, there is currently no requirement under the *Planning and Environment Act 1987* for councils to check conditions have been fulfilled during development. On the other hand, the *Building Act* 1995 requires an occupancy permit to be issued, to ensure at least initial compliance with the building permit.

A major impediment to regulating compliance is a lack of resources. The VBRC, however, held the view that local councils should do more to ensure compliance. Although the obligation to comply with permit conditions rests with the permit holder, this does not replace councils' responsibility to enforce the conditions.

The VBRC suggested the following ways by which councils could enforce planning conditions:

- Planning infringement notices;
- Application to VCAT for an enforcement order against the permit holder; and
- Prosecution for the offence.

However, the VBRC adds there are less formal methods to enforce compliance, such as letters, telephone calls or council officer visits.

There is also no explicit requirement to check whether either the planning or building permit is complied with over time. Building maintenance and other works for bushfire safety need to be maintained, particularly during the bushfire season. Currently there is no mechanism to do this and the VBRC found no practical way of ensuring ongoing compliance. The VBRC suggested a better integration of the role of Municipal Fire Prevention Officers (MFPOs) in issuing Fire Prevention Notices that align to WMO permit conditions.

The VBRC also had concern that council planners do not have the requisite skills to ensure adequate bushfire safety measures are incorporated into planning decisions and suggested an appropriate course aimed at planners should be developed by the CFA.

Balancing vegetation conservation and bushfire risk management

The problem of balancing the conservation of native vegetation with measures designed to reduce bushfire risk was addressed at many levels in the Commission. One area was the challenges councils face when deciding on planning permits and that individuals have to address when wanting to clear land as a bushfire mitigation treatment.

Key complexities were:

- The need to strike a balance between the complex and competing objectives of reducing bushfire risk and maintaining environmental values;
- The complexity of the current regulatory framework; and
- The difficulty of reconciling the objectives and obligations of the various pieces of legislation.

The VBRC sought to adress these issues by recommending the State amend the VPP to provide clear direction on how bushfire risk and vegetation conservation should be balanced.

Planning for bushfires

Whilst the planning and building chapter is the most pertinent to bushfire safety measures for the Officer Precinct, a search of the VBRC *Final Report* identified the following issues that may be indirectly relevant to the precinct design. It is beyond the scope of this project to examine these subjects in detail, but awareness of these areas may influence elements of design and long term planning for the Precinct.

Volume II, chapter 1 'Victoria's bushfire safety policy' emphasised that bushfire planning needs to occur at the local level. This local level planning would aim to interpret and contextualise the high level State plans and complement individual and household plans.

There are currently three processes at a local level that could be used to improve bushfire safety planning.

- Municipal Emergency Management Plans;
- Municipal Fire Prevention Plans (and their successor IFMP Municipal Fire Management Plans); and
- Township Protection Plans.

The VBRC saw little alignment between these three processes, but recognised improved integration of emergency management plans and fire prevention plans was occurring through the integrated fire management plan (IFMP) framework. The IFMP framework aims to take a risk-based approach in the reform of fire prevention planning and to assimilate the proposed framework into the emergency management planning process for Victoria (IFMP, 2009).

The IFMP process began in 2002, with the framework being approved by the State government in 2007. The VBRC were positive regarding these changes, but criticised the State over the slow implementation of the framework. A significant feature of the framework is the development of the Victorian Fire Risk Register, which provides local councils with a consistent way to identify and document (through maps) bushfire risk.

The VBRC recognised that bushfire safety policy relies on the strength of the statewide policy and resourcing, but its success is dependent on local application and implementation. This would require local government to assess, in consultation with other authorities, the bushfire safety options that are best suited to the local situation. In particular, the VBRC stipulated that local planning for each community should cover:

- Evacuation – assisted evacuation for vulnerable people who require support and emergency evacuation in the face of a bushfire threat; and
- Shelter options – community refuges and bushfire shelters.

Local government should provide detailed plans of possible evacuation routes, how evacuations would be coordinated, and triggers for actions to be taken. The VBRC asserted that local plans should be the primary source of bushfire safety option for people living or visiting the area. In the highest risk areas, local plans should include training and practice for the local community.

Shelter options

The VBRC strongly encouraged the State and local councils to identify a range of shelter options for the community, including:

- Community refuge – A place that provides people with short-term shelter during the passage of a bushfire, which is identified, constructed or refurbished by the State and maintained by municipal councils; and

- Bushfire shelter (Neighbourhood Safer Place) – A space which is a place of last resort for individuals to access and remain in during the passage of bushfire through their neighbourhood, without the need to take a high risk journey. They are intended to provide a place of relative safety.

In addition to these options, already under development by the State and local councils, the VBRC suggested a third option, 'safer precincts', be considered. Safer precincts are used in South Australia. The VBRC did not reach a conclusion in regard to the merits of safer precincts in the Victorian context, but encouraged the State to further explore this option.

Evacuation
The VBRC strongly advised that an emphasis on evacuation be incorporated more strongly into Victoria's bushfire safety planning and community safety advice. The VBRC noted that the success of evacuation relies on pre-planning, in particular whether emergency evacuation is a viable option in a given area.

Electricity caused bushfires

Volume II, Chapter 4 deals with electricity-caused fires. Most of the chapter addresses the regulation of the electricity sector in regard to reducing the potential for ignition by maintaining or replacing ageing electricity infrastructure.

Particularly relevant to local councils is how to manage the risk of trees which may cause fires by contacting powerlines if they break and fall. These are called hazard trees, and if outside the regulated clearance space, the VBRC found there was no explicit requirement for anyone to remove or otherwise make safe these trees. The solution proposed was for councils in high bushfire risk areas to make provision in their Municipal Fire Prevention Plans for the identification of hazard trees and the notification of those responsible to address the issue.

The undergrounding of electricity distribution lines within new subdivisions is an effective way of mitigating this risk.

Shared responsibility

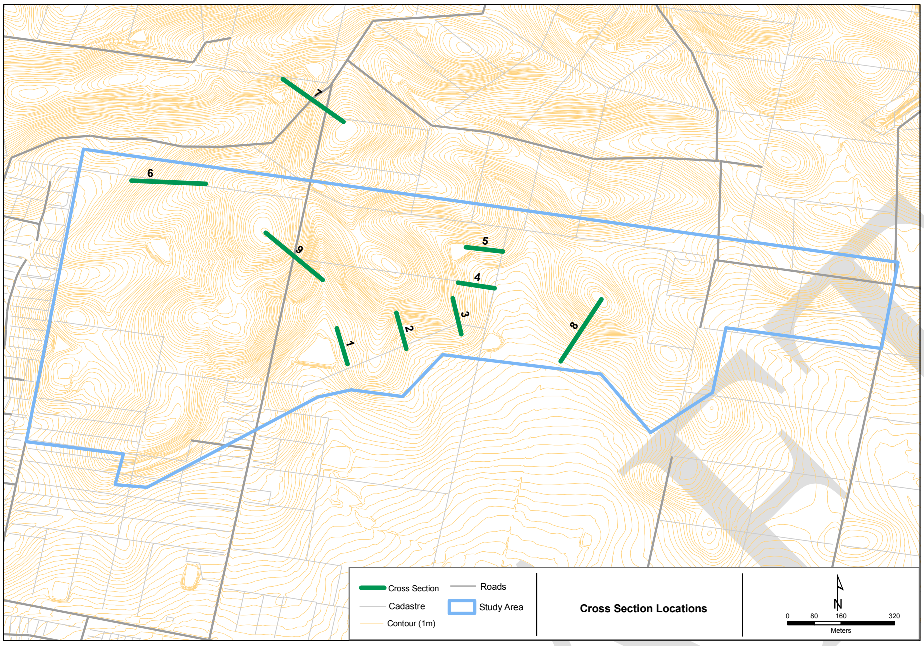
The VBRC suggested reconsideration of the concept of shared responsibility in regard to community safety in bushfires. Whilst it was acknowledged that responsibility for community safety is shared by the State, municipal councils, the broader community and individuals, the VBRC considered:

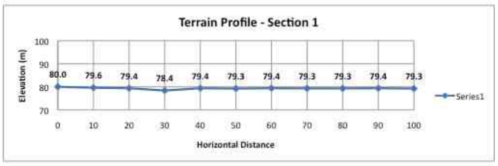
- All these groups must accept greater responsibility for bushfire safety; and
- Shared responsibility does not mean equal responsibility.

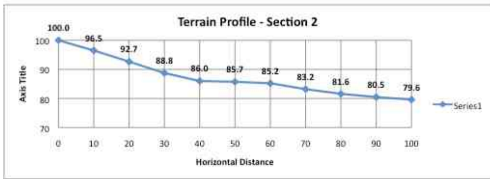
The VBRC considered that there are areas in which the State should assume greater responsibility for providing leadership and guidance. In particular, this applies to areas where the State (or State agencies) is more capable of identifying and addressing the risks.

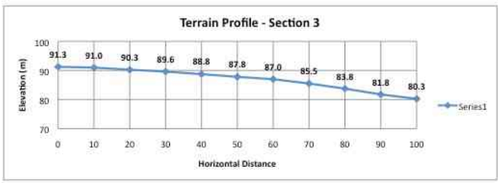
There also needs to be effort to avoid the cycle of complacency that sees community and government commitment to bushfire safety spike after major events but then diminish as time passes. The VBRC viewed the State as pivotal in ensuring ongoing compliance with revised bushfire safety policy resulting from the Black Saturday fires.

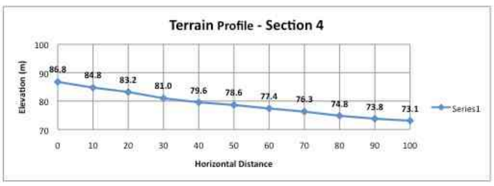
Appendix 4 – Topographical and fire behaviour analysis

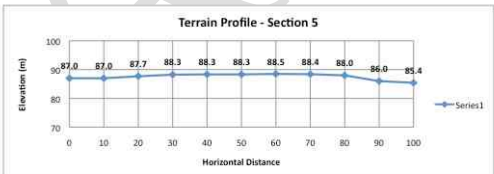


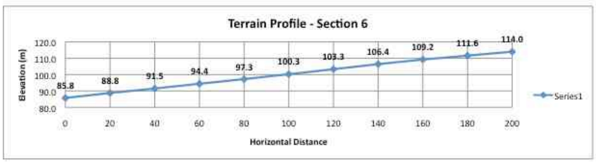


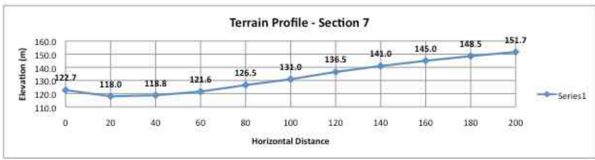


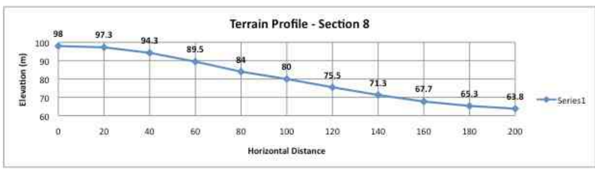


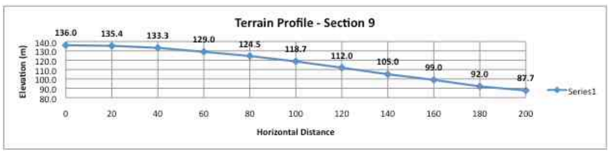












terramatrix

Cardinia Precinct Fire Model

V1.3

Weather Parameters	Value
KBDI	90
Days since rain	15
Rain (mm)	8
Drought factor	10
Curing (%)	100
Temperature (deg)	41
Relative humidity (%)	5.5
Wind speed	45

Fire Model Parameters	Value
FFDI	120
Wind speed	45
Intensity cap - Forest	120,000
Intensity cap - Grassland	60,000
Radiant heat threshold	29

Fire Model Modifications	Value
Woodland ROS factor	0.5
Medium Forest ROS factor	0.3

Zone Name	Vegetation Type	Fire Model	Fuel Load (t/ha)	Pasture Type	Vegetation Height (m)	Crowning?	Slope (deg)	SS ROS (km/h)	Intensity (kW/m)	Flame Length (m)	Distance to radiant heat threshold (m)	Spotting (m)	Set back distances (m): WMO Alternative Solution	WMO Deemed to Satisfy	AS3959 - 2009
1	Medium forest	Forest	30	N/A	25	Yes	0	4.3	67,187	25.4	34	13,348	59	60	25
2	Grassland	Grassland	3	Grazed	25	No	0	13.1	20,431	7.4	10	53,003	18	30	0
34	Medium forest	Forest	20	N/A	25	Yes	-5	2.0	21,148	20.1	11	6,784	31	60	25
5	Medium forest	Grass modified - forest	3	Grazed	25	Yes	0	3.9	6,129	4.3	3	15,649	7	60	25
61	Woodland	Grass modified - woodland	3	Grazed	25	No	-10	3.3	5,124	3.9	3	13,023	7	30	16
62	Woodland	Grass modified - woodland	3	Grazed	25	No	10	13.1	20,366	7.4	10	52,835	18	30	26
63	Woodland	Grass modified - woodland	3	Grazed	25	No	10	13.1	20,366	7.4	10	52,835	18	30	26
7	Grassland	Grassland	3	Grazed	0	No	0	13.1	20,431	7.4	10	53,003	18	30	0
81	Woodland	Grass modified - woodland	3	Grazed	25	No	10	13.1	20,366	7.4	10	52,835	18	30	26
82	Woodland	Grass modified - woodland	3	Grazed	25	No	10	13.1	20,366	7.4	10	52,835	18	30	26
9	Garden	Grass modified - woodland	1	Grazed	0	No	0	6.6	3,405	3.3	2	26,754	5	30	16
61 - MF	Medium forest	Forest	20	N/A	25	Yes	-10	1.4	14,977	19.0	8	4,699	27	60	25
62 -MF	Medium forest	Forest	20	N/A	25	Yes	10	5.7	59,534	24.7	30	19,750	55	90	39
63 - MF	Medium forest	Forest	20	N/A	25	Yes	10	5.7	59,534	24.7	30	19,750	55	90	39
5 - MF	Medium forest	Forest	20	N/A	25	Yes	0	2.9	29,861	21.4	15	9,727	36	60	25