



City of Greater Bendigo
Potential Growth Areas
FINAL BUSHFIRE ASSESSMENT
INCORPORATING TWO ADDITIONAL SITES

Prepared for
City of Greater Bendigo

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Terramatrix project: GreaterBendigoCC-2022-02 Municipal Bushfire Risk Assessment

Cover image: Box Ironbark Forest in the Bendigo Regional Park.

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GLOSSARY

BAL	<i>Bushfire Attack Level</i> - A means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kilowatts per metre squared, and the basis for establishing the requirements for construction to improve protection of building elements from attack by bushfire e.g. a building constructed to a BAL-12.5 standard is designed to be exposed to radiant heat not exceeding 12.5 kW/m ² .	Bushfire hazard	A specific source of potential damage or harm, typically consisting of three key elements; vegetation, weather and topography.
BMO	<i>Bushfire Management Overlay</i> - A planning scheme provision used to guide the development of land in areas of high bushfire hazard. The BMO applies to areas where there is potential for extreme bushfire behaviour, such as a crown fire and extreme ember attack and radiant heat	Bushfire risk	The chance or probability of damage or harm if exposed to a bushfire hazard and the severity of the impact i.e. consideration of the likelihood and consequences of impacts from bushfire.
BPA	<i>Bushfire Prone Area</i> - An area that is subject to, or likely to be subject to, bushfire attack as determined by the Minister for Planning.	Classified vegetation	Vegetation deemed to be a bushfire hazard in accordance with the Bushfire Management Overlay (BMO) and/or AS 3959-2018 <i>Construction of buildings in bushfire prone areas</i> .
Bushfire	An unplanned fire burning in vegetation; sometimes referred to as wildfire. A generic term which includes grass fires, forest fires and scrub fires.	CFA	<i>Country Fire Authority</i>
Bushfire attack	Attack by wind, burning embers, radiant heat or flame generated by a bushfire.	CoGB	<i>City of Greater Bendigo</i>
		Defendable space	An area of land around a building where vegetation is modified and managed to reduce the effects of flame contact and radiant heat associated with bushfire.
		DEECA	<i>Department of Environment, Energy and Climate Action</i>

DELWP¹	The former <i>Department of Environment, Land Water and Planning</i>	FBI	<i>Fire Behaviour Index</i> – A mathematically calculated scale of potential fire behaviour that ranges from 0 to 100+, based on fire behaviour models. Fire agencies use the FBI to inform decisions about the Fire Danger Rating (FDR) for a district.
DTP	<i>Department of Transport and Planning</i>	FDR	<i>Fire Danger Rating</i> – The FDR is set by fire agencies based on FBIs and indicates how difficult it will be to control or suppress a fire and communicate the level of bushfire risk. There are four FDRs; Moderate, High, Extreme and Catastrophic. 'No rating' may be shown when there is low risk.
Effective slope	The slope of the land (gradient, measured in degrees) under the classified vegetation which most influences the bushfire attack. The slope is determined on the basis of the fire moving towards the building and the rate of spread of the fire and not solely on the basis of the relative elevation of the vegetation.	FFDI	<i>Forest Fire Danger Index</i> – A numerical index representing the chance of a fire starting, its rate of spread, its intensity and the difficulty of its suppression, according to various combinations of air temperature, relative humidity, wind speed and both the long- and short-term drought effects.
Ember attack	Attack by smouldering or flaming windborne debris that is capable of entering or accumulating around a building, and that may ignite the building or other combustible materials and debris.	FFMvic	<i>Forest Fire Management Victoria</i>
EMV	<i>Emergency Management Victoria</i>	FRV	<i>Fire Rescue Victoria</i>
EVC	<i>Ecological Vegetation Class</i> - The standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (i.e. lower level in the classification) that occur across a biogeographic range and, although differing in species, have similar habitat and ecological processes operating.	LGA	<i>Local Government Area</i>
		PGA	<i>Potential Growth Area</i>

¹ Since 1 January 2023 the planning functions of the former government department DELWP, reside with the new Department of Transport and Planning (DTP). Some of the

content in this report references documents prepared by DELWP prior to the change, so the DELWP acronym is used in some parts of the report as appropriate.

RHF

Radiant heat flux - The heat transfer rate per unit area from thermal (electromagnetic) radiation, expressed as kilowatts per metre squared (kW/m^2). Calculated or measured for a specific surface to determine the radiant heat received by that surface from flames associated with a bushfire.

EXECUTIVE SUMMARY

Background

- This bushfire assessment has been prepared for the City of Greater Bendigo (CoGB), to identify locations where the objective and strategies for bushfire planning in the State planning policy for bushfire can be satisfied, and hence, where future urban growth may be accommodated within the CoGB local government area (LGA).
- The objective for the assessment is:
‘To understand where future growth and development should be directed to within the municipality that meets the state planning policy for bushfire planning’ (CoGB, 2022).
- The CoGB identified potential growth areas (PGAs) for the assessment to focus on, within approximately 10 km of the Bendigo city centre:
 - Marong Township Structure Plan area (528 ha)
 - Maiden Gully (North West) (681 ha)
 - Maiden Gully Precinct Structure Plan area (507 ha)
 - Maiden Gully (East) (45 ha)
 - Simpsons Road (238 ha)
 - Watson Street (206 ha)
 - Huntly (North and East) (602 ha)
 - Junortoun (102 ha)
 - Strathfieldsaye (South and East) (705 ha)
 - Big Hill (83 ha)
 - Lockwood Road (78 ha)
 - Olympic Parade (294 ha)
- The assessment aims to identify which of the identified PGAs, if any, are appropriate to direct growth and future development, in accordance with the Victorian planning and building controls that relate to bushfire, in particular the objective and strategies of Clause 13.02-1S *Bushfire Planning* in the Greater Bendigo Planning Scheme.
- All the PGAs are declared Bushfire Prone Areas (BPA) and have at least partial Bushfire Management Overlay (BMO) coverage.
- In accordance with the bushfire hazard identification and assessment strategies in Clause 13.02-1S, the hazard posed by vegetation, topographic and climatic conditions has been assessed at the following scales:
 - Broader landscape scale, considering conditions between 1 km and at least 20 km around the study area, to evaluate potential fire behaviour and delineate landscape risk typologies.
 - The local and neighbourhood scale up to 1 km around the study area to determine likely fire behaviour closer to the site and determine the applicable landscape typology.
 - The site scale, up to 150 m around the study area, including classifying vegetation and topography to determine potential BAL-LOW and BAL-12.5 development areas in accordance with key settlement planning safety thresholds in Clause 13.02-1S.
- The topography was analysed using publicly available 10m contour data, interpolated 5 m contour data, and a 10 m Digital Elevation Model (DEM).

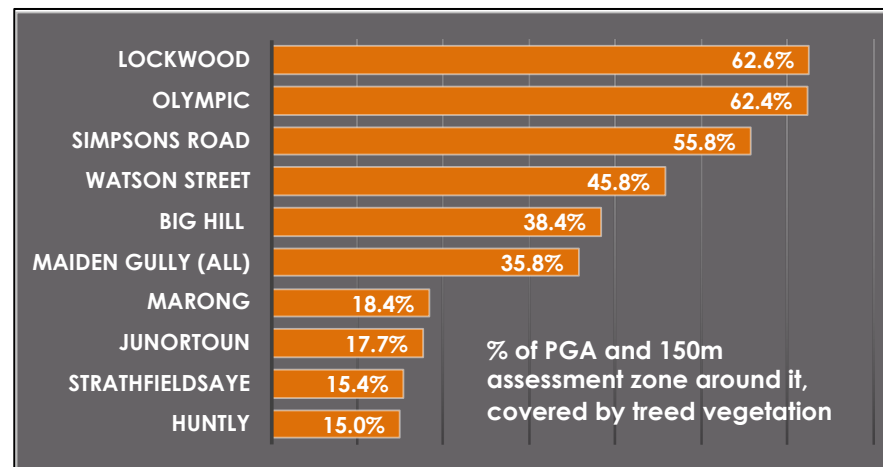
- In relation to climatic conditions, the frequency and severity of bushfire wind conditions has been analysed, using historical fire weather data from the closest Bureau of Meteorology (BOM) station considered representative of weather conditions for the study area, which is at Bendigo Airport, 4 km north-east of the Bendigo city centre.
- Since the 1950s there has been an increase in the length of the fire season and an increase in extreme fire weather due to climate change, and the trend is projected to continue (CSIRO/BOM, 2022).

Hazard assessment and risk analysis

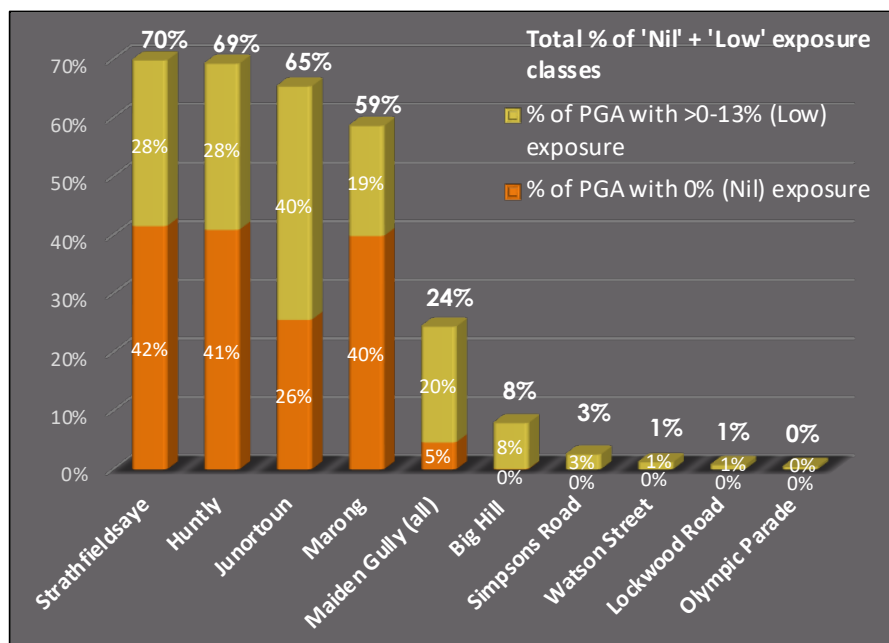
- Analysis of weather data on days of elevated fire danger shows the dominance of northerly and north-westerly winds, with westerly and south-westerly winds also occurring but less frequently, on days of when FFDI is greater than or equal to 50 (i.e. generally when the fire danger rating is Extreme or Catastrophic). The wind data shows that the PGAs are least likely to be exposed to direct bushfire attack from the east, south or south-east, which is typical of most locations in Victoria.
- The northern and western interfaces (including south-west) of the PGAs are, therefore, generally at higher risk than more easterly and southerly parts.
- Four landscape-scale bushfire metrics, where the pattern of topography and vegetation may interact with weather and atmospheric conditions to generate extreme bushfire behaviour, were assessed in an area extending at least 20 km around the PGAs to inform an assessment of landscape risk to the PGAs. The four metrics are:
 - Terrain Ruggedness
 - Convective Strength
 - Modelled House Loss Probability
 - Ember-storm Potential (Drop Zone).
- The analysis shows that the PGAs are unlikely to be subject to extreme fire behaviour, and hence, it is considered bushfire behaviour will be in accordance with the BMO/AS3959 design fire conditions.
- This conclusion is generally supported by FFMVic bushfire behaviour and house loss modelling for the Loddon Mallee Bushfire Management Strategy, which shows that all of the PGAs are comparatively least risk locations in the region for potential house loss under catastrophic conditions, except for:
 - The westernmost corner of the Strathfieldsaye PGA, which is a 'Low-Intermediate' risk location.
 - Approximately the southern two-fifths of Big Hill PGA, which is a 'Low-Intermediate' and 'Intermediate' risk location.
 - A small area towards the north-westernmost corner of Maiden Gully North West PGA, which is a 'Low-Intermediate' risk location, and another small area in the north-easternmost corner that is a 'Low-Intermediate' to 'High' risk location.
 - An area in the south-west corner of the Maiden Gully Precinct Structure Plan PGA, which is rated as a 'Low-Intermediate' and 'Intermediate' risk location.
 - All the Lockwood Road PGA, which is rated as a 'Low-Intermediate' and 'Intermediate' risk location.

- The Olympic Parade PGA that has areas of ‘Low-Intermediate’ risk increasing to ‘High’ Risk in the south.
- Overall, it is considered that the landscape around the PGAs is best characterised as BMO Broad Landscape Type 2 or 3, which is typical of BMO landscapes. All locations could, therefore, potentially be exposed to a fully developed bushfire (or grassfire) as envisaged in the BMO/AS 3959 methodology.
- The topography in the landscape is unlikely to be a significant influence on bushfire behaviour, and therefore not an appreciable contributor to the risk within the PGAs. For the purposes of determining BAL construction standards and defendable space/development setback distances, the applicable slope class is likely to be ‘All upslopes and flat land’ for most, if not all, of the study areas.
- The hazard posed by vegetation at the local and neighbourhood scales around the PGAs was identified by delineating classified vegetation types from Ecological Vegetation Classes (EVCs).
- The analysis reveals that 70% of the land area in and up to 1 km around the PGAs, potentially comprises an EVC. Just over half that area is Box Ironbark Forest, almost a third is Grassy Woodland, and a little less than 10% comprises Plains Grassy Woodland.
- Analysis of EVC bioregional benchmarks shows all EVCs (that have at least 1% coverage of land) within, and up to 1 km around, the PGAs are likely most appropriately classified in the AS 3959 Woodland group.
- At the site scale, within 150 m of the PGAs the hazard comprises Grassland or Woodland vegetation. The following chart shows the

proportion of each PGA and the 150 m assessment zone around it that comprises vegetation in the AS 3959 Woodland group.



- Analysis of the neighbourhood hazard exposure was undertaken to determine the relative risk (% exposure) of all parts of the study areas to hazardous areas of dense treed vegetation within 400 m to the north and west, and 150 m in other directions. That is, the *area of hazard* within 400 m to north and west (including south-west), and 150 m to south and east, around 30 m x 30 m cells, was calculated and reported back to the subject cell, and then ranked as a percentage of total possible exposure.
- The results of the analysis are summarised in the following chart that provides a comparative analysis of the hazard exposure for each PGA. It shows the percentage of land area within each PGA that has ‘Nil’ exposure or is in the ‘Low’ exposure class i.e. ‘>0-13%’ of its land area exposed to hazardous treed vegetation.

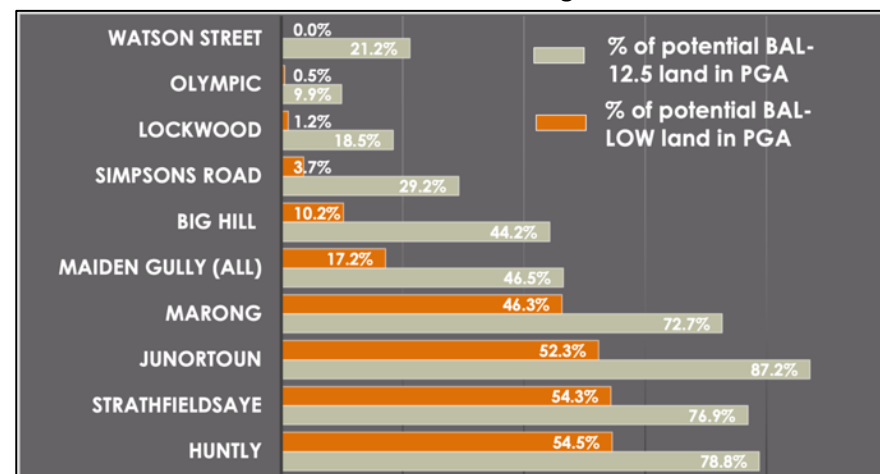


- The results are shown in Map 11 and the analysis of the least risk classes correlates well with BPA coverage and Clause 13.02-1S analysis of potential 'low risk' areas in each PGA where BAL-12.5 development could occur, i.e. where RHF is calculated to not exceed 12.5 kW/m².
- The mapping of the higher risk classes also correlates well with BMO coverage and potentially indicates areas which may be more, or less, suitable for BMO schedules.
- An assessment was made of the ability of the PGAs to meet key settlement planning safety thresholds for BAL and RHF exposure, being:
 - Potential 'low risk' areas where BAL-12.5 development could occur, that is, where RHF calculated to not exceed 12.5 kW/m² i.e.

at least 33 m from patches of Woodland and 19 m from Grassland in the 150 m assessment zone around the PGAs.

- Potential BAL-LOW areas where human life may be better protected from the effects of bushfire, i.e. land at least 50 m from Grassland around the PGAs and 100 m from Woodland patches.

- The results are summarised in the following chart.



- A summary of all the analysis was made based on the assessment attributes for each PGA. It ranks them according to the favourability or suitability of the attribute for (or against) potential urban growth. A higher ranking (i.e. lower rank number) is indicative that a PGA may be comparatively more suitable for development than a PGA with a lower ranking.
- The summary table of the PGA rankings has been compiled as a simple sum of all the ranking 'scores', as an 'overall ranking' table as follows.

Sum of Ranked Results	Potential Growth Area	Ranked Result According To Each Attribute						Colour legend for ranked attributes (comparative suitability for growth)
		% of potential BAL-LOW within PGA	% area covered by treed vegetation within and up to 150m around PGA	% area of BMO within PGA	% FFMVic Freehold Moderate Risk Land in PGA	% of PGA with 0 to 13% neighbourhood hazard exposure	Egress to a place of relative safety	
9	Huntly	1	1	2	2	2	1	More suitable ↑ ↓ Less suitable
12	Strathfieldsaye	2	2	3	3	1	1	
16	Marong	4	4	1	1	4	2	
23	Junortoun	3	3	4	8	3	2	
27	Maiden Gully (all)	5	5	5	4	5	3	
31	Big Hill	6	6	6	5	6	2	
39	Simpsons Road	7	8	7	6	7	4	
45	Watson Street	10	7	9	9	8	2	
47	Lockwood Road	8	10	8	10	9	2	
48	Olympic Parade	9	9	10	7	10	3	

- The comparative ranking indicates the most suitable PGAs for potential growth and development towards the top of the table, with the least suitable PGAs towards the bottom of the table i.e. it shows the most suitable PGAs for potential growth and development are Huntly, Marong and Strathfieldsaye. Development in Maiden Gully could be carefully considered, and to some extent Junortoun, although Junortoun has high exposure to hazardous vegetation on public land.
- Big Hill, Watson Street, Simpsons Road, Lockwood Road and Olympic Parade are comparatively less favourably suited to development.
- Note in relation to the Maiden Gully and Junortoun PGAs:
 - The development potential of the Maiden Gully PGAs is significantly influenced by the future vegetated state of these PGAs under a growth scenario/s. The existing patchwork of native

vegetation could allow fire to penetrate deep within and across the PGAs. Concentrated urban-residential development could, however, create large low threat areas of relative safety. Alternatively, lower density development with good vegetation controls to manage vegetation in a low threat state could result in a similar outcome.

- Therefore, the ability of development in the Maiden Gully PGAs to mitigate risk is significantly influenced by the extent to which vegetation can be removed and/or managed in a low threat state in perpetuity.
- Whilst Junortoun has very good potential for BAL-12.5 and BAL-LOW development, it's narrow shape and location in the landscape between large tracts of forest to the north and south-

south-east, requires careful consideration for siting and layout of development.

- It is important to note that the ranking is based on some metrics available as outcomes of the analysis. It does not consider every attribute relevant to bushfire risk and so should not be seen as definitive. It is a simplified comparative ranking tool only, as a guide to assist in deciding where, if anywhere, growth might be directed, from a bushfire safety perspective only.
- Further, the ranking does not consider the weighting of one attribute more than another in its importance for bushfire safety, i.e. it assumes all attributes are equally significant in influencing bushfire safety and risk, which may not be the case.
- It is noted that there may be non-bushfire related opportunities or constraints in the PGA's that affects the growth opportunities. Examples may include whether an activity centre is designated, proximity to public transport and services, and buffers with incompatible land uses, flooding and the like.
- As PGAs develop and result in new areas of non-vegetated or low threat land, they have the potential to decrease the bushfire risk to existing (adjacent) communities.

Conclusion and planning and design response

- Over 70% of the Huntly, Strathfieldsaye, Junortoun and Marong PGAs, and almost half of the Maiden Gully PGAs, can potentially meet the

12.5 kW/m² RHF safety threshold² and, therefore, be deemed low risk locations in accordance with Clause 13.02.1S.

- Based on the 'All upslopes and flat land' slope class, this requires a minimum 33 m setback of development from Woodland areas and a 19 m minimum setback from any areas of classified Grassland around (or within) the PGAs.
- Additionally, over half of the Huntly, Strathfieldsaye and Junortoun PGAs, and almost half of the Marong PGA, is likely to be able to meet the definition of a BAL-LOW area under the State Planning Policy AS 3959 criteria for BAL-LOW. There are no evident obstacles to future development providing good access to these areas within the PGAs.
- The ability of development in the Maiden Gully PGAs to mitigate risk is significantly influenced by the extent to which vegetation can be removed and/or managed in a low threat state in perpetuity.
- Whilst Junortoun has very good potential for BAL-12.5 and BAL-LOW development, its narrow shape and location in the landscape between large tracts of forest to the north and south-south-east, requires careful consideration for siting and layout of development.
- Big Hill, Watson Street, Simpsons Road, Lockwood Road and Olympic Parade are comparatively less suited to direct growth from a bushfire perspective.
- The landscape risk analysis and assessment of the fuel hazard posed by the vegetation, fire weather and topography beyond 150 m around the study areas, demonstrates that fire behaviour is not likely to be extreme enough to preclude appropriate development in favourable PGAs.

² Which is commensurate with a BAL-12.5 construction standard.

- Accordingly, if the development layout responds to the bushfire risk and future buildings are setback sufficiently from hazardous vegetation it is considered the risk can be deemed to be acceptable for at least some growth in numerous, if not all, PGAs. However, as identified above, some are comparatively lesser risk locations than others and, therefore, are better suited to growth.
- Generally, any ‘vulnerable uses’³ should be directed to least risk central parts of the lower risk PGAs, which are those areas outside a BPA, have very good access to places of relative safety, or that could potentially achieve BAL-LOW.
- Lot sizes of between 800 - 1,200 m² should be considered in PGA locations directly adjacent to a bushfire hazard, in accordance with DTP design guidelines for settlement planning on the bushfire interface, with the aim to provide a minimum 10 m separation between dwellings.
- This is especially desirable for any areas on or close to a northern, north-western or western interface, as these are areas of higher hazard based on the most likely directions of approaching fire under elevated fire danger conditions.
- Higher density conventional residential lots should be concentrated more centrally within the BAL-12.5 and potential BAL-LOW parts of PGAs.
- It is also desirable to consider the need for vegetation controls or guidelines to be applied to any areas with an interface with a bushfire hazard, to ensure vegetation is maintained as low threat. For example, planning controls or structure plan requirements could specify that vegetation within 150 m of an identified hazard be managed in accordance with the defensible space requirements of Table 6 to Clause 53.02-5.
- This is considered especially desirable in the Maiden Gully PGAs, which have the highest (almost 80%) proportion of land area in the FFMVic ‘high risk freehold land’ class.
- This measure will assist to minimise the risk for fire spread into and within the PGAs but is likely not needed in conventional density areas (e.g. UGZ, TZ, GRZ, NRZ or MUZ) within those PGAs most suitable to direct growth to, i.e. especially Huntly, Strathfieldsaye and Marong. These more intensively developed zones typically result in smaller lot sizes that comprise only non-vegetated and low threat cultivated garden or lawn areas.
- Vegetated areas to be permanently retained (e.g. as conservation reserves, drainage reserves, areas adjacent to PGAs) and which may pose a tree/shrub or grassland hazard, should be identified in growth/development plans and setbacks from them defined to facilitate adjacent BAL-12.5 development.
- It is presumed that any local parks and sports reserves will comprise only managed grassland and low threat landscaped areas from which no setbacks would be required.
- Perimeter roads should be incorporated along the boundaries of growth areas and any patches of hazardous vegetation to contribute to separation from adjacent residential areas. This is especially

³ Considered to be Class 9a health-care buildings, Class 9b early childhood centres, primary or secondary schools and Class 9c residential care buildings.

important along any interface with any creek corridors, and any interface areas on or close to a northern, north-western or western interface. Planning controls or growth/development plans should include this as a requirement.

- The use of building envelopes can also provide, or contribute to, setbacks from hazardous vegetation.
- There should be no obstacles to future subdivision providing appropriate access/egress within PGAs for emergency vehicles and residents via a conventional residential road network in accordance with the requirements for roads in residential subdivisions at Clause 56.06.
- Additionally, roads should comply with the CFA's *Design Requirements, Vehicle Access and Water Supply Requirements in Residential Developments*.
- The road layout should provide at least two access and egress routes to existing or future BAL-LOW/low threat areas.
- A guideline could be included in growth/development plans for landscape design and plant selection in open spaces, including waterways and drainage corridors that ensures a low risk of bushfire, i.e. comprises low threat vegetation in accordance with AS 3959-2018.
- It is desirable to discourage, restrict or prohibit the use of combustible fences such as non-bushfire resistant timber fences and brush fences, especially in interface parts of PGAs. Accordingly, a guideline, or requirement, could be proposed for all fencing adjoining fire hazard areas to be of non-combustible materials.
- Subject to the extent and pattern of development proposed and any proposed vegetation removal, it is likely that the BMO1 or BMO2

schedules (which facilitate BAL-12.5 and BAL-29 development respectively) could be extended to some parts of the PGAs that are currently covered by the BMO parent provision, e.g. potentially Huntly, Strathfieldsaye, Marong, Junortoun and Maiden Gully.

- Overall, the risk to development in the more favourable PGAs can be deemed to be acceptably mitigated such that development can proceed, if the objective and strategies of Clause 13.02-1S, the DTP settlement planning guidelines, and compliance with BPA and BMO measures are successfully implemented as identified in this report. These can be incorporated into bushfire requirements and guidelines in growth and development plans.
- With BPA (or BMO) compliance, and bushfire responsive siting and layout of development, including good access/egress to BAL-LOW/low threat areas, appropriate bushfire protection measures can be adequately implemented.
- Once developed with reliably low threat and non-vegetated areas, parts of some PGAs can likely meet the criteria for future excision from the BPA, creating more easily accessible areas of relative safety from bushfire attack for existing and future residents.

SECTION 1: BACKGROUND & CONTEXT

1 Introduction

Terramatrix prepared a Bushfire Assessment for the City of Greater Bendigo (CoGB) to help identify locations where future urban growth may be accommodated within the CoGB local government area (LGA).

The CoGB LGA comprises almost 300,000 ha of land (see Map 1), which, based on 2021 census data, had a population of 121,470 with 53,055 private dwellings (ABS, 2023). Population growth is occurring at well over 1% p.a. (ABS, 2023; CoGB, 2016) and is forecast to grow to over 200,000 residents over the next 30 years (CoGB, 2022). The CoGB residential strategy identified that to meet forecast demand between 2014 and 2031, CoGB needed to provide an average of 820 new dwellings per annum (CoGB, 2016).

Council has been planning over several years how to accommodate this growth. Changes in December 2017 to State policy in relation to bushfire planning and native vegetation, made planning for growth more challenging (CoGB, 2022).

Consequently, toward the end of 2022, CoGB sought to prepare a municipal bushfire risk assessment (MBRA) for the entire CoGB LGA, with a particular focus around the Bendigo urban area and small towns. The aim of the assessment was to identify areas of low, medium and high bushfire risk to ensure growth could be directed to low risk areas in accordance with State policy; and together with other constraints, inform

the direction of future population growth and development within the municipality (CoGB, 2022).

Council subsequently sought a review of the initially proposed methodology to undertake the MBRA. Amongst other recommendations, the review advised that a municipal wide BRA was not required, and that locations for growth should be based on *‘purposeful spatial areas’* focussed on *‘Bendigo (city) and the alternative locations within this housing market’* (Kevin Hazell Bushfire Planning, 2022).

‘The options for realising growth in Bendigo (city) are relatively obvious and may number about 5-7 broad locations. A focus on assessing these would likely be sufficient to demonstrate that alternative locations under c13.02-1S Bushfire Planning has been given sufficient emphasis in the evidence base’ (Kevin Hazell Bushfire Planning, 2022).

Consequently, the CoGB identified ten potential growth areas (PGAs) for the assessment to focus on, within approximately 10 km of the Bendigo city centre (see Map 1). Subsequently CoGB requested that another two sites be assessed as part of the study which are:

- Lockwood Road PGA - 77.5 ha of land west-southwest of the western Urban Growth Boundary (UGB).
- Olympic Parade PGA - 294.2 ha of land west of the western Urban Growth Boundary (UGB).

1.1 Purpose

The objective for the bushfire assessment is:

‘To understand where future growth and development should be directed to within the municipality that meets the state planning policy for bushfire planning’ (CoGB, 2022).

This report aims to identify which of the identified PGAs, if any, are appropriate locations to which to direct growth and future development, in accordance with the Victorian planning and building controls that relate to bushfire, in particular the objective and strategies of Clause 13.02-1S *Bushfire Planning* in the Greater Bendigo Planning Scheme.

The purpose of the assessment is also to identify and make recommendations about appropriate bushfire protection measures that could be implemented to acceptably mitigate the bushfire hazard, and the resulting risk, in and around the PGAs.

The assessment has been undertaken, and this report prepared, in accordance with applicable guidance for the assessment of and response to bushfire risk provided in:

- *Design Guidelines Settlement Planning at the Bushfire Interface* (DELWP, 2020a)
- *Bushfire State Planning Policy Amendment VC140*, Planning Advisory Note 68 (DELWP, 2018)
- *Local planning for bushfire protection*, Planning Practice Note 64 (DELWP, 2015a)

- *AS 3959-2018 Construction of buildings in bushfire prone areas* (Standards Australia, 2020)
- *Planning Permit Applications Bushfire Management Overlay Technical Guide* (DELWP, 2017).

All the PGAs are declared Bushfire Prone Areas (BPA) and have at least partial Bushfire Management Overlay (BMO) coverage (see Figure 2).

1.2 Study area

The initial 10 PGA locations identified by CoGB as the focus for this assessment, and the landscape surrounding them, comprise the broad study area.

- Marong Township Structure Plan area (528 ha)
- Maiden Gully (North West) (681 ha)
- Maiden Gully Precinct Structure Plan area (507 ha)
- Maiden Gully (East) (45 ha)
- Simpsons Road (238 ha)
- Watson Street (206 ha)
- Huntly (North and East) (602 ha)
- Junortoun (102 ha)
- Strathfieldsaye (South and East) (705 ha)
- Big Hill (83 ha)

The additional two PGAs that are included in this final assessment and report are:

- Lockwood Road PGA - 77.5 ha of land west-southwest of the western Urban Growth Boundary (UGB).
- Olympic Parade PGA - 294.2 ha of land west of the western Urban Growth Boundary (UGB).

All the PGAs are shown in Map 2. As the three Maiden Gully PGAs are contiguous to each other and share similar characteristics, for the purposes of the study they are differentiated in the mapping but were assessed as the one location.

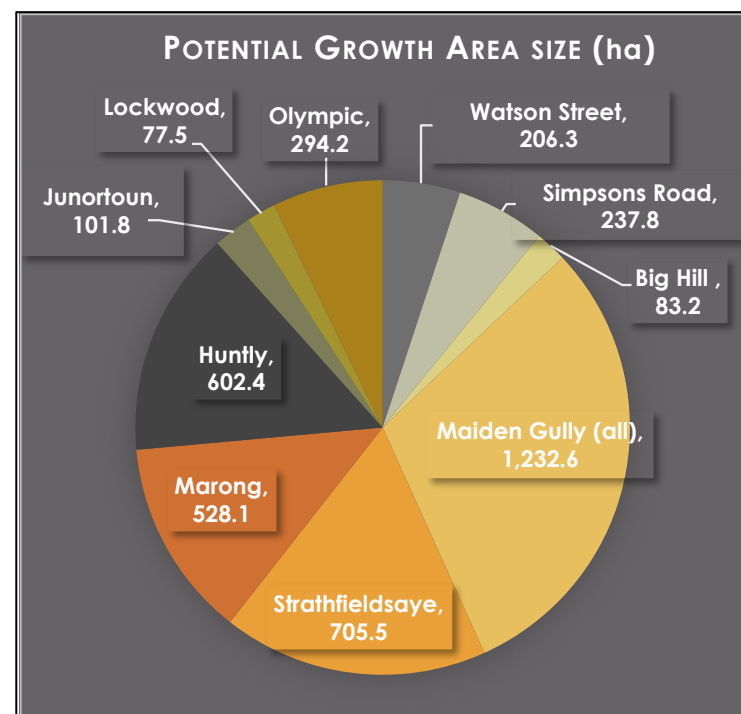
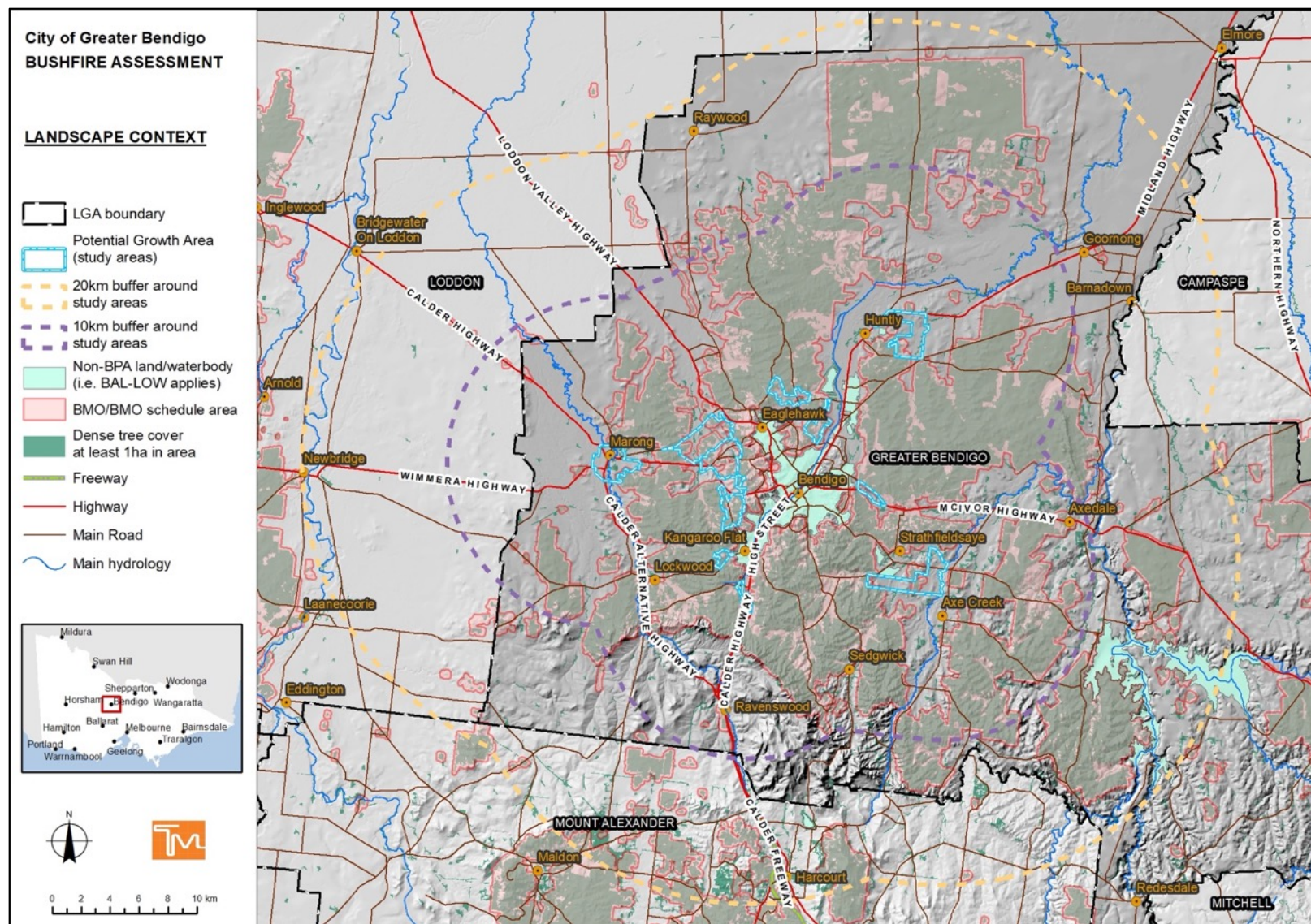
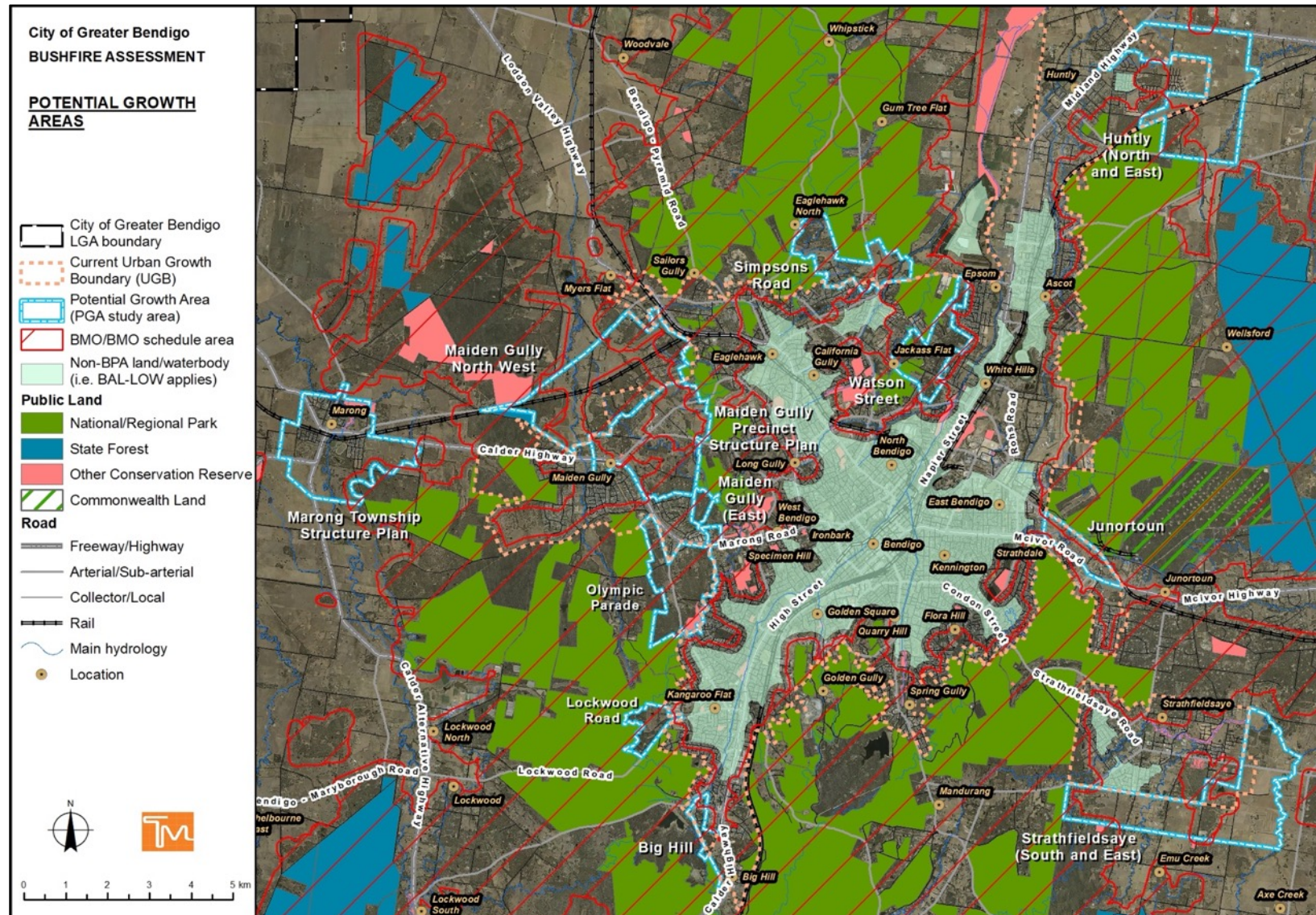


Figure 1 – PGA land area chart

Map 1 – Landscape context of the PGA study locations



Map 2 – Potential growth locations



2 Bushfire planning and building controls

This section summarises the applicable planning and building controls that relate to bushfire. Sections 11 and 12 assess how planning and design for the PGAs can respond to and comply with the controls.

2.1 Greater Bendigo Planning Scheme

2.1.1 Clause 02 Municipal Planning Strategy

The Municipal Planning Strategy for Greater Bendigo recognises that bushfire is one of the key environmental risks for the municipality. Accordingly, one of the strategic directions for settlement is to avoid development in bushfire and flood prone areas unless the risk can be managed (Greater Bendigo Planning Scheme, Cl. 02.03-1). One of the settlement policy guidelines is that land rezoning requests for residential, industrial and commercial purposes outside the urban growth boundary must consider *‘Potential impact of bushfire, including whether the rezoning would require prescribed burning to be undertaken on Crown land in the vicinity’* (Greater Bendigo Planning Scheme, Cl. 11.01-1L-01).

2.1.2 Clause 12 Environmental and landscape values

A strategy for protection of biodiversity in the municipality is to *‘Protect and enhance forested biolinks along roadways and waterways that contribute to a network of remnant habitat and wildlife corridors in a*

manner that does not increase bushfire risk to human life’ (Greater Bendigo Planning Scheme, Cl. 12.01-1L).

The Urban Forest Interface policy (at Clause 12.05-2L) applies to land that abuts forested areas in the General Residential Zone, Low Density Residential Zone, Industrial 1 Zone and Industrial 3 Zone. The policy objective is to protect the ecological values of forested private and public land around Bendigo from the impacts of urban development. Policy guidelines to be considered as relevant, include:

- *‘Mitigating risks associated with bushfire through a combination of urban design and land management measures.*
- *Designing subdivisions (including a road) to be setback 5 metres from the forest boundary.*
- *Providing a 30 metre buffer, which may incorporate a road, from habitable buildings to the forest boundary. This buffer should not include trees, except for street trees’* (Greater Bendigo Planning Scheme, Cl. 12.05-2L).

A strategy in the Urban Forest Interface policy is to *‘Avoid rezoning areas to an urban use that abut public and private forest unless it will produce a positive outcome and does not result in increased bushfire risk’* (Greater Bendigo Planning Scheme, Cl. 12.05-2L). This presumably includes at least those parts of the study area where future development will abut classified Woodland vegetation. Another strategy is to *‘Avoid increasing risks associated with bushfire through a combination of best practice*

urban design or land management or both' (Greater Bendigo Planning Scheme, Cl. 12.05-2L)

2.1.3 Clause 13.01-1S Natural hazards and climate change

The objective of this Clause is to minimise the impacts of natural hazards and adapt to the impacts of climate change through risk-based planning.

Specified strategies to achieve the objective are:

- *'Respond to the risks associated with climate change in planning and management decision making processes.*
- *Identify at risk areas using the best available data and climate change science.*
- *Integrate strategic land use planning with emergency management decision making.*
- *Direct population growth and development to low risk locations.*
- *Develop adaptation response strategies for existing settlements in risk areas to accommodate change over time.*
- *Ensure planning controls allow for risk mitigation and climate change adaptation strategies to be implemented.*
- *Site and design development to minimise risk to life, health, property, the natural environment and community infrastructure from natural hazards'* (Greater Bendigo Planning Scheme, Cl. 13.01-1S).

Especially in southern and eastern Australia, since the 1950s there has been an increase in the length of the fire weather season and an increase in extreme fire weather (CSIRO/BOM, 2022). The trend of a longer fire

season and increased number of dangerous fire weather days is projected to continue. Climate change is contributing to these changes in fire weather including by affecting temperature, relative humidity and associated changes to the fuel moisture content (CSIRO/BOM, 2022).

The Australasian Fire and Emergency Service Authorities Council (AFAC) identify that a failure of building codes and land use planning to adequately adapt to climate change is a significant risk (AFAC, 2018).

The Greater Bendigo Municipal Fire Management Plan also identifies that the trends associated with climate change likely include changed fuel loads across the municipality, an increase in the duration and intensity of the Fire Danger Period, and an increase in the number of extreme fire risk days (CoGB, 2020).

Climate change trends associated with the risk of bushfire, support the adoption of a precautionary and conservative approach in identifying and responding to the risk, which has been adopted in this report as appropriate. Climate change in relation to fire weather is discussed further in the hazard assessment in Section 5 of this report.

2.1.4 Clause 13.02-1S Bushfire planning

Clause 13.02-1S has the objective *'To strengthen the resilience of settlements and communities to bushfire through risk based planning that prioritises the protection of human life'* (Greater Bendigo Planning Scheme, Cl. 13.02-1S). The policy must be applied to all planning and

decision making under the Planning and Environment Act 1987, relating to land which is:

- Within a designated Bushfire Prone Area (BPA);
- Subject to a Bushfire Management Overlay (BMO); or
- Proposed to be used or developed in a way that may create a bushfire hazard.

Priority must be given to the protection of human life by:

- *‘Prioritising the protection of human life over all other policy considerations.*
- *Directing population growth and development to low risk locations and ensuring the availability of, and safe access to, areas where human life can be better protected from the effects of bushfire.*
- *Reducing the vulnerability of communities to bushfire through consideration of bushfire risk in decision-making at all stages of the planning process’* (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

Key strategies are stipulated that require strategic planning documents, planning scheme amendments and development plan approvals to properly assess bushfire risk and include appropriate bushfire protection measures. In a BPA this also applies to planning applications for uses and developments that are:

- Subdivisions of more than 10 lots
- Accommodation
- Child care centre

- Education centre
- Emergency services facility
- Hospital
- Indoor recreation facility
- Major sports and recreation facility
- Place of assembly
- Any application for development that will result in people congregating in large numbers.

Development should not be approved where *‘...a landowner or proponent has not satisfactorily demonstrated that the relevant policies have been addressed, performance measures satisfied or bushfire protection measures can be adequately implemented’* (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

This study assesses the hazard in accordance with the hazard identification strategies of Clause 13.02-1S and identifies the required bushfire protection measures.

It is considered that development can appropriately prioritise the protection of human life and meet the objectives of Clause 13.02-1S by directing growth to the lesser risk PGAs and ensuring a bushfire responsive design and layout in those PGAs that amongst other things, ensures higher density and vulnerable development is sited away from areas of high hazard and future dwellings will not be exposed to radiant heat flux (RHF) above 12.5 kW/m², which is commensurate with a Bushfire Attack Level (BAL)-12.5 construction standard.

The maximum 12.5 kW/m² safety threshold is required in settlement planning as the upper limit for acceptable risk. Responsible authorities must *‘Not approve any strategic planning document, local planning policy, or planning scheme amendment that will result in the introduction or intensification of development in an area that has, or will on completion have, more than a BAL- 12.5 rating under AS 3959-2018 Construction of buildings in a bushfire prone area’* (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

This assessment identifies development setbacks likely required so that development does not exceed BAL-12.5, and appropriate design and layout features that respond to the hazard assessment and incorporate the DELWP guidelines for settlement planning as detailed in Section 11. A summary of how growth can respond to the strategies of Clause 13.02-1S is provided in Section 12 of this report.

2.1.5 Clause 19.02-6L-01 Open space and public land – Greater Bendigo

This local policy applies to the allocation of land and the use and development of land for open spaces and public land in Greater Bendigo. A policy guideline, to consider as relevant, is *‘Avoiding new public open space that has the potential to increase bushfire risk and designing the space to incorporate bushfire management requirements’* (Greater Bendigo Planning Scheme, Cl. 19.02-6L-01).

2.1.6 Clause 44.06 Bushfire Management Overlay (BMO)

The purposes of the BMO, which applies to 37%⁴ of the Greater Bendigo municipality and has a variable degree of coverage across all the PGAs (see Figure 2 and Map 2), are:

- *‘To implement the Municipal Planning Strategy and the Planning Policy Framework.*
- *To ensure that the development of land prioritises the protection of human life and strengthens community resilience to bushfire.*
- *To identify areas where the bushfire hazard warrants bushfire protection measures to be implemented.*
- *To ensure development is only permitted where the risk to life and property from bushfire can be reduced to an acceptable level’* (Greater Bendigo Planning Scheme, Cl. 44.06).

The BMO largely applies to patches of treed vegetation greater than 4 ha in size, where head fire intensity has been modelled to be 30,000 kW/m or more. It also extends over land extending 150 m (and in situations where head fire intensity may be extreme, up to 300 m) from the edge of the vegetation, based on research into house loss from bushfires which found that 92% of house loss occurs within 150 m of the bushfire hazard (DELWP, 2019).

Objectives and compliance measures for Clause 44.06 BMO applications are specified in associated Clause 53.02 *Bushfire Planning*, which contains:

⁴ Includes areas subject to a Schedule to the BMO.

- **‘Objectives:** An objective describes the outcome that must be achieved in a completed development.
- **Approved measures (AM):** An approved measure meets the objective.
- **Alternative measures (AltM):** An alternative measure may be considered where the responsible authority is satisfied that the objective can be met. The responsible authority may consider other unspecified alternative measures.
- **Decision guidelines:** The decision guidelines set out the matters that the responsible authority must consider before deciding on an application, including whether any proposed alternative measure is appropriate’ (Greater Bendigo Planning Scheme, Cl. 53.02).

The existing BMO coverage of the study areas is generally considered appropriate and should be retained, although subject to the extent and location of any future rezoning and residential development, it is likely that some BMO schedule areas could be extended over new residential development in some PGAs. For example, subject to the extent of any proposed new development and the future vegetated state of the Maiden Gully PSP area, the BMO1⁵ (or BMO2⁶) would likely be appropriate to extend over some new residential areas. This may also be appropriate for some parts of Huntly, Junortoun, Strathfieldsaye, and possibly Big Hill.

Big Hill, Maiden Gully and Simpsons Road PGAs have less than 1% of their area covered by the BMO1, Watson Street has less than 1% covered by the BMO1 and BMO2. Other PGAs only have BMO the parent provision. See Figure 2 and the coverage, including schedule, shown in Maps 12 - 20.

⁵ The BMO1, amongst other requirements, stipulates a BAL-12.5 construction standard.

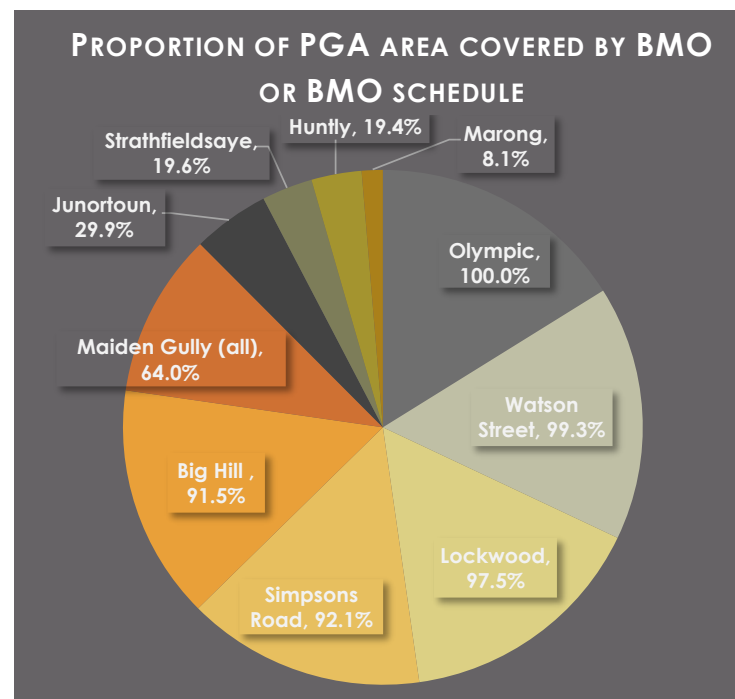


Figure 2 - BMO coverage chart of PGAs (Includes BMO1 and BMO2 coverage)

2.1.7 Clause 71.02-3 Integrated decision making

Clause 71.02-3 states that planning and responsible authorities should endeavour to integrate planning policies relevant to the issues to be determined and balance conflicting objectives in favour of net community benefit and sustainable development. However, in bushfire affected

⁶ The BMO2, amongst other requirements, stipulates a BAL-29 construction standard.

areas, the protection of human life must be prioritised over all other policy considerations (Greater Bendigo Planning Scheme, Cl. 71.02-3).

2.2 Bushfire Prone Area (BPA)

Almost 98% of the CoGB is designated as a Bushfire Prone Area (BPA) and all land within the PGAs is a BPA (see Map 2). BPAs are those areas subject to, or likely to be subject to bushfire, as determined by the Minister for Planning. Those areas of highest bushfire risk within a BPA are designated as BMO areas.

In a BPA, the Building Act 1993 and associated Building Regulations 2018, through application of the National Construction Code 2022 (NCC), require specific design and construction standards for Class 1, 2 and 3⁷ buildings, certain Class 9 and 4 buildings⁸, and Class 10A buildings⁹ or decks adjacent to, or connected with, these classes of buildings.

For Class 1 buildings (dwellings) and associated Class 10A buildings or decks, the applicable performance requirement in the NCC is:

‘A Class 1 building or a Class 10a building or deck associated with a Class 1 building that is constructed in a designated bushfire prone area must be designed and constructed to—

- (a) *reduce the risk of ignition from a design bushfire with an annual exceedance probability not more than 1:50 years; and*
- (b) *take account of the assessed duration and intensity of the fire actions of the design bushfire; and*
- (c) *be designed to prevent internal ignition of the building and its contents; and*
- (d) *maintain the structural integrity of the building for the duration of the design bushfire (ABCB, 2023).*

The performance requirement for Class 1, 2 and 3 buildings and associated Class 10a buildings and decks, is deemed to be satisfied by design and construction in accordance with AS 3959-2018 *Construction of buildings in bushfire prone areas*. For Class 1 buildings and associated decks, the NASH Standard – *Steel Framed Construction in Bushfire Areas* (NASH, 2021) is also deemed to satisfy the performance requirement. More onerous performance measures apply to certain Class 9 buildings.

In Victoria, buildings in a BPA must be constructed to a minimum BAL-12.5, or higher as determined by a site assessment, planning scheme requirement or other NCC requirement¹⁰.

⁷ Class 1, 2 and 3 buildings are defined in the NCC and are generally those used for residential accommodation, including houses and other dwellings, apartments, hotels and other buildings with a similar function or use.

⁸ Applicable Class 9 buildings are Class 9a health-care buildings, Class 9b early childhood centres, primary and secondary schools, Class 9c residential care buildings, and any Class 4 parts of a building associated with these Class 9 buildings.

⁹ Class 10a buildings are defined in the NCC as non-habitable buildings including sheds, carports, and private garages.

¹⁰ Class 9 buildings are typically required to meet an enhanced BAL-19 construction standard, as well as comply with other bushfire protection specifications.

A BAL is a means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact. There are six BALs defined in AS 3959; which range from BAL-LOW, which has no bushfire construction requirements, to BAL-FZ (Flame Zone) where flame contact with a building is expected (see Appendix - BALs & RHF).

There should be no obstacles to future development complying with the applicable building regulations and NCC requirements invoked by the BPA coverage.

If development results in the creation of large, reliably low threat or non-vegetated areas, some parts of PGAs may become eligible for excision from the BPA.

The DTP reviews and excises eligible areas from the BPA approximately every 6 months, particularly in growth areas where the hazard is removed as urban development occurs.

Land becomes eligible for excision from the BPA if it satisfies statewide hazard mapping criteria, including that the land typically needs to be:

- At least 150 m and up to 300 m from areas of classified vegetation, except grassland, more than 2 ha in size; and
- At least 60 m from areas of classified grassland more than 2 ha in size (DELWP, 2019).

For areas of vegetation less than 2 ha, the shape of the area and connectivity to any other hazardous vegetation is a further consideration (DELWP, 2019).

2.3 Other controls

2.3.1 Zoning

The zones that currently apply within the PGAs have no inherent implications for bushfire safety. However, any rezoning of land to an urban residential or other more intensive land use zone that facilitates more intensive development in a BPA (or BMO), may result in an increase in risk, as more people would be exposed to a hazard.

The three largest zones that occur within each PGA (i.e. the three zones with the largest coverage of each PGA) are shown in Table 1.

Table 1 - Three largest zones in each PGA

PGA	Zone	Area (ha)	% of PGA land
Big Hill	LDRZ	41.9	50.3%
	FZ	40.7	48.9%
	PUZ6	0.7	0.8%
Huntly	RLZ	478.3	79.4%
	FZ	63.5	10.5%
	UGZ	47.2	7.8%
Junortoun	LDRZ	84.1	82.6%
	TRZ2	13.8	13.6%
	IN3Z	2.5	2.5%
Lockwood	FZ	77.4	99.8%
	IN1Z	0.1	0.1%
Maiden Gully	FZ	1,005.6	81.6%
	LDRZ	98.9	8.0%
	GRZ	72.3	5.9%
Marong	FZ	254.0	48.1%
	TZ	143.6	27.2%
	SUZ6	45.5	8.6%
Olympic	FZ	266.5	90.6%
	PPRZ	16.5	5.6%
	TRZ3	5.6	1.9%
Simpsons	FZ	237.8	100.0%
Strathfieldsaye	RLZ	694.4	98.4%
	GRZ	6.7	0.9%
	TRZ2	4.4	0.6%
Watson	LDRZ	103.8	50.3%
	FZ	59.5	28.9%
	IN3Z	17.4	8.4%

In many growth areas, schedules to a zone include a requirement that an application for residential subdivision includes a Bushfire Management Plan, to be approved by the responsible authority, which addresses bushfire risk during and, where necessary, after construction, including specifying:

- The staging of development and the likely bushfire risks at each stage;
- An area of land between the development edge and non-urban areas consistent with the separation distances specified in AS 3959-2018, where bushfire risk is managed;
- The land management measures to be undertaken by the developer to reduce the risk from fire within any surrounding rural or undeveloped landscape to protect residents and property from the threat of grassfire and bushfire; and
- How adequate opportunities for access and egress will be provided for early residents, construction workers and emergency vehicles.

This requirement, or similar, should be implemented for potential new residential subdivisions in any PGAs where growth will occur, as it will help to ensure that bushfire risk is managed during the construction phase, when areas of interim hazard may be retained in proximity to new or existing development. It will also support subdivision applications to demonstrate how bushfire risk will be mitigated in a Clause 13.02-1S response/application.

2.3.2 Overlays

Apart from the BMO, none of the overlays that currently apply in the PGAs have any appreciable implications for bushfire safety. However, overlays that contain vegetation controls (e.g. VPO, ESO, or SLO) may have implications for vegetation removal to create defensible space¹¹ or other low threat land areas where occupants can be better protected from bushfire. It is noted though, that a range of exemptions apply for vegetation removal for fire protection and the creation of defensible space e.g. Clause 52.12 *Bushfire Protection Exemptions*.

It is not known if new overlay controls are proposed, however it is unlikely that any new overlays would have significant bushfire risk implications. An overlay such as a Design and Development Overlay (DDO) could usefully incorporate bushfire protection objectives and measures if appropriate.

¹¹ Defined at Clause 73.01 as ‘An area of land around a building where vegetation is modified and managed to reduce the effects of flame contact and radiant heat associated with bushfire’ (Greater Bendigo Planning Scheme, Cl. 73.01).

3 Regional bushfire assessments, plans and strategies

3.1 Loddon Mallee Bushfire Management Strategy 2020

Strategic bushfire management planning in Victoria is jointly delivered by Forest Fire Management Victoria (FFMVic), Country Fire Authority (CFA), Fire Rescue Victoria (FRV), Emergency Management Victoria (EMV) and local government. A key output is a Bushfire Management Strategy for each of the six planning regions that cover the state. Each strategy informs more detailed operational-level planning, including municipal fire prevention planning, the FFMVic and CFA joint fuel management program, and readiness and response planning.

The CoGB is covered by the Loddon Mallee Bushfire Management Strategy (LMBMS). The strategy notes that CoGB is the most populated LGA in the region and that the significant interface between forest and urban environments presents ongoing challenges in managing bushfire risk (DELWP, 2020b).

The strategy stipulates planning is required for two actions for managing bushfire risk in Bendigo, both with a 'Very High' priority:

- *'Complex urban-forest interface requires additional planning and likely engagement with local homeowners.'*
- *'Urban expansion is driving a rapidly changing regional risk profile. A more complex analysis considering regional growth planning can enhance risk mitigation strategies'* (DELWP, 2020b).

The LMBMS also presents modelled house loss mapping representing comparative bushfire risk within the region. House loss modelling is shown in Map 6 and Map 21 of this assessment and is discussed further in Section 7.2.3. It shows that most of the PGAs are comparatively least risk locations in the region for potential house loss under catastrophic conditions, except for:

- The westernmost corner of the Strathfieldsaye PGA is a 'Low-Intermediate' risk location.
- Approximately the southern two-fifths of Big Hill PGA is a 'Low-Intermediate' and 'Intermediate' risk location.
- A small part of the Maiden Gully PSP area and all of the Lockwood Road PGA are 'Low-Intermediate' or 'Intermediate' risk locations.
- The Olympic Road PGA has areas of 'Low-Intermediate' risk increasing to 'High Risk' in the south of the PGA.

3.2 Regional Bushfire Planning Assessment (RBPA) Loddon Mallee Region

As part of the response to the 2009 Victorian Bushfires Royal Commission, Regional Bushfire Planning Assessments (RBPAs) were undertaken across six regions that cover the whole of Victoria. The RBPAs provide information about 'identified areas' where a range of land use planning matters intersect with a bushfire hazard to influence the level of risk to life and property from bushfire. The RBPAs state that *'This information*

should be addressed as part of strategic land use and settlement planning at the regional, municipal and local levels’ (DPCD, 2012).

The RBPA – Loddon Mallee Region includes the CoGB. The RBPA identifies Bendigo city as Victoria’s third largest urban centre outside of Melbourne, and notes the city is surrounded by national, state and regional parks, resulting in bushfire interface areas and development pressure in areas of bushfire hazard. It also identifies that areas adjoining the urban fringes of Bendigo contain vegetation susceptible to bushfire at the interface between rural-residential settlements and the broader landscape (DPCD, 2012).

No specific matters are identified pertaining to the Marong, Huntly or Strathfieldsaye PGAs.

Small lots (<0.4 ha) in or close to a hazard are identified as an issue for the Big Hill, Simpsons Road and parts of Maiden Gully PGAs. A central-eastern part of the Maiden Gully PGA is also identified as an area with *‘Small and medium size lots mixed with scattered trees, some larger patches of trees and grassland areas’* (DPCD, 2012).

Multiple matters are identified in the south-eastern half of the Junortoun PGA, consisting of:

- *‘Clusters of small and medium rural-residential lots in or in close proximity to bushfire hazard area.*
- *Development pressure is being experienced north of Mclvor Highway between Junortoun and Longlea settlements which are in close proximity to high bushfire hazard areas.*

- *Sheepwash and Emu Creeks contain riparian vegetation and bushfire hazard corridors with direct interface to small and rural-residential lots.*
- *Includes vegetation of high and very high conservation significance’* (DPCD, 2012).

The north-eastern boundary of the Watson Street PGA is shown as an urban/bushfire hazard interface, as is the northern part of the Simpsons Road PGA and the western boundary of the Big Hill PGA.

3.3 Greater Bendigo Municipal Fire Management Plan (MFMP) 2019

In addition to the impacts associated with climate change, as identified in Section 2.1.3 of this report, the CoGB MFMP reinforces that population size and forecast growth provide challenges in the management of bushfire risks across the municipality (CoGB, 2019).

The MFMP states that one of the outcomes of the 2018 review of the Greater Bendigo Planning Scheme was the need for planning scheme guidance for settlement planning in the municipality, *‘i.e. where growth should be directed, whether any new buffers were required for townships, whether there is safe access to places of last resorts (Sic.) and how development at settlement edge could effectively manage bushfire risk such as lot sizes, and design treatment’* (CoGB, 2019). It noted that this work was underway and that fire management planning across the various land tenures was a complex issue.

SECTION 2: BUSHFIRE HAZARD ASSESSMENT

4 Methodology overview

One of the bushfire hazard identification and assessment strategies in Clause 13.02-1S is to use the best available science to identify the hazard posed by vegetation, topographic and climatic conditions (Greater Bendigo Planning Scheme, Cl. 13.02-1S). The basis for the hazard assessment should be:

- *‘Landscape conditions - meaning the conditions in the landscape within 20 kilometres and potentially up to 75 kilometres from a site;*
- *Local conditions - meaning conditions within approximately 1 kilometre from a site;*
- *Neighbourhood conditions - meaning conditions within 400 metres of a site; and*
- *The site for the development’* (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

Planning Practice Note 64 *Local Planning for Bushfire Protection* suggests an assessment of the landscape context in 20 km, 10 km and 1 km radii around a study area (DELWP, 2015). The BMO also requires an assessment of landscape risk beyond the 150 m site assessment area around a development site.

This section includes an assessment of the hazard posed by vegetation and topography at the:

- Broader landscape scale, considering conditions beyond 1 km and for a minimum 20 km around the PGAs, to evaluate potential fire behaviour and delineate landscape risk typologies.
- The local and neighbourhood scale up to 1 km around the PGAs to determine likely fire behaviour closer to the sites and determine the applicable landscape typologies.
- The site scale, up to 150 m around each PGA, including classifying vegetation and topography to determine potential BAL-LOW and BAL-12.5 development areas in accordance with key settlement planning safety thresholds in Clause 13.02-1S.

local and 400 m neighbourhood assessment areas and Maps 12 - 20 comprise bushfire hazard site assessment plans (as required by a BMO application) showing classified vegetation within the 150 m site assessment area around all PGAs.

In relation to climatic conditions, the frequency and severity of bushfire wind conditions has been analysed, using historical fire weather data from the Bureau of Meteorology (BOM) weather station at Bendigo Airport, which is 4 km north-east of Bendigo (see Section 5).

The topography was analysed using publicly available 10 m contour data, interpolated 5 m contour data, and a 10 m Digital Elevation Model (DEM).

In accordance with Clause 13.02-1S hazard identification strategies, Maps 3 - 7 show the hazard in the broader landscape extending at least 20 km around the study area (as recommended in Planning Practice Note 64 (DELWP, 2015)). Figure 4 also shows the landscape up to 75 km around the PGAs as suggested in Clause 13.02-1S.

Map 9 comprises a bushfire hazard landscape assessment plan (as required in a BMO application) and shows the landscape and bushfire hazard information up to 20 km around the site. Map 10 shows the 1 km

5 Fire weather and climate

5.1 Fire danger indices

The Forest Fire Danger Index (FFDI) and the Grassland Fire Danger Index (GFDI) represent the level of bushfire threat based on weather (and fuel) conditions. An FFDI 100/GFDI 130 is applied in non-alpine areas of Victoria by the building system, to establish a BAL based on building setback distances from classified vegetation in accordance with AS 3959-2018.

The FFDI and GFDI can also be used for predicting fire behaviour, the difficulty of suppression and were used for forecasting daily Fire Danger Ratings (FDRs). The FFDI/GFDI were replaced by the Fire Behaviour Index (FBI) for the new Australian Fire Danger Rating System (AFDRS) adopted by all jurisdictions on 1st September 2022. Table 2 displays the new FDRs, their FBI range, the anticipated fire behaviour and recommended actions for each FDR.

The new AFDRS and FBIs do not correlate directly with the FFDI/GFFDI indices that are still applied in the planning and building system. However, the benchmark FFDI 100 used to represent a 'one size fits all' model of extreme fire weather conditions (and the threshold for the previous 'Code Red' FDR), is considered analogous to the new FBI 100 'Catastrophic' FDR.

Note that these extreme conditions have been exceeded during significant fire events, including at some locations in Victoria on 'Black Saturday' 2009 and are not necessarily the *worst-case* conditions for any particular location, including the CoGB.

Additionally, as identified in Section 2.1.3, in southern and eastern Australia, since the 1950s there has been an increase in the length of the fire season and an increase in extreme fire weather (CSIRO/BOM, 2022). The trend of a longer fire season and increased number of elevated fire weather days is projected to continue. Climate change is contributing to these changes in fire weather, including increases in temperature, reduced relative humidity and associated reductions to fuel moisture content (CSIRO/BOM, 2022).

The LMBMS states that in Victoria climate change is expected to extend the length of the Fire Danger Period and increase the frequency of days of elevated fire danger, with potential for larger, more severe and frequent bushfires (DELWP, 2020b).

The latest climate projections for the Murray Basin cluster, that the study area is in, state that there is a 'very high confidence' level that average temperatures in all seasons will continue to increase, with more hot days and warm spells combined with a decline in mean annual rainfall. There is a 'high confidence' in a harsher future fire weather climate, although a 'low confidence' in the magnitude of the change (CSIRO/BOM, 2023).

Climate change trends associated with the risk of bushfire, support the adoption of a precautionary and conservative approach in identifying and responding to the risk. However, as CFA and DTP have no published policy on FFDI recurrence intervals, there is no compelling reason to apply a different FFDI/GFDI from the FFDI 100/GFDI 130 threshold used throughout non-Alpine areas of Victoria in the planning and building system¹².

Table 2 - Fire Danger Ratings (Source: BoM 2022)

Forest Behaviour Index	Fire Danger Rating (FDR)	Fire Behaviour	Action
>=100	Catastrophic	If a fire starts and takes hold, lives are likely to be lost.	○ These are the most dangerous conditions for a fire. ○ Your life may depend on the decisions on you make, even before there is a fire. ○ For your survival, do not be in bushfire risk areas. ○ Stay safe by going to a safer location early in the morning or the night before. ○ If a fire starts and takes hold, lives and properties are likely to be lost. ○ Homes cannot withstand fires in these conditions. You may not be able to

Forest Behaviour Index	Fire Danger Rating (FDR)	Fire Behaviour	Action
			leave and help may not be available.
50-99	Extreme	Fires will spread quickly and be extremely dangerous.	○ These are dangerous fire conditions. ○ Check your bushfire plan and that your property is fire ready. ○ If a fire starts, take immediate action. If you and your property are not prepared to the highest level, go to a safer location well before the fire impacts. ○ Reconsider travel through bushfire risk areas. ○ Expect hot, dry and windy conditions. ○ Leaving bushfire risk areas early in the day is your safest option.
24-49	High	Fires can be dangerous.	○ There is a heightened risk. Be alert for fires in your area. ○ Decide what you will do if a fire starts. ○ If a fire starts, your life and property may be at risk. The safest option is to avoid bushfire risk areas.
12-23	Moderate	Most fires can be controlled.	○ Stay up to date and be ready to act if there is a fire.

¹² In Alpine areas of Victoria an FFDI 50 applies for determining BALs using Method 1 of AS 3959-2018.

5.2 Fire weather analysis (wind speed and direction)

Analysis of weather data was undertaken by Terramatrix to determine wind speed and direction on days of elevated fire danger (and therefore the direction/s of highest threat i.e. most likely direction/s of approach of a possible bushfire).

The analysis is based on a calculated ‘historical’ FFDI, using data obtained for the closest Bureau of Meteorology (BOM) station considered representative of weather conditions for the study area, which is the BOM Automatic Weather Station (AWS) at Bendigo Airport (BOM Station No. 081123), located just 4 km north-east of the Bendigo city centre.

The analysis is based on synoptic weather data records available for all records that had all the required relative humidity, temperature and wind speed inputs for calculating the FFDI. The drought factor, which is also required to calculate FFDI, was assumed to be 10^{13} , which is ‘worst case’, long term drought conditions.

Table 3 summarises the attributes of the station and data.

The data was sorted to retain only those records for which all three inputs were available to calculate the FFDI, i.e. relative humidity (%),

¹³ The drought factor (DF) is a numerical scale from 1 to 10, which represents an estimate of the proportion of fine fuels available to be consumed in a fire, based on seasonal weather conditions and time since last rainfall. DF=10 means driest fuel conditions with 100% of fine fuels available to be burnt.

temperature (°C) and wind speed (km/h at 10 m above ground level, averaged for the 10 min period before the reading).

Table 3 - Summary of Bendigo Airport BOM station and data attributes

Attribute	Bendigo Airport
Distance and direction from site	4 km north-east of city centre
Elevation	210 m
BOM Station No.	081123
BOM district name	Upper North
Opened	1991
Data available	Synoptic
Date of oldest record with all inputs*	28/10/1991
Date of most recent record with all inputs*	6/9/2022
No. of years of data	31
No. of records with all inputs when FFDI $\geq$ 50*	218

*Record with all inputs = record that has all three attributes required to calculate FFDI assuming DF = 10; i.e. relative humidity, temperature and wind speed.

The FFDI analysis was undertaken to assist in analysing the hazard posed by the weather and does not necessarily equate to the actual FFDI or fire weather conditions that may have occurred¹⁴.

As wind speed and direction is a major influence on fire behaviour, a wind rose was generated to show the frequency of wind speed and direction

¹⁴ Uncertainty values associated with FFDIs are significant, reflecting the imprecision of the input values, and may cross a number of FDR classes (Yeo *et al.*, 2014; AFAC, 2017).

on days of elevated fire danger (i.e. days when calculated FFDI was greater than or equal to 50).

The results are provided in Figure 3 and show the dominance of northerly or north-westerly winds on days of elevated fire danger.

The wind rose supports the contention that on days of elevated fire danger the sites are least likely to be exposed to direct bushfire attack from the east, south or south-east.

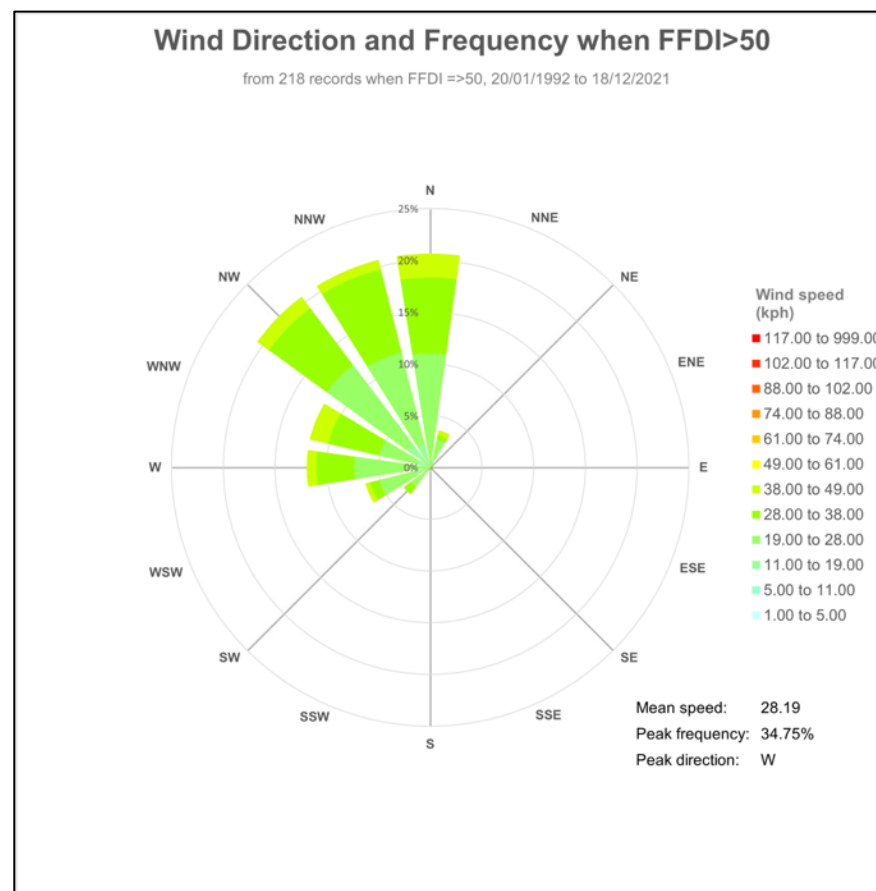


Figure 3 – Bendigo airport wind rose

6 Topography

Map 3 is an elevation map that shows the topography in and within 1 km of, and up to 5 km around, the PGAs.

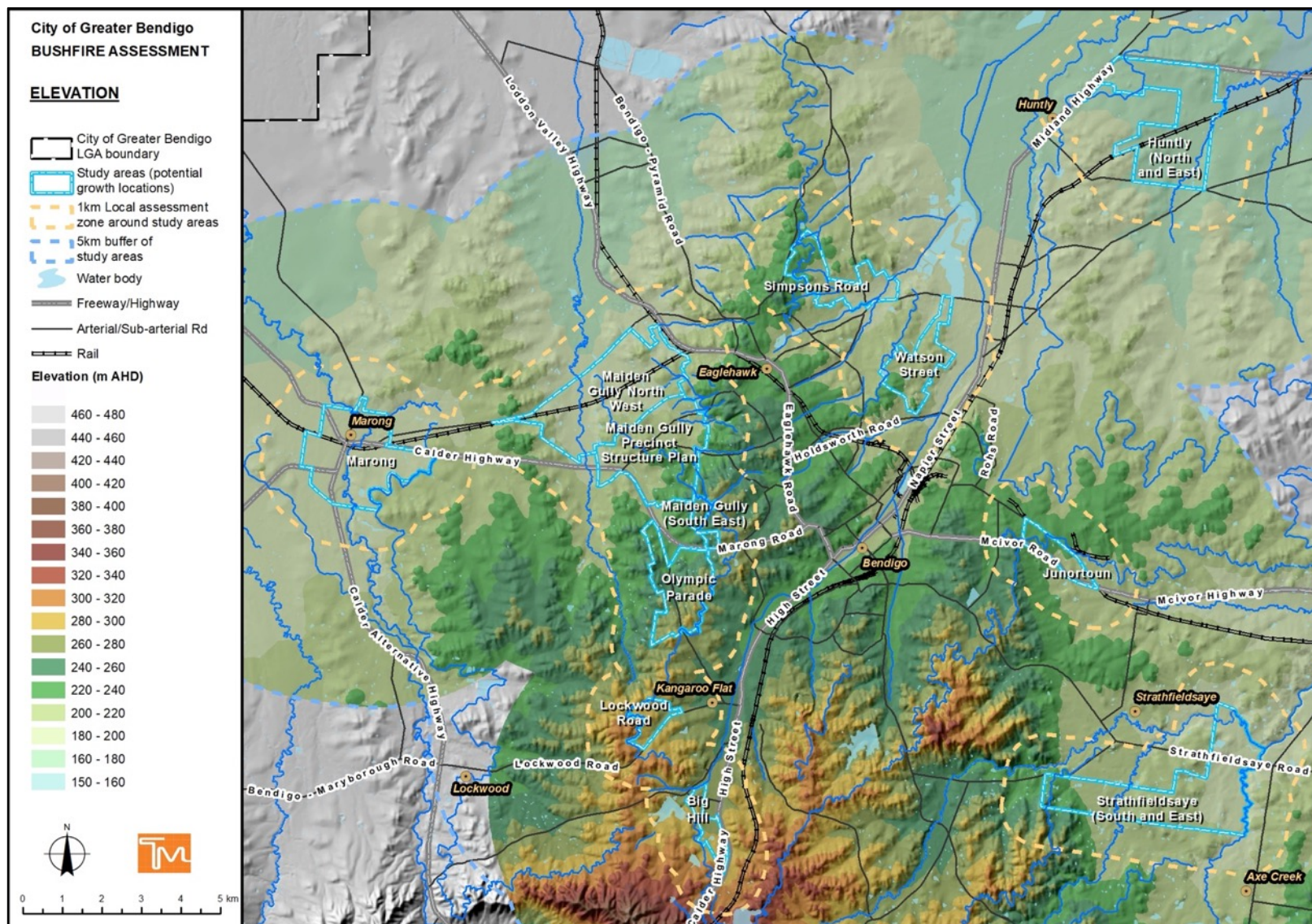
Land to the north, north-west and north-east of the broad study area (i.e. within 5 km of the PGAs) is generally flat but becomes increasingly undulating and hilly further to the south, south-west and south-east.

The land is generally dissected by only minor hydrology, comprising creeks, with the Campaspe River occurring further to the east.

From a fire behaviour perspective, the topography is not considered a significant influence in relation to the PGAs.

For the purposes of determining BAL construction standards and defensible space/development setback distances, the applicable slope class is likely to be 'All upslopes and flat land' for most, if not all, of the PGAs.

Map 3 – Elevation map of the study areas and surrounding landscape



7 Broad landscape assessment

7.1 Locality description

Bendigo is in north-central Victoria, approximately 120 km north-northwest of Melbourne. As Victoria's third largest urban centre outside metropolitan Melbourne, the city is a major regional centre for the region.

Population growth has created an increasingly culturally, religiously and ethnically diverse community. Whilst most people live within the urban area of Bendigo, about one in seven live in outlying townships and rural areas beyond the Bendigo Urban Growth Boundary (Greater Bendigo Planning Scheme, Cl. 02.01) (see Map 1).

The topography of the city's more urbanised areas, and the PGAs, is generally flat to undulating. However, around the city centre the topography becomes more undulating with steeper hills and valleys, especially to the south of Bendigo. The elevation within 1 km of the PGAs generally ranges from 160 to 380 m above sea level (see Map 3).

Sometimes referred to as the City in Forest, Bendigo is surrounded by extensive areas of national, state and regional parks and reserves (see Map 9). Remnant vegetation cover is dominated by dry sclerophyll (box ironbark) forest. Additionally, the municipality is home to several significant wetland and grassland ecosystems.

The city of Bendigo itself is in the centre of the region and serves as a hub for commercial and residential activities. Settlement beyond the Bendigo city area is characterised by a dispersed pattern, with a mix of rural and semi-rural land uses, including smaller rural townships and agricultural activities such as grazing and cropping.

Land use in the Bendigo region is dominated by agriculture, with grazing and cropping being the primary farming activities. Additionally, as a major regional service centre for north-central Victoria, the construction, manufacturing, healthcare, education and financial services sectors are major contributors to economic output, along with mining, retail and tourism (Greater Bendigo Planning Scheme, Cl. 02.01).

The region has a rich history of gold mining, with many of the towns and settlements in the area being established during the gold rush era.

Overall, the Bendigo locality is a diverse region with a mix of urban and rural land uses, characterised by undulating hills and dry sclerophyll or grassy woodland and grassland vegetation cover.

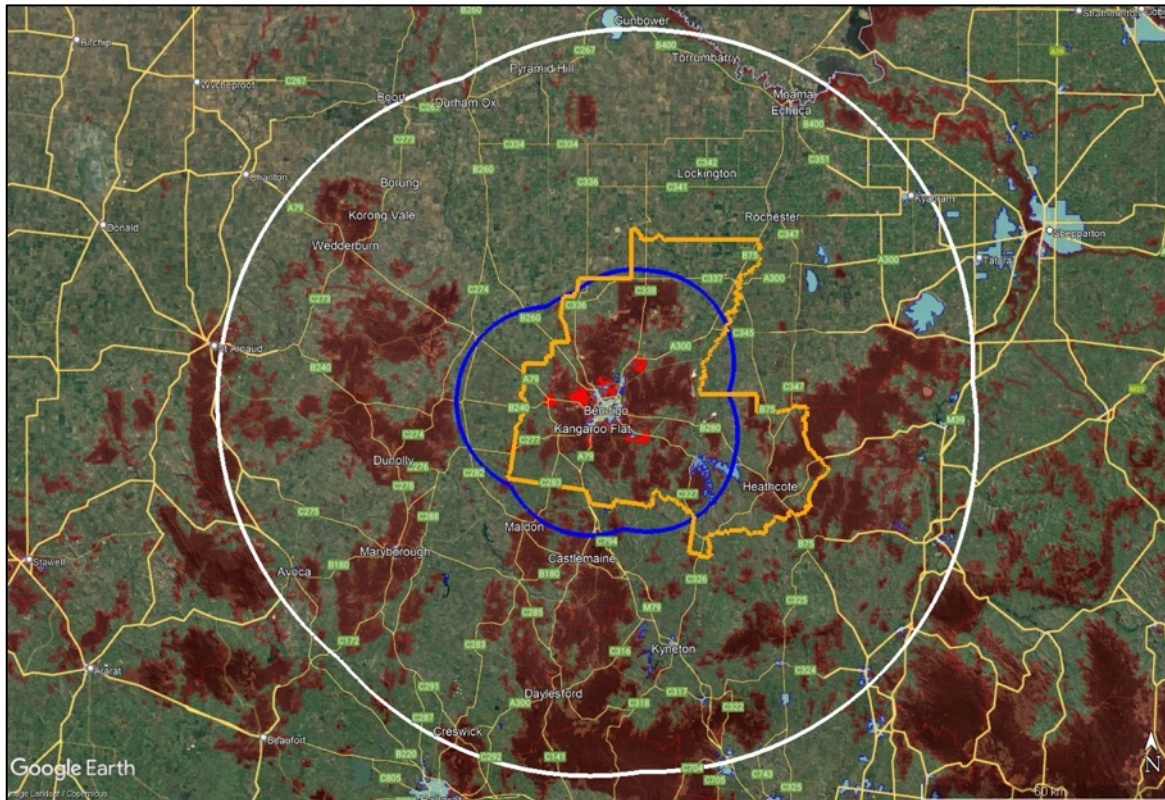


Figure 4 – Broad Landscape context of the PGAs (CoGB LGA in orange outline, 20km buffer of PGAs in blue outline, 75km buffer in white outline). Non-BPA land is shown in blue fill, BMO coverage is shown in semi-transparent red fill

7.2 Landscape-scale fire behaviour

As identified in Section 2.1.4, the State Planning Policy for bushfire at Clause 13.02-1S requires, amongst other things, that the protection of human life be prioritised by directing population growth and development to low risk locations with safe access to areas where human life can be protected from the effects of a bushfire (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

The State policy and the BMO/AS 3959 methodology also require that development is setback from hazardous vegetation ('classified' vegetation) a distance such that radiant heat flux (RHF) will not exceed defined BAL/RHF safety thresholds. These RHF setback distances are calculated based on a set of assumptions about, and models for, how fuel (vegetation), weather and topography interact to influence likely fire behaviour.

However, these assumptions and models may be less credible in locations the pattern of topography and vegetation may interact with weather and atmospheric conditions to generate extreme bushfire behaviour that is beyond the design fire conditions underpinning the BMO/AS 3959 model.

To help identify such locations with the potential for extreme fire behaviour, Tolhurst (2014) described four landscape metrics influencing fire behaviour:

1. Terrain Ruggedness
2. Convective Strength
3. Modelled House Loss Probability
4. Ember-storm Potential (Drop Zone).

The following sections analyse these four metrics in the landscape extending at least 20 km around the PGAs, to determine the potential for extreme fire behaviour i.e. where BMO Broad Landscape Type 4 characteristics might apply as identified in the Technical Guide – Planning Permit Applications Bushfire Management Overlay (see Section 7.4).

The analysis is in accordance with the Clause 13.02-1S bushfire hazard identification and assessment strategy for '*Applying the best available science to identify vegetation, topographic and climatic conditions that create a bushfire hazard*' (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

In summary, the analysis shows that the PGAs are not high risk Type 4 locations with likelihood of extreme fire behaviour. Hence, it is considered bushfire behaviour can credibly be expected to be within the BMO/AS3959 design fire conditions.

Data for the mapping and analysis is reproduced with permission (pers. comm. to the author from Dr Kevin Tolhurst, April 2023).

7.2.1 Terrain ruggedness

Terrain ‘ruggedness’ has been associated with very large fires exhibiting extreme fire behaviour including lightning ignition ‘swarms’, development of pyrocumulus/pyrocumulonimbus convective plume driven fires, and atypical fire spread resulting from wind phenomena in mountainous terrain including channelling and lee-side effects (Weber *et al.*, 2008; Sharples *et al.*, 2012; McRae and Sharples, 2013).

Tolhurst (2014) analysed the location of houses involved in the 2009 Black Saturday fires and found a strong association between areas of house loss and terrain ‘ruggedness’, indicating that terrain complexity may be an important contributing factor to house loss in severe bushfires.

McRae *et al.* (2007), when analysing a large number of fires that occurred in 2003, which were associated with dry thunderstorms in high country areas across south-east Australia, found that those ignited by lightning occurred preferentially in the most rugged terrain locations, providing further evidence that rugged terrain was a landscape risk factor for bushfire development and behaviour.

Using a 10 m statewide DEM for Victoria, terrain ruggedness was calculated for more than 20 km around the PGAs, following the method of Weber *et al.* (2008) and McRae and Sharples (2013). The method used GIS analysis to determine the range in elevation (m) within a 1.5 km radius of 30 m x 30 m cells. The following terrain complexity classes were then assigned:

- Flat: <150 m elevation range
- Undulating: 150 – 300 m elevation range
- Rugged: >300 m elevation range.

The results of the analysis are shown in Map 4.

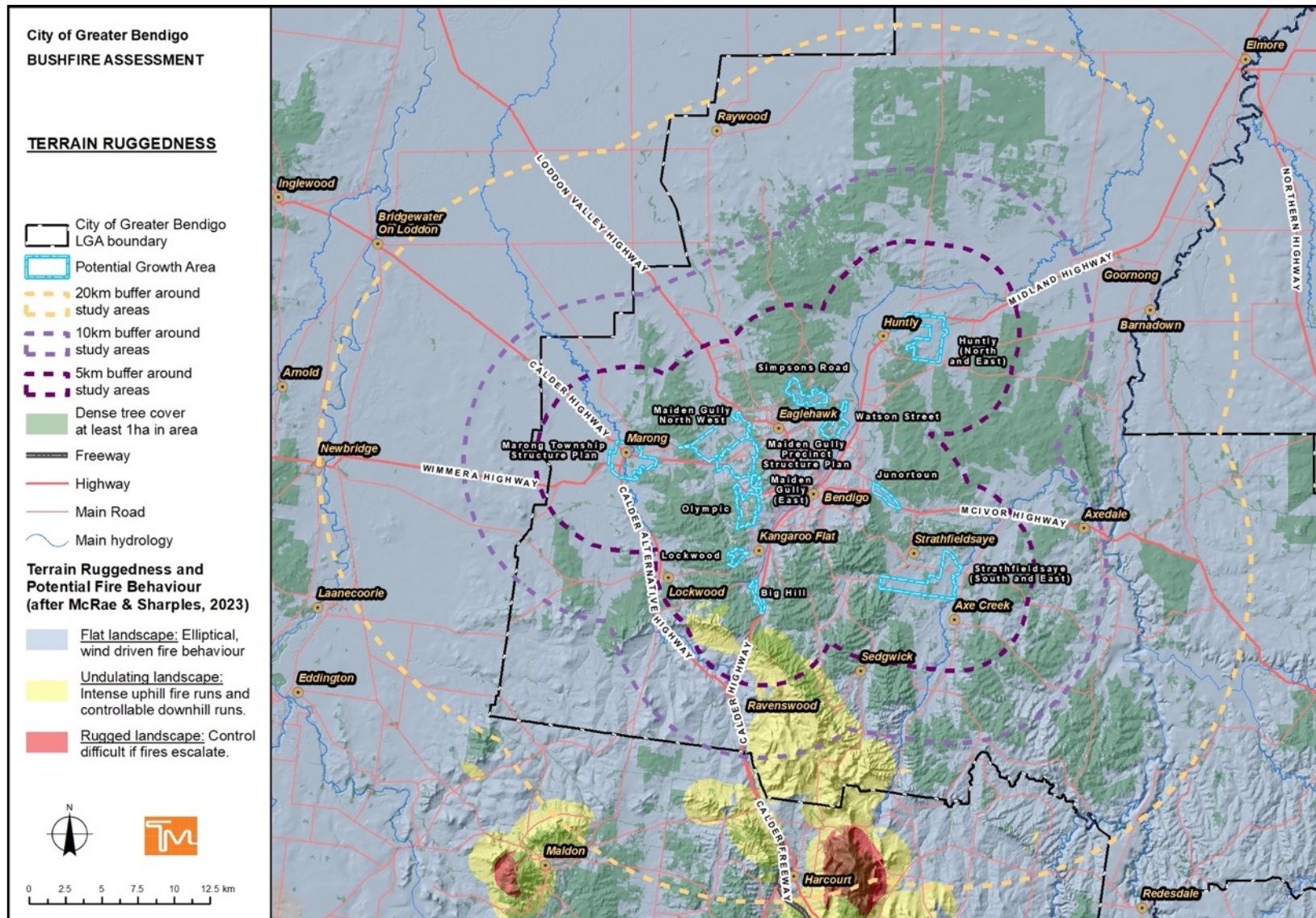
Tolhurst (2014) suggests a similar scale for landscape susceptibility to extreme fire behaviour associated with rugged terrain, being:

<u>Rating</u>	<u>Elevation range within 1.5 km</u>
Low:	0 – 150 m
Moderate:	>150 – 300 m
High:	>300 – 500 m
Extreme:	> 500 m

The analysis shown in Map 4 identifies that whilst an area of rugged terrain occurs within 20 km of the PGAs, it is a relatively small area and to the south, a direction not typically associated with an elevated fire danger threat.

Except for the Big Hill PGA, within 5 km the terrain is more benign from a bushfire perspective and considered ‘Flat’ in terms of the ruggedness classes, including for over 20 km to the north, west and east of all PGAs. Based on the wind analysis in Section 5.2 of this report, winds from the west to the north are most frequently associated with elevated fire danger conditions. This matches findings for most of Victoria, where extreme fire weather days correlate closely with prevalent winds from the north and north-west (Long, 2006).

Map 4 –
Landscape
assessment:
Terrain
ruggedness



7.2.2 Convective strength

As identified above, the AS 3959/BMO approach (and Clause 13.02-1S in the Planning Policy Framework) is based on applying development setbacks to achieve RHF thresholds that are considered to provide acceptable safety. However, up to around 80% of heat energy from a bushfire can be in the form of convection, with only around 20-40% being radiation (Tolhurst and Cheney, 1999).

Tolhurst and Chong (2011) found there was a strong correlation between convective strength and houses lost during the 2009 ‘Black Saturday’ bushfires. There is also a strong correlation between convective strength and severe winds that can cause tree fall, create openings in the building fabric such that embers can penetrate and land on combustible surfaces, or, in more extreme situations, cause catastrophic damage such as rooves being blown off or significantly compromised and/or windows blown in (Tolhurst *et al.*, 2017).

Therefore, the development setback distances (defendable space) for buildings from vegetation in the BMO and AS 3959, which are based only on RHF, do not consider other forces that may impact on a building and cause it to lose tenability during a bushfire, such as the severe winds and convective energy associated with extreme fire behaviour that is typically associated with large convective driven bushfires. The fire behaviour

associated with such plumes can be extreme when it is coupled with atmospheric conditions. They are formed by fire-heated air that ascends and condenses due to cooling as it rises, which adds further heat into the system. They are associated with high rates of spread, erratic and unpredictable winds, a deep convective core and intense spotting (Badlan *et al.*, 2021).

Map 5 shows the average computed convective strength (MW) calculated by Tolhurst (2014) using the PHOENIX RapidFire bushfire simulation model, with fire weather inputs based on conditions for ‘Ash Wednesday’, 16th February 1983¹⁵. Fire characteristics within 180 m x 180 m cells across the state, were calculated from ignitions across a 2 km statewide grid, which resulted in approximately 50,000 simulated fires. The fire characteristics for each cell were averaged from every occasion it was impacted by a simulated fire.

Convective Strength is based on the total fire intensity within a cell as a function of the amount of fuel available to burn, the topography of the land, severity of the weather conditions and hence, the size and rate of spread of the fire.

The resultant relative ‘Convective risk rating’ for the study areas is shown to be ‘Low’ (not exceeding 200 MW), with the closest next higher risk rating, ‘Moderate’ (>200 MW to 600 MW), being an area occurring

¹⁵ Including a Forest Fire Danger Index (FFDI) of 140 (c.f. the FFDI 100 applied in the planning and building system), long term drought conditions (i.e. Drought Factor 10), and no recent fire history (i.e. vegetation in long unburnt state analogous to maximum fuel

loads). As the weather data was based on Melbourne Airport records, relative humidity and air temperature were adjusted for elevation (Tolhurst K., *pers. comm.* to the author).

centrally within Bendigo. Note however, that for damaging fire-induced convective winds to develop, an area of shrubland or forest vegetation would need to be within 2 km of a site and large enough to support a fully developed 5 km fire front. The area of forested vegetation would need to be at least 3,000 ha in size (5 km x 6 km) to allow a significant convection column to form (Tolhurst, 2014).

The PGAs are, therefore, considered relatively lesser risk locations for convective-driven, extreme fire behaviour, although the risk cannot entirely be ruled out, given the expansive areas of national, state and regional parks around Bendigo.

7.2.3 Modelled house loss probability

The same PHOENIX RapidFire bushfire simulation undertaken to produce the Convective Strength output mapping was applied to calculate a relative risk of house loss probability. This was based on an analysis of approximately 5,000 houses that were destroyed, damaged or survived, in areas affected by the ‘Black Saturday’ fires that occurred in early February 2009 (Tolhurst, 2014).

The probability of house loss (0 - 1) most closely correlated with¹⁶, and is therefore derived from, a combination of convective strength, flame cross sectional area and ember density (Tolhurst and Chong, 2011).

The resultant risk ranking of house loss probability (adapted from Tolhurst, 2014) is presented in Map 6. It shows that except for Huntly PGA, which has a rating of High, and Olympic, Lockwood and Big Hill PGAs, which are High to Very High respectively, almost all the other growth locations are generally rated as Low to Moderate or Moderate risk locations. The western parts of Strathfieldsaye and Maiden Gully North West PGAs, and the northern part of Simpsons Road PGA, have a comparatively higher risk.

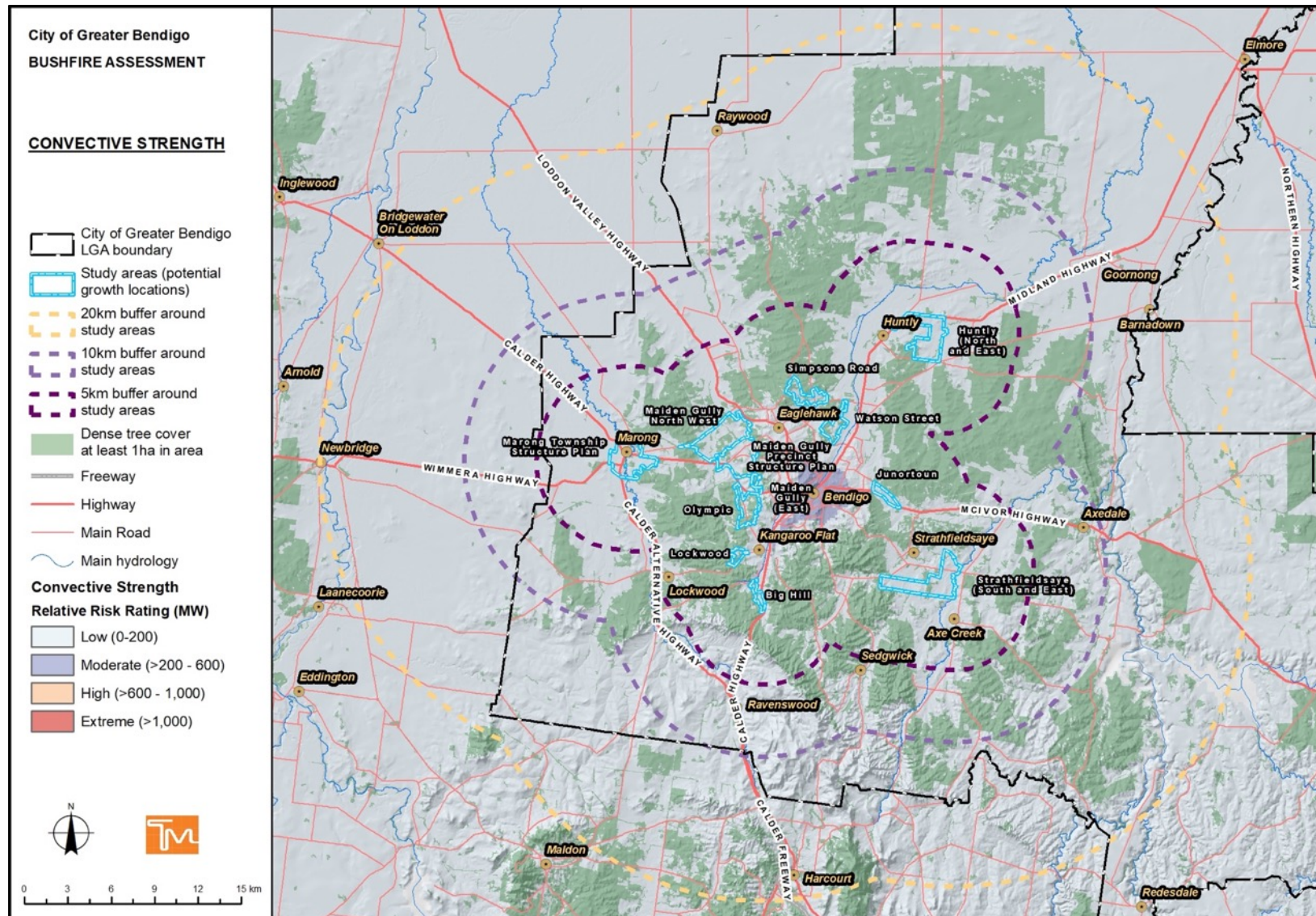
FFMVic bushfire behaviour and house loss modelling was also undertaken for the Loddon Mallee Bushfire Management Strategy (see Section 3.1) as a risk ranking for potential house loss within the region (DELWP, 2020b).

The inputs used by Tolhurst were different to those for the FFMVic modelling so they are not directly comparable. However, both models show a relatively higher risk towards the western end of the Strathfieldsaye PGA, in the Big Hill, Lockwood and Olympic PGAs and the westernmost end of Maiden Gully North West PGA.

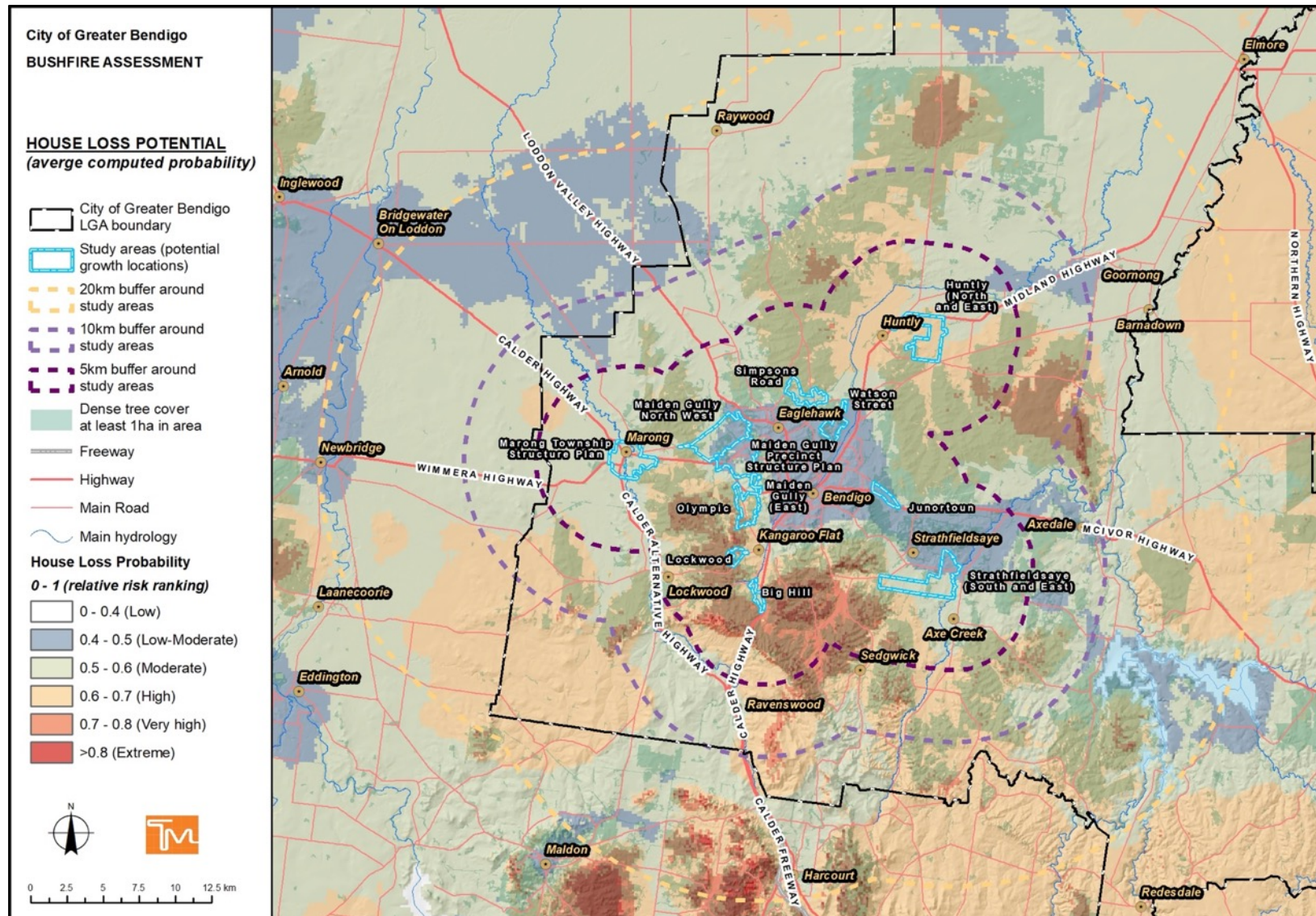
N.B. The house loss is a relative ranking based on modelled bushfire simulations using assumptions about extreme fire weather and fuel conditions. It should not be seen as definitive, rather a comparative risk tool to inform strategic land-use planning at the neighbourhood/ locality scale. It should not be applied at a finer scale to assess individual property risk or for statutory planning purposes.

¹⁶ Ignoring other factors such as house design, materials and maintenance, the type and extent of landscaping around the house and level of defence during the fire.

**Map 5 – Landscape
assessment:
Convective
strength**



**Map 6 – Landscape
assessment:
Modelled house
loss probability**



7.2.4 Ember storm (Drop Zone) potential

Tolhurst defines a ‘Drop Zone’ as an area downwind of the main fire area that is exposed to mass ignition from spotting, leading to firestorm conditions. In the 2009 Black Saturday fires, Strathewen, Narbethong, and Marysville were examples of drop zone locations (Tolhurst, 2014).

The landscape characteristics associated with a drop zone and hence, potentially extreme fire behaviour, are a plateau or ridge 300 m above and within about 5 km of a site, such that significant quantities of embers and firebrands can ‘rain down’ into the drop zone, causing mass ignition of spot fires that can coalesce into a firestorm (Tolhurst, 2014). This type of fire behaviour is described by Badlan *et al.* (2021) as ‘deep flaming’, whereby spot fires from lightning strikes and/or embers coalesce into a sustained, large and intense area of flaming over hundreds of hectares, which can develop into a violent pyroconvective event.

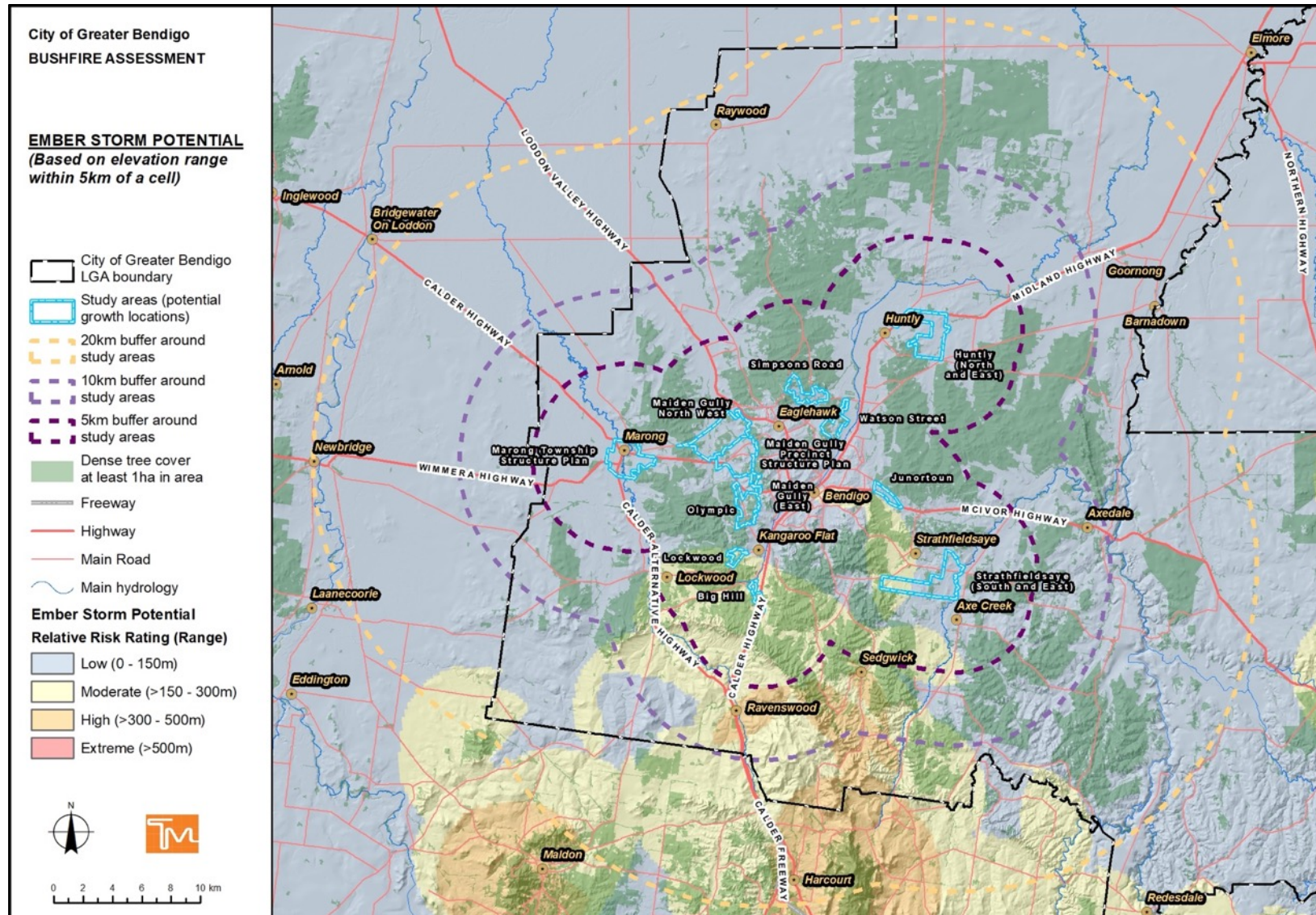
A drop zone is more likely if the higher ground above the site is a forested ridge, since the fire will have accelerated to the top of the ridge, increasing the amount of energy for the ember launch (Tolhurst, 2014). If the ridge or plateau is dominated by shrub, heath or grassland vegetation, it is unlikely that the area downwind will experience a firestorm as these vegetation types do not typically generate significant levels of embers.

Map 7 shows that except for Lockwood and Big Hill PGAs, the western end of Strathfieldsaye and western edge of Junortoun, the potential growth locations are at a low risk of an ‘ember storm’.

Any PGAs with large areas of vegetation with a high proportion of stringybark Eucalypts (e.g. Red Stringybark *Eucalyptus macrohyncha*) in the canopy within 400 m to the west or north-west (directions associated with prevailing winds on days of elevated fire danger, see Wind analysis presented in Section 5.2), are at higher risk of ember attack, as vegetation with a high cover of fine, fibrous barked Eucalypts can pose an extreme bark hazard that is associated with elevated levels of ember attack.

However, analysis of EVCs in Section 8 of this report shows the bark hazard associated with vegetation within, and up to 1 km around all PGAs, is not likely to exceed ‘Very High’ and that stringybark Eucalypts are not a character species of EVCs within 1 km of the PGAs (see Map 7).

**Map 7 – Landscape assessment:
Ember storm (drop zone) potential**



7.3 FFMVic Fire Management Zones

FFMVic have defined Fire Management Zones (FMZs) across areas of largely public land, to protect people and assets by managing fuels to reduce the spread of bushfires and to improve ecosystem resilience (FFMVic, 2023). Four different FMZs exist:

- **‘Asset Protection Zone** - *An area around properties and infrastructure where we intensively manage fuel to provide localised protection to reduce radiant heat and ember attack on life and property in the event of a bushfire. Aim to reduce fuel through planned burning or other methods approximately every 5 to 7 years.*
- **Bushfire Moderation Zone** - *An area around properties and infrastructure where we manage fuel to reduce the speed and intensity of bushfires and to protect nearby assets, particularly from ember attack in the event of a bushfire. Aim to reduce fuel through planned burning or other methods approximately every 8 to 15 years. Length of time between planned burns in some areas can vary due to ecological considerations.*
- **Landscape Management Zone** - *An area where we manage fuel to minimise the impact of major bushfires, to improve ecosystem resilience and for other purposes (such as to regenerate forests and protect water catchments). Planned burning will focus on maintaining and improving ecosystem resilience, and fuel management will also be undertaken for risk reduction.*
- **Prescribed Burning Exclusion Zone** - *An area where we try to avoid planned burning, mainly to protect particular areas that can’t tolerate fire’ (FFMVic, 2023).*

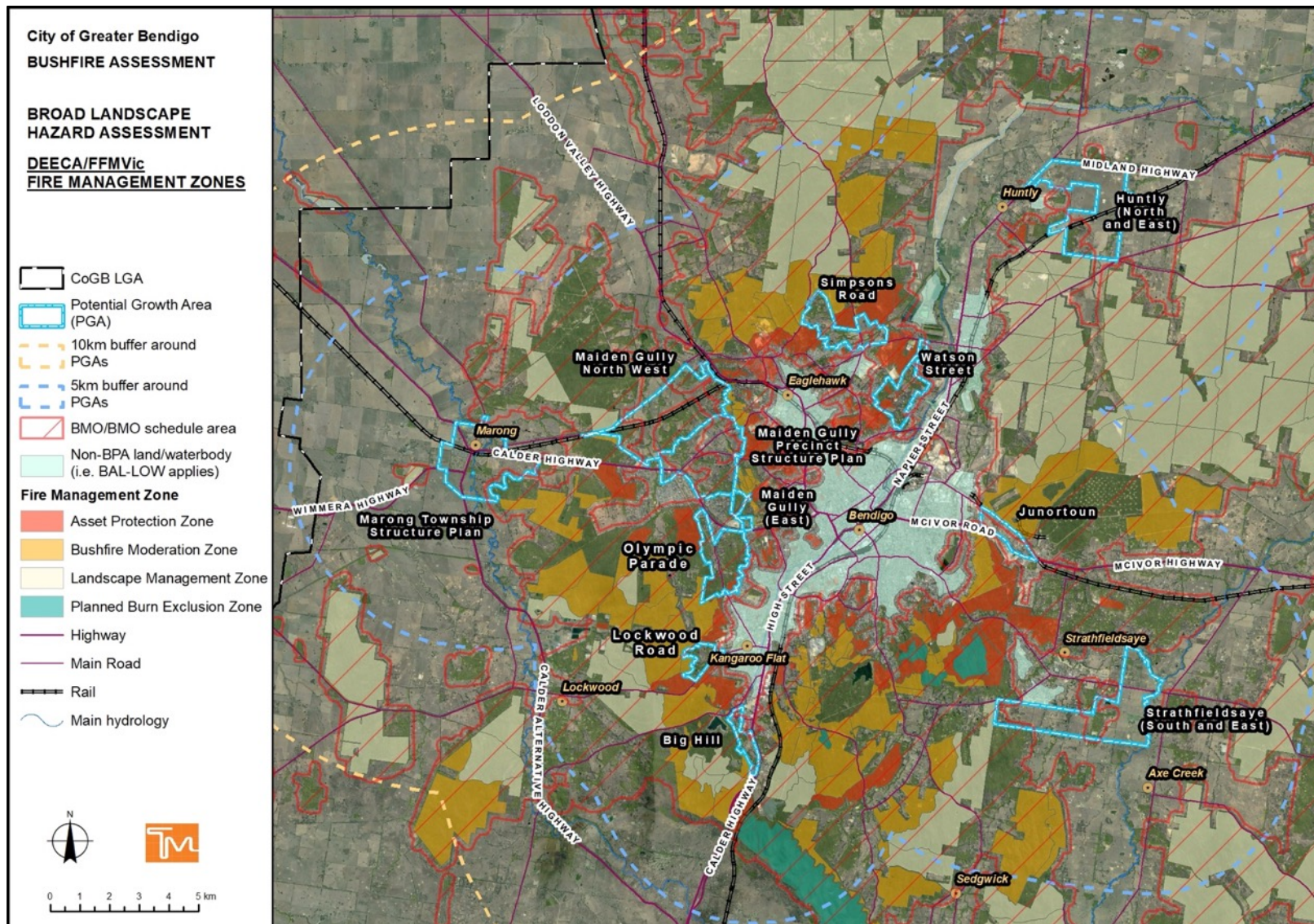
Fuel management in an FMZ may include planned burning, slashing/mowing and clearing works, including creating fuel breaks, with the broad aim of reducing the spread and intensity of bushfires to make suppression more achievable and safer (FFMVic, 2023).

The type and location of FMZs in the land surrounding the site is shown in Map 8. FFMVic states that *‘In areas close to towns, burns are more frequent to protect people and the things they value’*. Large areas of land around populous parts of Bendigo, including in the vicinity of Simpsons Road, Watson Street, Big Hill, Junortoun and Maiden Gully PGAs, are therefore designated as an Asset Protection Zone, the most intensively managed FMZ.

It should be noted that FMZs typically assist to manage bushfire risk at a strategic and landscape or local scale. Whilst they can contribute to moderation of fire behaviour at that broader landscape scale, they cannot be relied upon to mitigate risk at a site scale. Planned burning is also subject to resource and weather constraints in any particular year.

Therefore, public land FMZs and proposed planned burning can contribute to risk mitigation but cannot be relied upon to enable development, or on their own as a protection measure, acceptably mitigate risk on adjacent or nearby areas of private or other public land.

Map 8 – FFMVic Fire Management Zones



7.4 BMO landscape risk typologies

To assist in assessing landscape risk, four 'Broader Landscape Types' (BLTs), representing different landscape risk levels, are described in the technical guide *Planning Applications Bushfire Management Overlay*. These are intended to streamline decision-making, and support more consistent decisions based on the landscape risk (DELWP, 2017).

The four types range from lower risk landscapes, where there is little hazardous vegetation beyond 150 m of a site except grasslands and extreme bushfire behaviour is not credible, to extreme risk landscapes with limited or no evacuation options and where fire behaviour could exceed BMO/AS 3959-2018 presumptions (see Table 4).

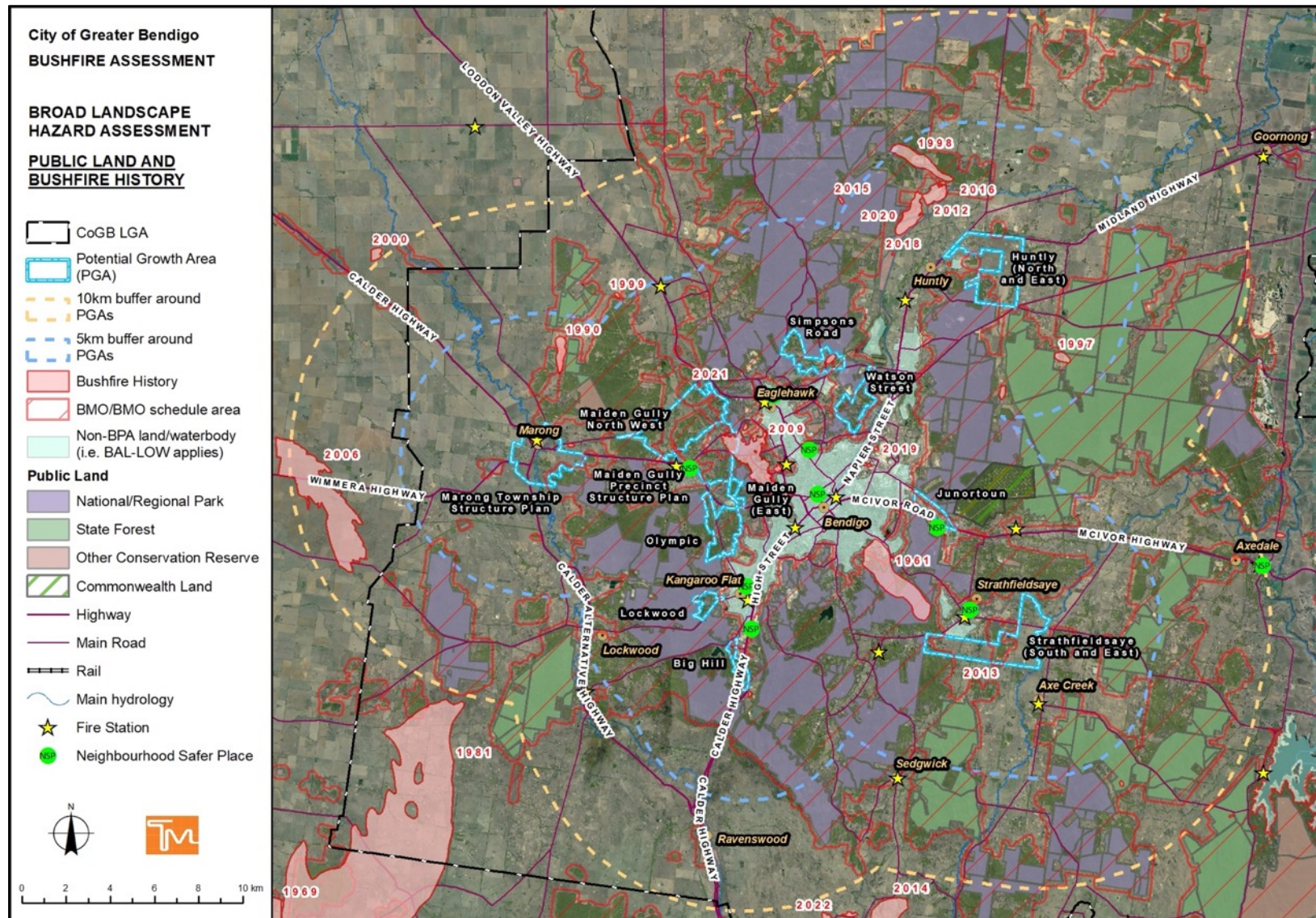
Analysis of the potential for extreme fire behaviour in Section 7.2, indicates that the landscape surrounding the PGAs is not one with affinity to BLT 4.

Overall, it is considered that the landscape around the PGAs is best characterised as Landscape Types 2 or 3, which is typical of BMO landscapes. All locations could, therefore, potentially be exposed to a fully developed bushfire (or grassfire) as envisaged in the BMO/AS 3959 methodology.

Table 4 – BMO landscape risk typologies (from DELWP, 2017)

Broader Landscape Type 1	Broader Landscape Type 2	Broader Landscape Type 3	Broader Landscape Type 4
• There is little vegetation beyond 150 metres of the site (except grasslands and low-threat vegetation). • Extreme bushfire behaviour is not possible. • The type and extent of vegetation is unlikely to result in neighbourhood-scale destruction of property. • Immediate access is available to a place that provides shelter from bushfire	• The type and extent of vegetation located more than 150 metres from the site may result in neighbourhood-scale destruction as it interacts with the bushfire hazard on and close to a site. • Bushfire can only approach from one aspect and the site is located in a suburban, township or urban area managed in a minimum fuel condition. • Access is readily available to a place that provides shelter from bushfire. This will often be the surrounding developed area.	• The type and extent of vegetation located more than 150 metres from the site may result in neighbourhood-scale destruction as it interacts with the bushfire hazard on and close to a site. • Bushfire can approach from more than one aspect. • The site is located in an area that is not managed in a minimum fuel condition. • Access to an appropriate place that provides shelter from bushfire is not certain.	• The broader landscape presents an extreme risk. • Evacuation options are limited or not available. • Fires have hours or days to grow and develop before impacting.
I N C R E A S I N G R I S K 			

**Map 9 – Bushfire
Hazard Landscape
Assessment Plan**



This is evidenced by the fact that all the PGAs have some BMO coverage in and around them, reflecting the proximity of hazardous vegetation and the location of Bendigo as a city surrounded by extensive areas of remnant vegetation in national or regional parks, state forests or other conservation reserves.

Map 9 comprises a Bushfire Hazard Landscape Assessment Plan in accordance with the BMO application requirements. It shows the extent of these public lands and the recorded fire history in the landscape for at least 10 km around the PGAs.

Whilst overall the broader landscape risk, beyond 150 m around the PGAs, has some characteristics of BLT 3, once development occurs, if currently hazardous vegetation is removed and good access to places of relative safety from bushfire is provided, the risk may lessen more towards BLT 2.

It is important to note that the landscape types are broad and subjective, there are no criteria to objectively define them, they represent a spectrum of risk, and the risk to each PGA is not homogenous.

The BLT3 attributes include the likelihood and scale of potential 'neighbourhood destruction' from bushfire, and availability of access to shelter from bushfire, which varies for each PGA according to the:

- Extent and direction of treed remnant vegetation around the PGA

- Proximity of, and ability to easily access, places of relative safety from bushfire i.e. low threat developed/urban areas large enough to provide refuge from bushfire impacts
- Future vegetated state of land within each proposed growth area.

Accordingly, more detailed analysis of the hazard at the local and neighbourhood scales has been undertaken and is presented in Section 8. This includes neighbourhood hazard analysis from which indicative BMO landscape types in the vicinity of the PGAs have been derived (see Map 11).

Likely bushfire scenarios that could threaten each PGA are identified in Section 10.2.2.

8 Local and neighbourhood assessment

8.1 Local hazard identification

The hazard posed by vegetation at the local and neighbourhood scales around the PGAs has been identified based on DEECA modelled Ecological Vegetation Classes (EVCs) mapping. The modelled occurrence of EVCs within and up to 1 km around each PGA is shown on Map 10 and is summarised in Table 5 and Table 6.

The analysis reveals that just over 70% of the land area in and up to 1 km around the PGAs, potentially comprises an EVC. Just over half that area is Box Ironbark Forest, almost a third is Grassy Woodland, and a little less than 10% comprises Plains Woodland. Table 7 shows that the dominant EVCs in and up to 1 km around PGAs are best classified in the AS 3959 Woodland group.

Table 5 - Proportion of EVCs within and up to 1 km around PGAs

Ecological Vegetation Class	Proportion of all EVCs
Box Ironbark Forest	52.3%
Grassy Woodland	30.9%
Plains Woodland	8.3%
Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	3.1%
Creekline Grassy Woodland	2.3%
Heathy Dry Forest	1.9%
Sandstone Ridge Shrubland	0.5%
Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic	0.4%
Grassy Dry Forest	0.2%
Alluvial Terraces Herb-rich Woodland	0.0%

Table 6 - EVC coverage by Bioregion and EVC Group

EVC name by Bioregion and EVC Group	% of total EVC cover
Goldfields	89.6%
Box Ironbark Forests or dry/lower fertility Woodlands	52.0%
Box Ironbark Forest	52.0%
Lower Slopes or Hills Woodlands	28.2%
Grassy Woodland	27.8%
Grassy Woodland/Alluvial Terraces Herb-rich Woodland Mosaic	0.4%
Herb-rich Woodlands	2.8%
Alluvial Terraces Herb-rich Woodland	0.0%
Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	2.8%
Plains Woodlands or Forests	2.7%
Plains Woodland	2.7%
Dry Forests	2.1%
Grassy Dry Forest	0.2%
Heathy Dry Forest	1.9%
Riverine Grassy Woodlands or Forests	1.1%
Creekline Grassy Woodland	1.1%
Mallee	0.5%
Sandstone Ridge Shrubland	0.5%
Victorian Riverina	10.4%
Plains Woodlands or Forests	5.6%
Plains Woodland	5.6%
Lower Slopes or Hills Woodlands	3.2%
Grassy Woodland	3.2%
Riverine Grassy Woodlands or Forests	1.1%
Creekline Grassy Woodland	1.1%
Herb-rich Woodlands	0.3%
Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	0.3%
Box Ironbark Forests or dry/lower fertility Woodlands	0.2%
Box Ironbark Forest	0.2%
Grand Total	100.0%

**Map 10 –
Modelled EVCs in
and up to 1 km
around PGAs**

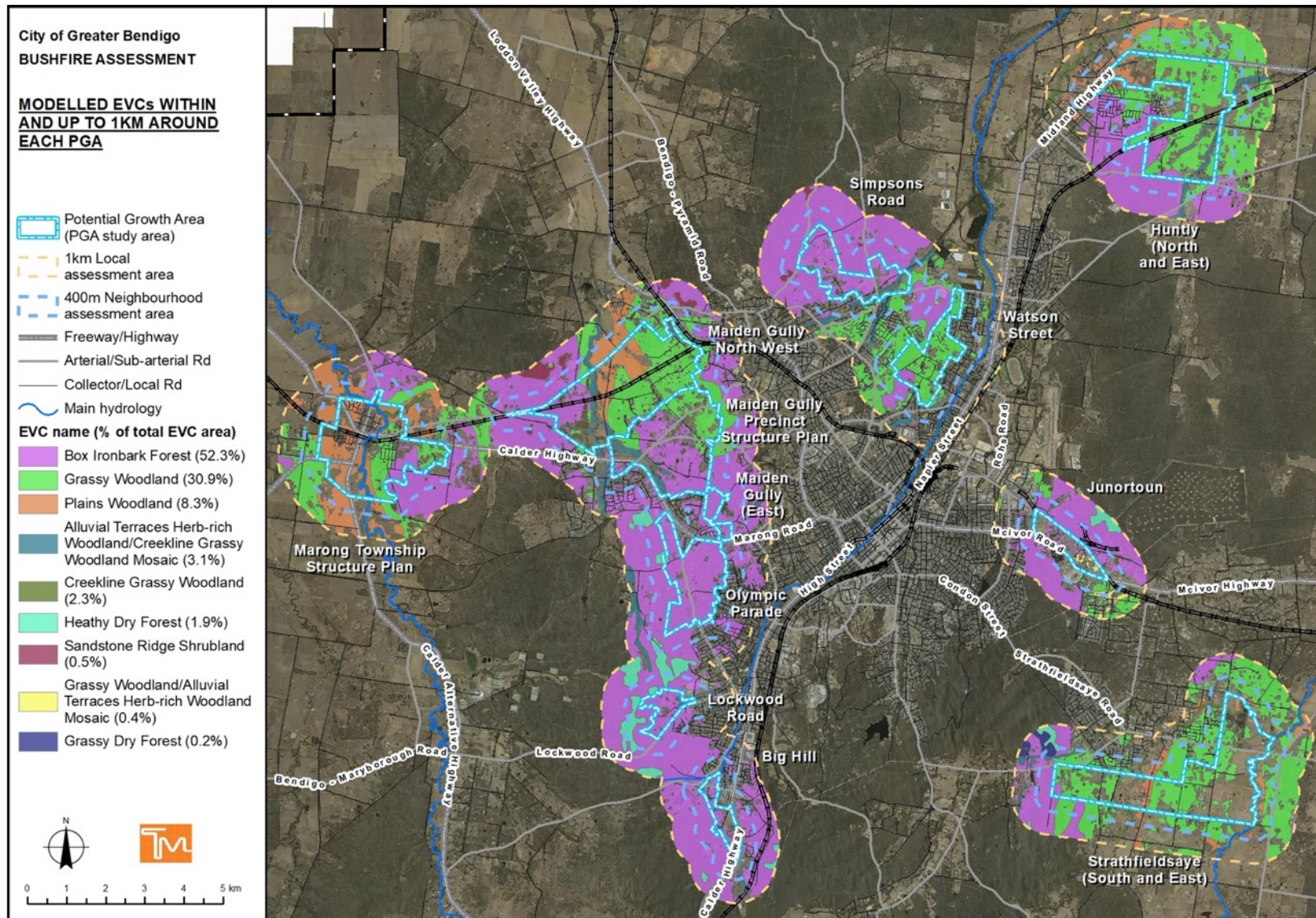


Table 7 – EVC analysis and derived AS 3959 classification from bioregional benchmark information

EVC No., Name (% of total EVC cover)	Bioregional EVC description	% Tree canopy cover & character species	AS 3959-2018 Classification
EVC 61 - Box Ironbark Forest (52.3% of EVC cover within 1 km of PGAs)	Goldfields: 'Occurs in low rainfall areas on gently undulating rises, low hills and peneplains on infertile, often stony soils derived from a range of geologies. The open overstorey to 20 m tall consists of a variety of eucalypts, often including one of the Ironbark species. The mid storey often forms a dense to open small tree or shrub layer over an open ground layer ranging from a sparse to well-developed suite of herbs and grasses' (DSE, 2004a).	30% • Grey Box • Red Ironbark • Red Box • Yellow Gum	Woodland
EVC 175 - Grassy Woodland (30.9% of EVC cover within 1 km of PGAs)	Goldfields: 'A variable open eucalypt woodland to 15 m tall over a diverse ground layer of grasses and herbs. The shrub component is usually diverse but sparse in cover. In the Goldfields bioregion, Grassy Woodland occurs on sedimentary soils on the lowest slopes at the interface between the plains and the infertile woodlands of the sedimentary hills' (DSE, 2004b).	15% • Grey Box • Yellow Gum	Woodland
EVC 803 - Plains Woodland (8.3% of EVC cover within 1 km of PGAs)	Victorian Riverina: 'An open, eucalypt woodland to 15 m tall occurring on a number of geologies and soil types. Occupies fertile clays and clay loam soils on flat or gently undulating plains at low elevations in areas with <600 mm annual rainfall. The understorey consists of a few sparse shrubs over a species-rich grassy and herbaceous ground layer and chenopods are often present' (DSE, 2004c).	15% • Grey Box • Yellow Box • River Red Gum • Black Box • Yellow Gum • Buloke	Woodland
EVC 67 - Alluvial Terraces Herb-rich Woodland (occurs as a mosaic with EVC 68 Creekline Grassy Woodland) (3.1% of EVC cover within 1 km of PGAs)	Goldfields: 'Open woodland to 15 m tall on broad alluvial plains and along ephemeral drainage lines. Soils are generally poorly drained duplex soils with sandy loam overlying a heavier clay subsoil. Understorey consists of few, if any shrubs with the striking feature of this EVC being the high species-richness of the ground-layer and the low biomass of this cover, particularly in summer' (DSE, 2004d).	15% • Grey Box • Yellow Box • Yellow Gum • Buloke	Woodland
EVC 68 - Creekline Grassy Woodland (2.3% of EVC cover within 1 km of PGAs)	Goldfields: 'Eucalypt-dominated woodland to 15 m tall with occasional scattered shrub layer over a mostly grassy/sedgy to herbaceous ground-layer. Occurs on low-gradient ephemeral to intermittent drainage lines, typically on fertile colluvial/alluvial soils, on a wide range of suitably fertile geological substrates. These minor drainage lines can include a range of graminoid and herbaceous species tolerant of waterlogged soils, and are presumed to have sometimes resembled a linear wetland or system of interconnected small ponds' (DSE, 2004e).	15% • River Red Gum • Grey Box • Yellow Box	Woodland
EVC 20 - Heathy Dry Forest (1.9% of EVC cover within 1 km of PGAs)	Goldfields: 'Grows on shallow, rocky skeletal soils on a variety of geologies and on a range of landforms from gently undulating hills to exposed aspects on ridge tops and steep slopes at a range of elevations. The overstorey is a low, open eucalypt forest, poor in form to 20 m tall with an open crown cover. The understorey is dominated by a low, sparse to dense layer of ericoid-leaved shrubs including heaths and peas. Graminoids and grasses are frequently present in the ground layer, but do not provide much cover' (DSE, 2004f).	30% • Red Stringybark • Red Box • Red Ironbark • Bundy	Woodland or Forest

8.2 Proximity to hazard

As identified above, the development setbacks in Clause 13.02-1S and the BMO/AS 3959 model, are based on proximity to hazardous (classified) vegetation to ensure that a BAL outcome (maximum BAL-12.5 for settlement planning) is met, based on RHF exposure thresholds for a building (see Appendix - BALs & RHF for an explanation of BALs and RHF exposure thresholds).

However, it is known that embers, much more than radiant heat, account for the majority of houses lost in bushfires in Australia (Blanchi and Leonard, 2005; DELWP, 2017) and that the density of embers decreases exponentially with distance from vegetation, which correlates with decreasing probability of house damage (Tolhurst & Howlett, 2003).

Proximity to hazardous vegetation has been shown to strongly correlate with house loss/survivability data from major bushfires throughout Australia. Chen and McAneney (2004, 2010) undertook a spatial analysis of building loss in a number of major fires that impacted on peri-urban areas in south-eastern Australia. Based on cumulative data from all the fires, it was found that:

- Approx. 50% of buildings lost were within 20 m of bushland
- Approx. 35% of buildings lost were >20 m to 100 m from bushland
- Approx. 10% of buildings lost were >100 m to 200 m from bushland
- Approx. 5% of buildings lost were located >200 m-700 m from bushland
- No buildings were lost beyond 700 m from bushland.

Other researchers have reported similar findings regarding house loss and the proximity of vegetation (e.g. Crompton *et al.*, 2011; Gibbons *et al.*, 2012; Newnham *et al.* 2012).

Distance to bushland also strongly correlates with statistics for life loss in bushfires. A 2012 CSIRO study of 825 bushfire fatalities in the period 1901-2011, found that over 50% of all fatalities occurred within 10 m of forest, 78% occurred within 30 m and 85% occurred within 100 m. Within buildings, the life loss data showed 95% of fatalities were in buildings within 50 m of forest and 88% were in buildings within 30 m (Blanchi *et al.*, 2012).

George *et al.* (2020) produced more recent cumulative house loss data that included findings from bushfires that occurred in NSW in December 2019-January 2020. Their study reiterated the statistical dependence of house loss data on distance to bushland, but they found the correlation was less significant where ember attack was a major element of the fire behaviour.

Notwithstanding, the results shows that in the nine major Australian bushfires analysed, 95% of all destroyed buildings were within 400 m of bushland in all but one major event, where the 400 m threshold equated to approximately the 93rd percentile.

The findings are shown in Figure 5, with 400 m (the Clause 13.02-1S neighbourhood assessment distance) and 150 m (BMO site assessment distance) indicators added by Terramatrix as dashed lines.

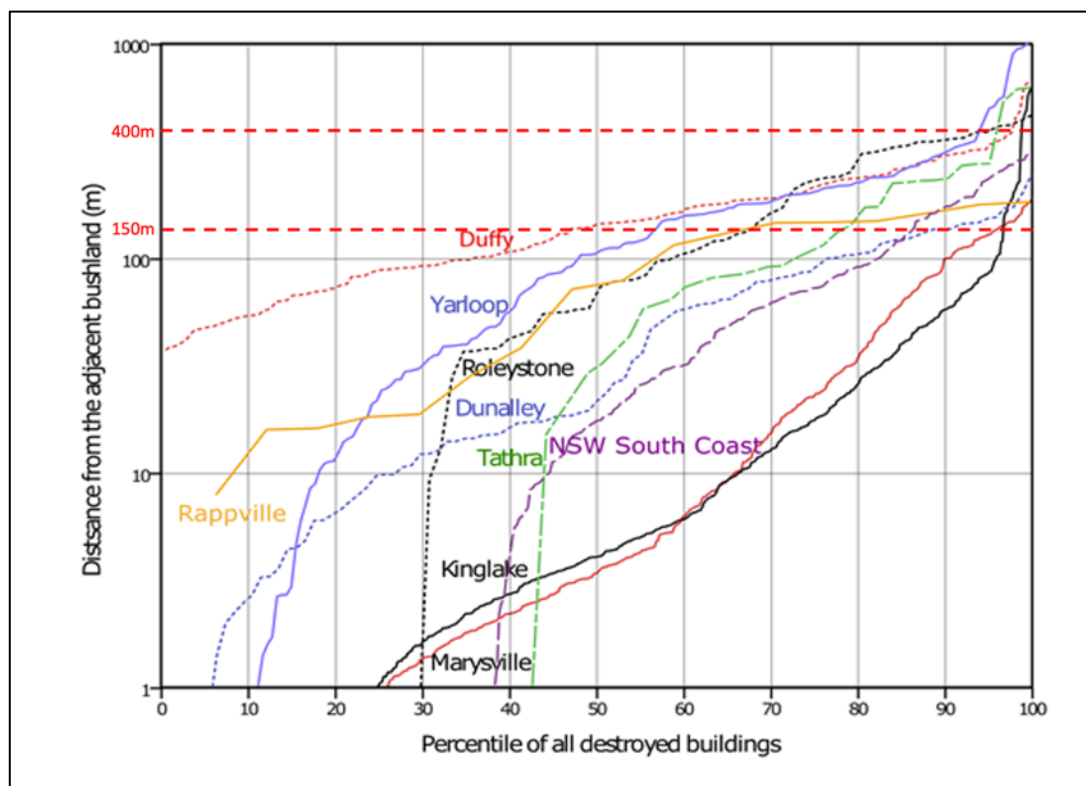


Figure 5 – Percentiles of destroyed buildings and proximity to bushland (from George *et al.*, 2020)

Note that BMO coverage extends 150 m (and in situations where head fire intensity may be extreme, up to 300 m) from the edge of hazardous vegetation. This indicates that beyond 300 m from the BMO coverage, or a forest/bushland edge, acceptable safety is potentially able to be achieved by compliance with the building regulations, as long as the landscape risk is not extreme, i.e. as long as fire weather, fuel and fire behaviour characteristics at the location will not likely exceed

AS3959/BMO presumptions. Note also, that one of the criteria for an area of land to qualify for exclusion from the BPA designation, is that it must be at least 150 m and up to 300 m from areas of classified vegetation, except grassland, more than 2 ha in size (DELWP, 2019).

The distance to hazardous vegetation is, therefore, a useful metric for establishing what constitutes an ‘acceptable risk’ for strategic planning purposes, e.g. if zero house loss is the acceptable risk threshold then no development should occur within at least 1.3 km of bushland based on South Coast NSW house loss survey data of 426 properties (George *et al.*, 2020). This is considered overly precautionary as the data shows approximately 95% of house losses are within 400 m.

It should be noted, however, that the house loss findings are based on historical data that does not take into account other factors such as house-to-house ignitions; house design, maintenance and construction; landscaping around a house; or brigade/householder intervention.

The statistics also do not consider the composition, minimum size or shape, an area of vegetation needs to be to pose a hazard based on its proximity to an asset. Further, the data is based on large Forest fires and do not necessarily reflect Grassland/Open Woodland bushfire impacts.

8.3 Neighbourhood hazard exposure

Terramatrix has analysed the neighbourhood hazard exposure to determine the relative risk (% exposure) of all parts of the PGAs to hazardous vegetation (defined as areas of dense treed vegetation as identified in bushfire hazard site assessments (see Section 9.1)).

The analysis identifies the cumulative extent of potentially hazardous treed vegetation that occurs within 400 m to the north, north-west and west (based on these being higher threat directions), and 150 m in other

directions, for each 30 m x 30 m cell, created as a grid across the CoGB LGA. Therefore, the assessment considers the area of exposure, not just the proximity, within defined radii around all parts of the study area and surrounding land.

This cell (raster)-based GIS analysis technique is based on the method of Beverley *et al.* (2010, 2020). The method indicates the spatial pattern of areas with elevated exposure, which reflects not only the amount of hazardous fuel that occurs in an area, but also the size and arrangement of fuel patches (Beverly, 2010). In Canada, Beverly (2020) found the exposure analysis correlated well with historical fire frequency data and provided a rating of the potential for fire transmission to a location given surrounding fuel composition and configuration, irrespective of weather or other fire controls.

A raster of the CoGB LGA and 400 m area around it was created with a 30 m x 30 m cell size. Using statistical analysis tools in ArcGIS, the *area of hazard* within 150 m and 400 m around every cell was calculated and reported back to the subject cell, and then ranked as a percentage of total possible exposure, i.e. if 100% of cells within 150 m and 400 m of a cell contains hazardous treed vegetation, then that cell has a 100% hazard exposure rating, or if a cell has a hazard exposure rating of 50%, then 50% of the land area around that cell is covered by hazardous vegetation.

The results for the landscape around each PGA are shown in Map 11 with the relative risk rankings and derived BLTs. The risk rankings, nomenclature and derived broad landscape types are subjective, but are based on the natural breaks (Jenks) data classification method.

Figure 6 provides a comparative analysis of the hazard exposure for each PGA. It shows the percentage of land area within each PGA that has 'Nil' exposure or is in the 'Low' exposure class, i.e. '>0-13%' of its land area exposed to hazardous treed vegetation (see Map 11).

As shown in Map 11, the analysis of the least risk classes correlates well with BPA coverage and Clause 13.02-1S analysis of potential 'low risk' areas in each PGA where BAL-12.5 development could occur, i.e. RHF is calculated to not exceed 12.5 kW/m² (see following Section 10.2).

The mapping of the higher risk classes also correlates well with BMO coverage¹⁷ and potentially indicates areas which may be more, or less, suitable for BMO schedules.

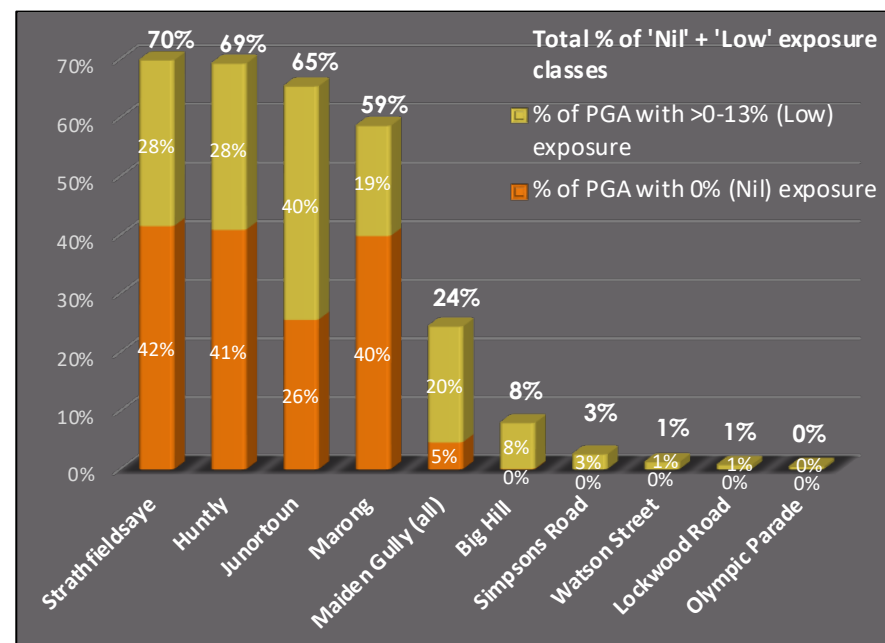
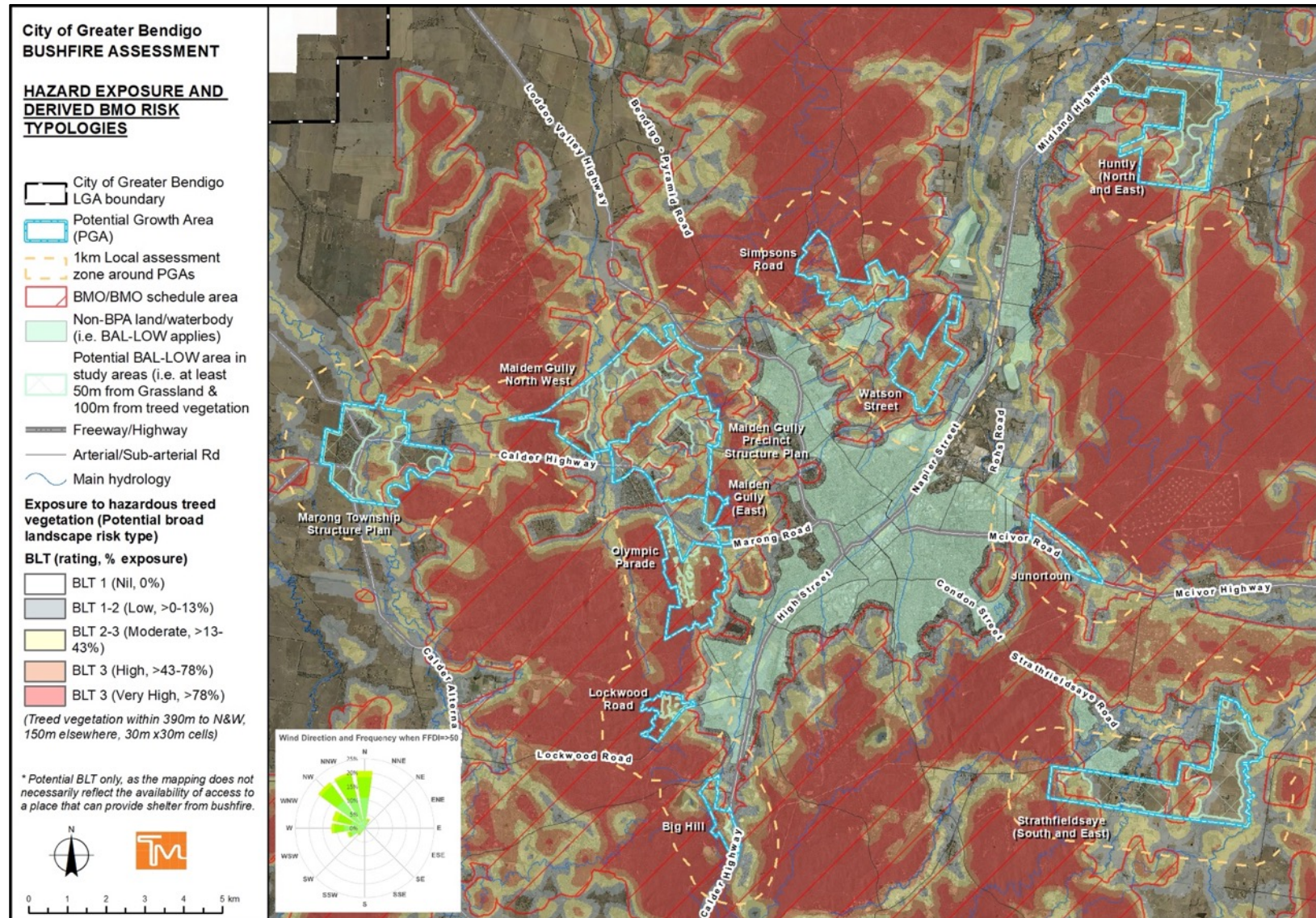


Figure 6 – Comparative hazard exposure of each PGA, showing the proportion of land within each PGA in the two lowest hazard exposure classes¹⁸

¹⁷ Note in the mapping, that the analysis effectively weights exposure to a hazard to the north and west of a location more highly, whereas the BMO coverage assumes equal risk from all directions.

¹⁸ Therefore, generally the comparative ranking is from PGAs with least exposure to hazardous treed vegetation at the left of the chart, to PGAs with higher exposure at the right.

Map 11 – Hazard exposure analysis and derived BMO landscape types



9 Site assessment

9.1 Vegetation

Vegetation within the 150 m assessment zone around the PGAs has been classified in accordance with the BMO/AS 3959 methodology, to identify the hazard at the site scale and the potential of PGAs to meet key settlement planning safety thresholds in Clause 13.02-1S *Bushfire Planning*. Specifically, the extent of areas that are likely to be able to support BAL-12.5 development (i.e. where RHF is anticipated to not exceed 12.5 kW/m²) and those areas that could be defined as BAL-LOW.

These safety thresholds are policy tests for settlement planning. Clause 13.02-1S directs population growth and development to ‘low risk locations’, defined as ‘...locations assessed as having a radiant heat flux of less than 12.5 kilowatts/square metre under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas...’ (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

The second key policy test for settlement planning at Clause 13.02-1S is ‘Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire’ (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

See analysis for these strategies that is presented in Section 12 and Maps 22-30.

Classified vegetation is vegetation that is deemed hazardous from a bushfire perspective. The vegetation classification system is not directly analogous to Ecological Vegetation Classes (EVCs) but uses a generalised description of vegetation based on the Australian Natural Resources Atlas: No. 7 - Native Vegetation (AUSLIG) classification system. The classification is largely based on the structural characteristics of the vegetation at maturity, but the key determinant should be the likely fire behaviour that it will generate.

9.1.1 Woodland

Areas of remnant treed vegetation, where the overall foliage cover is greater than 10%, are considered to accord best with the AS 3959/BMO ‘Woodland’ vegetation group, for which the typical characteristics are: ‘Trees to 30 m high; 10%–30% foliage cover dominated by eucalypts and/or callitris with a prominent grassy understorey. May contain isolated shrubs’ (Standards Australia, 2020).

Most of the areas of Woodland looked at during site visits had a shrubby rather than grassy understorey. However, Box-Ironbark vegetation is typically assigned to the Woodland group (Douglas, 2011; Douglas *et al.*, 2014), and the analysis of EVCs in Section 8 and Table 7 shows a

Woodland classification is more appropriate than a higher hazard Forest classification.

Note that the AS 3959/BMO methodology presumes that Woodland has a total fuel load of 25 t/ha and an understorey fuel load of 15 t/ha, whilst the higher hazard Forest group is presumed to have a total fuel load of 35 t/ha and an understorey fuel load of 25 t/ha (Standards Australia, 2020).

The fuel loads typically found in Box-Ironbark Forest are more commensurate with Woodland than with Forest.

The Woodland is identified as areas¹⁹ of ‘Potentially hazardous treed vegetation’ within and beyond the 150 m assessment area around each PGA.

9.1.2 Grassland

Areas of grassy vegetation with no canopy cover, or open grassy woodland areas with overstorey foliage cover of less than 10%, are classifiable in the Grassland group of AS 3959-2018, which is defined as *‘All forms (of vegetation) (except tussock moorlands) including areas with shrubs and trees, if the overstorey foliage cover is less than 10%. Includes pasture and cropland’* (Standards Australia, 2020).

¹⁹ These areas were delineated across the CoGB LGA and 1 km around it, from spatial data obtained from the Victorian DataShare portal. The key spatial layer used was the Vicmap Vegetation Tree Extent dataset, which is generalised to 2 m pixels with clustering rules applied to group the data into three density classes, being Dense, Medium, and Sparse. It shows the spatial separation of woody vegetation >2 m tall, with pixels allocated a density

Grassland vegetation is considered hazardous, and therefore classifiable, when it is unmanaged i.e. more than 100 mm tall. Grassland areas are assumed to be unmanaged and classifiable unless there is ‘reasonable assurance’ that they will be managed in perpetuity, in a low threat state, no more than 100 mm high.

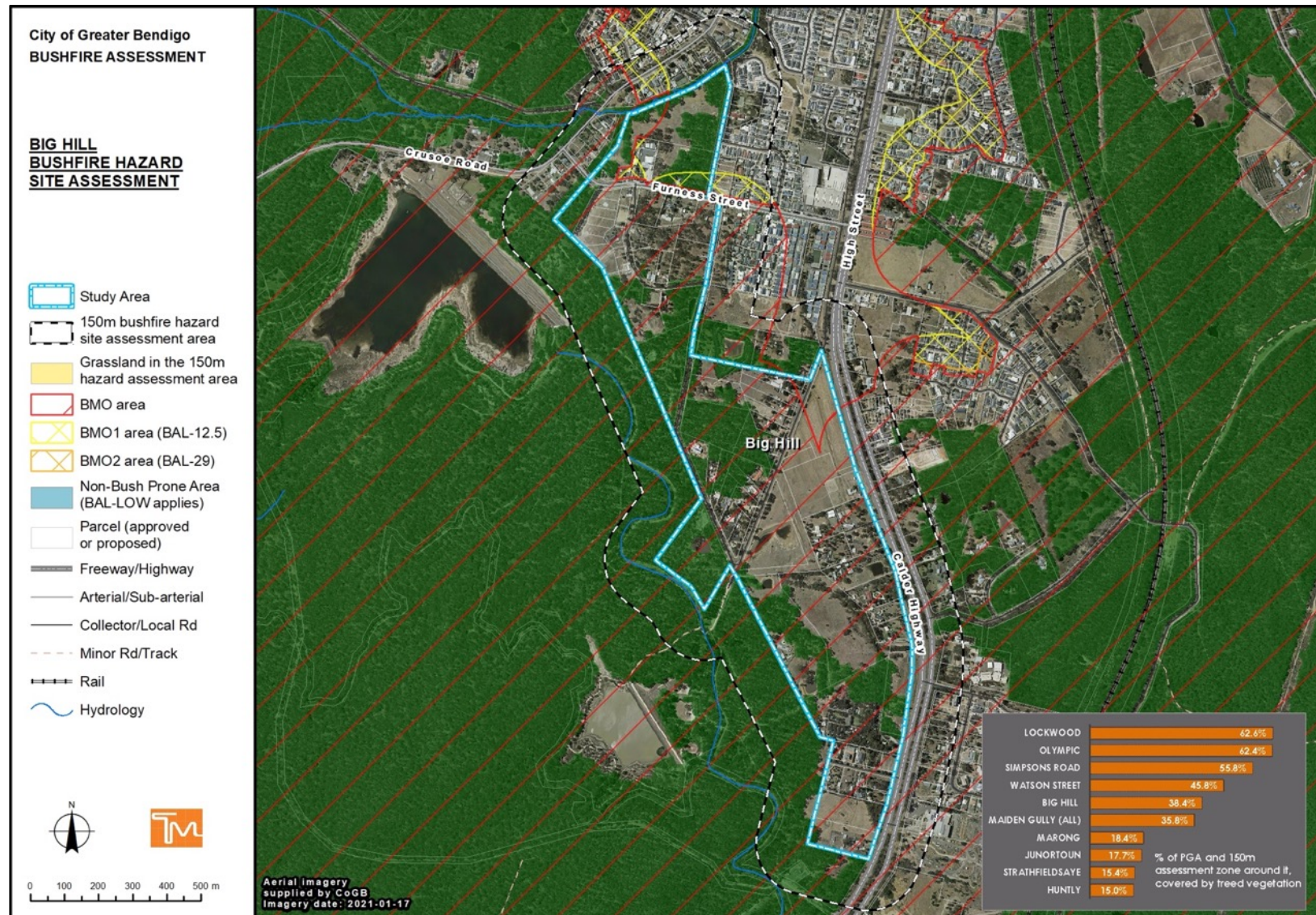
Areas within the 150 m assessment zones around the PGAs that are potentially classifiable as Grassland are shown in the Bushfire Hazard Site Assessment Plans²⁰ provided as Maps 12 - 20.

Note that Grassland areas were mapped from CoGB supplied aerial imagery and are shown between the PGA boundaries and the 150 m assessment zone. It is assumed most, or all, of the open Grassland areas *within* the PGAs, would become non-vegetated or low threat under a growth scenario and therefore no classified grassland within the PGAs is shown.

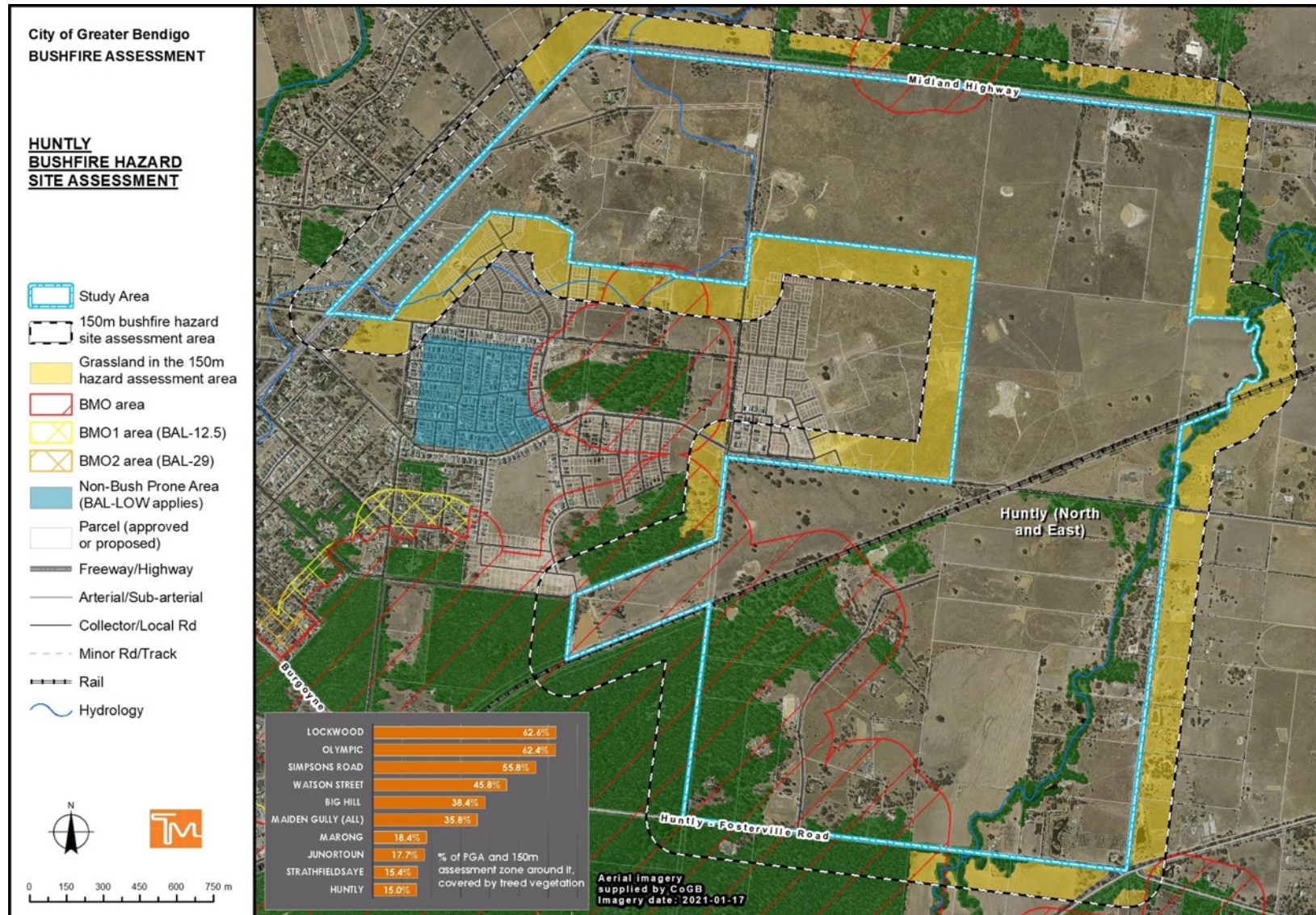
classification based on neighbouring pixels (DELWP, 2021). The Dense tree class most closely represented Woodland or Forest tree cover, and within at least 1 km around PGAs it was manually edited to best accord with aerial imagery and site assessments.

²⁰ As per a BMO application requirement at Clause 44.06-3.

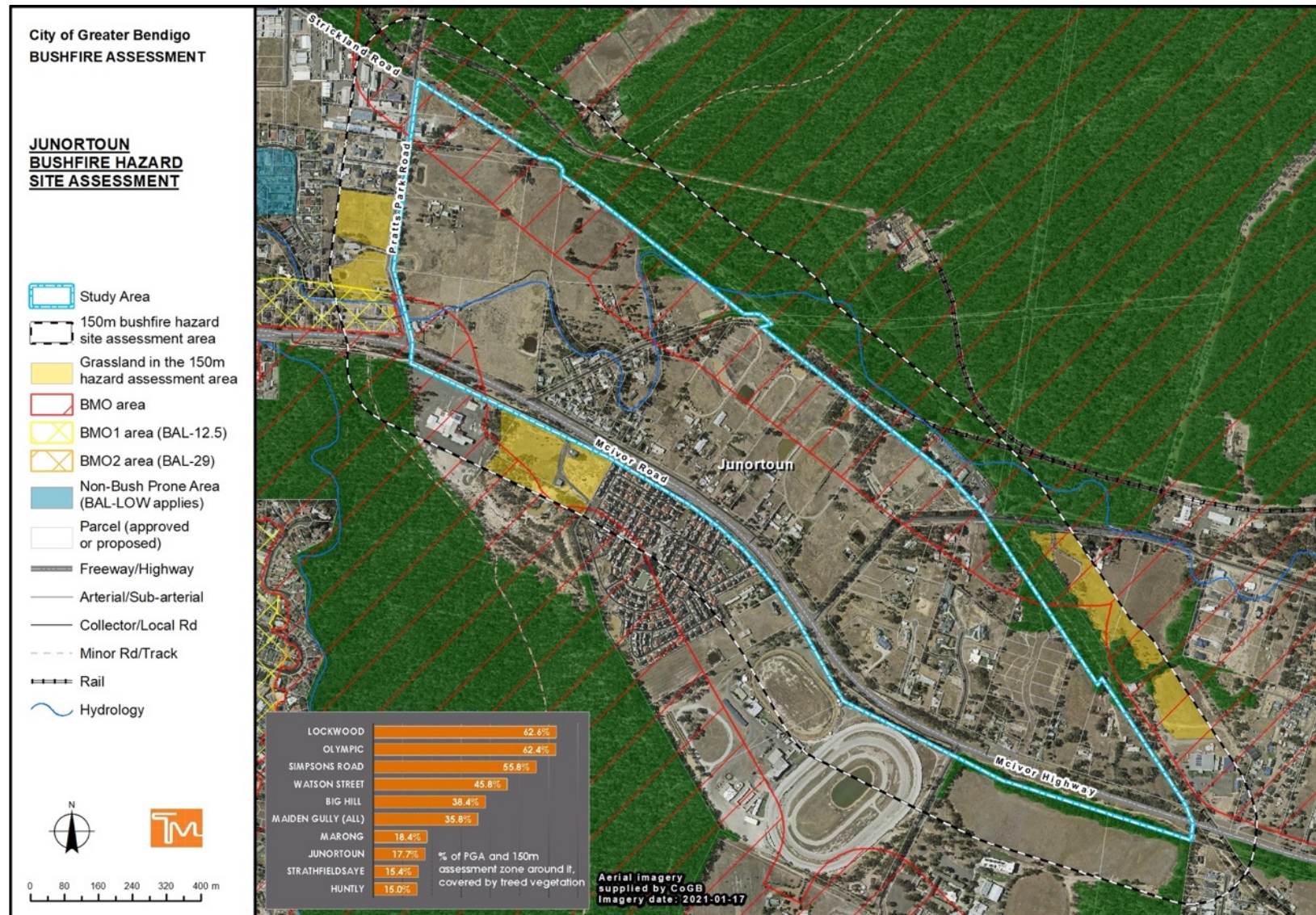
**Map 12 – Big Hill
Bushfire Hazard
Site Assessment
Plan**



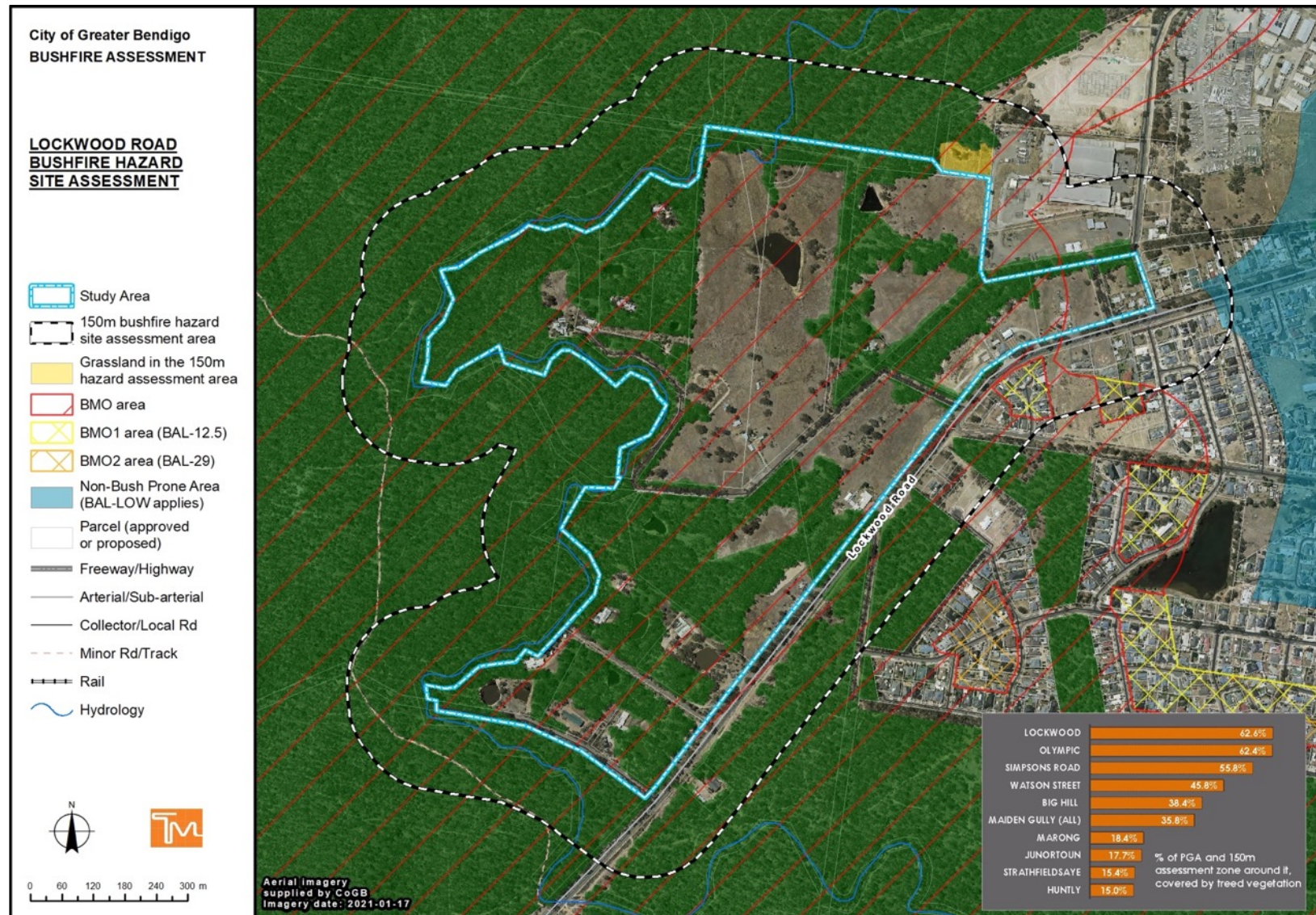
**Map 13 – Huntly
Bushfire Hazard
Site Assessment
Plan**



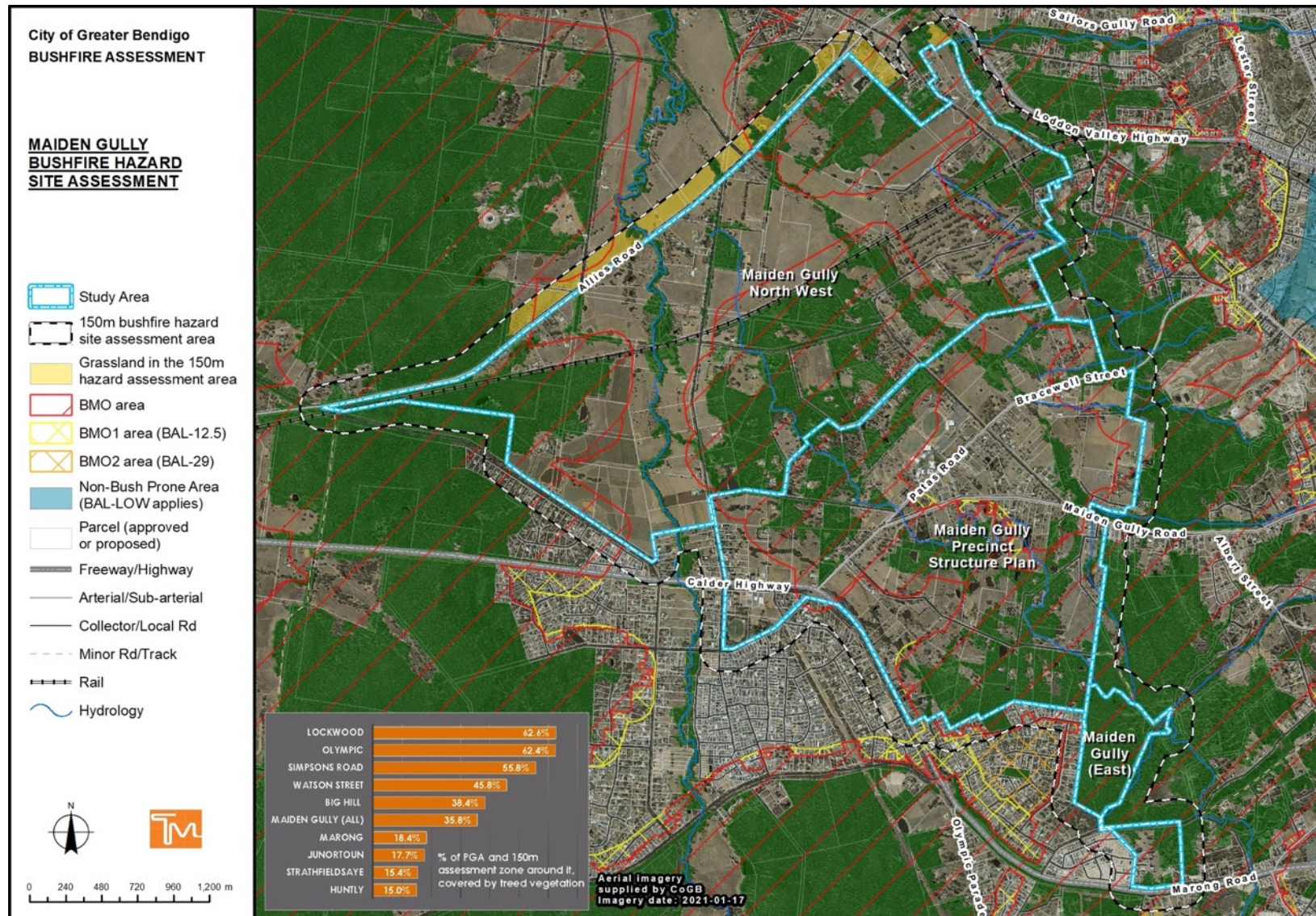
**Map 14 –
Junortoun Bushfire
Hazard Site
Assessment Plan**



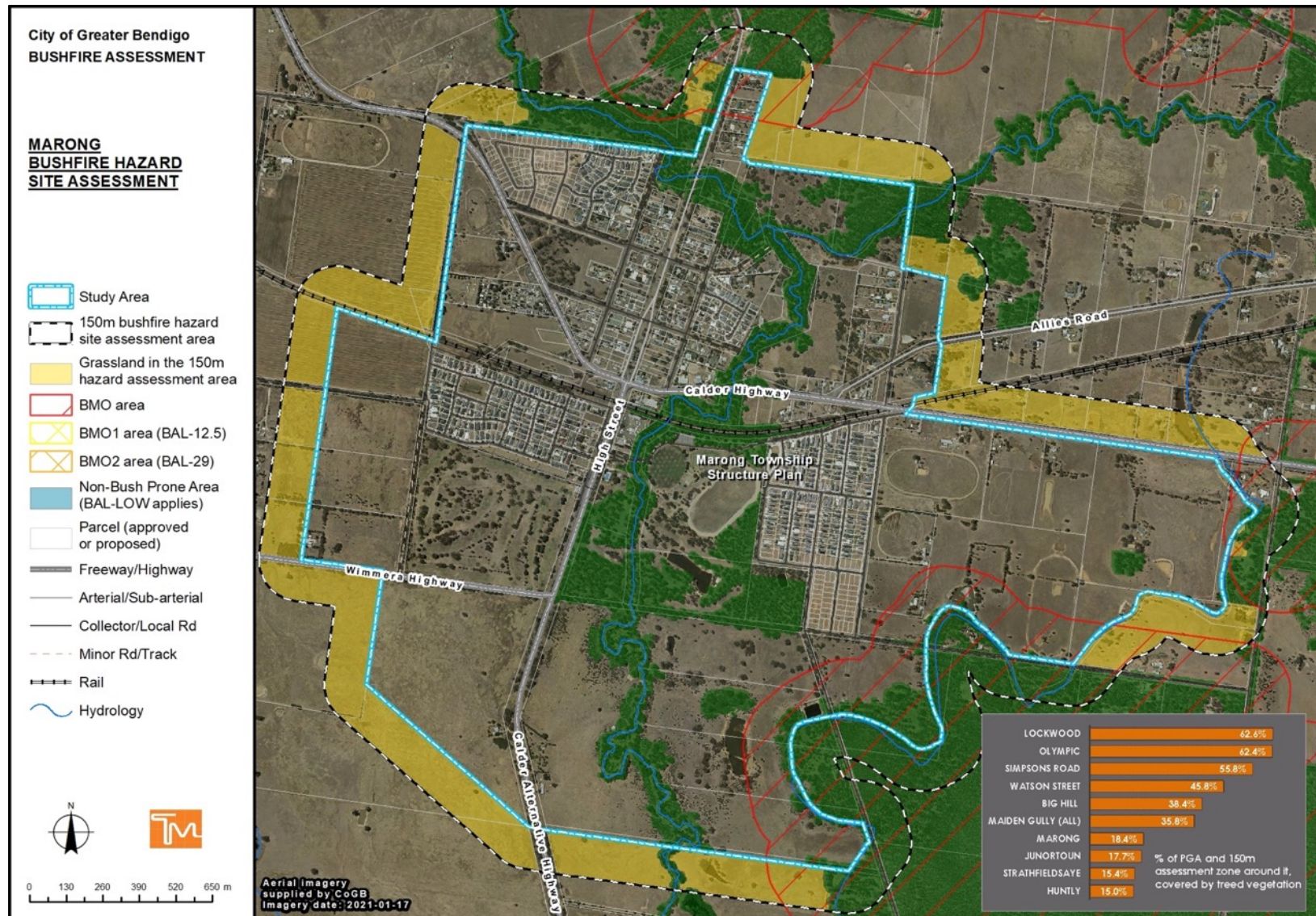
**Map 15 –
Lockwood Bushfire
Hazard Site
Assessment Plan**



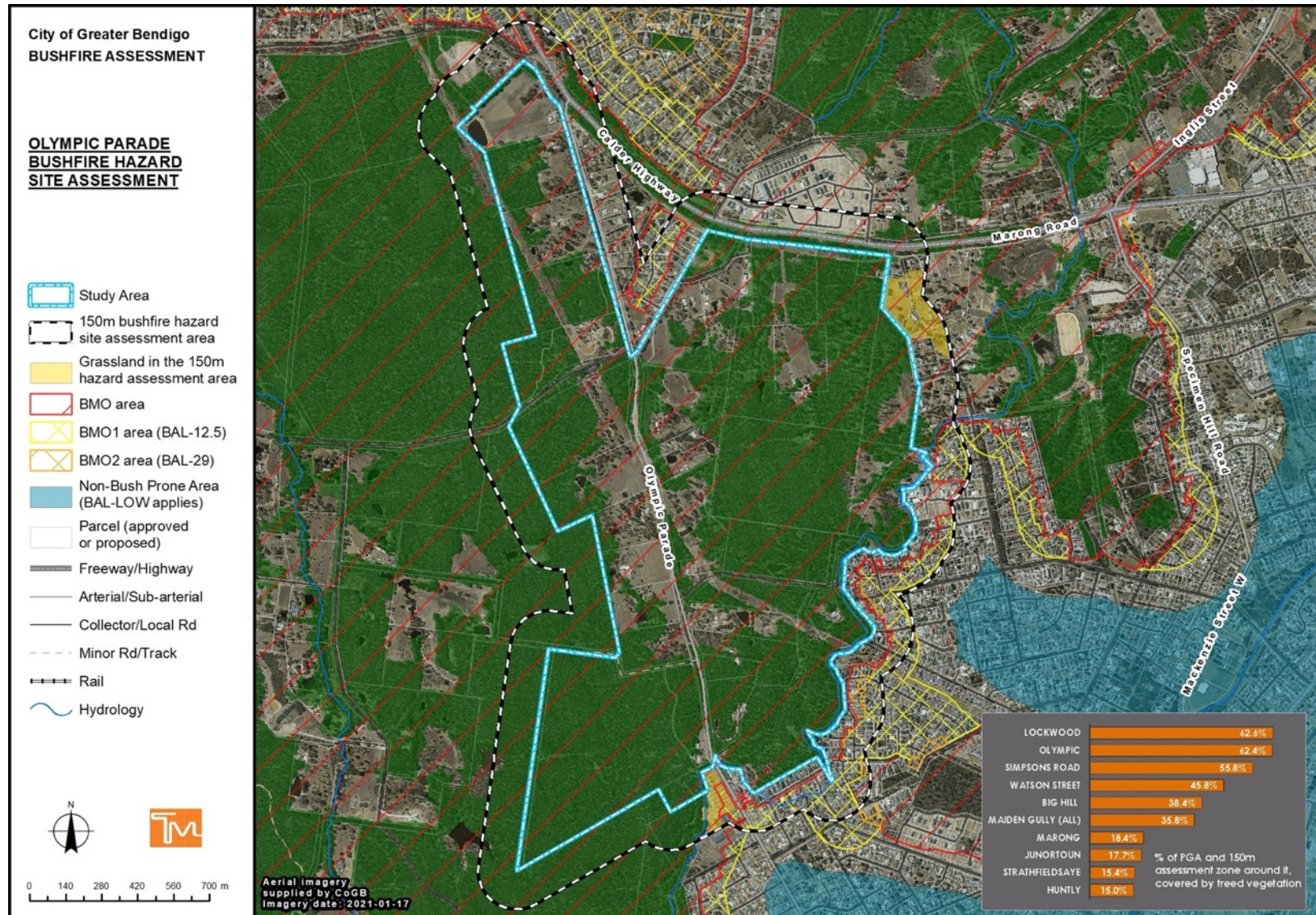
Map 16 – Maiden Gully Bushfire Hazard Site Assessment Plan



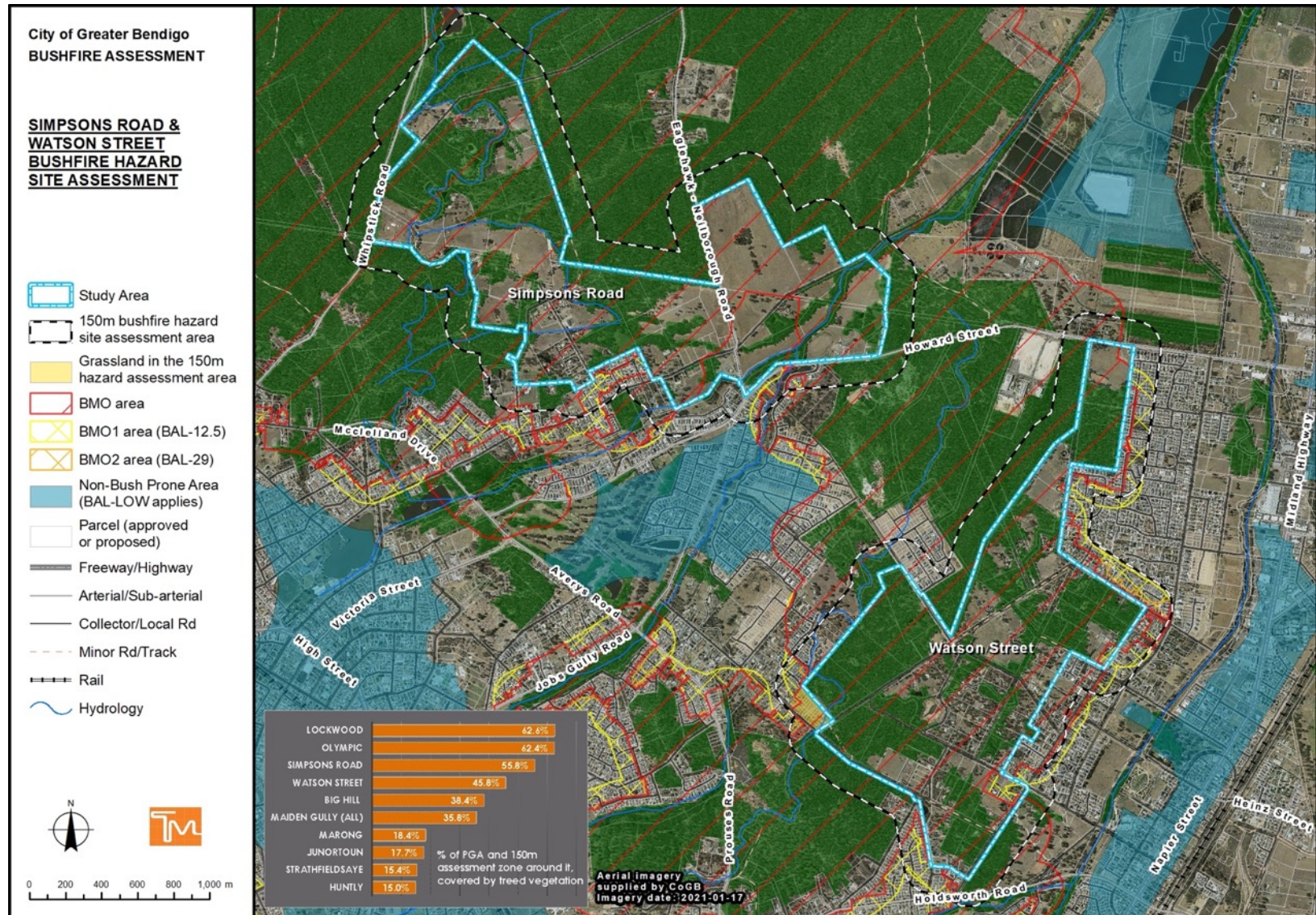
**Map 17 – Marong
Bushfire Hazard
Site Assessment
Plan**



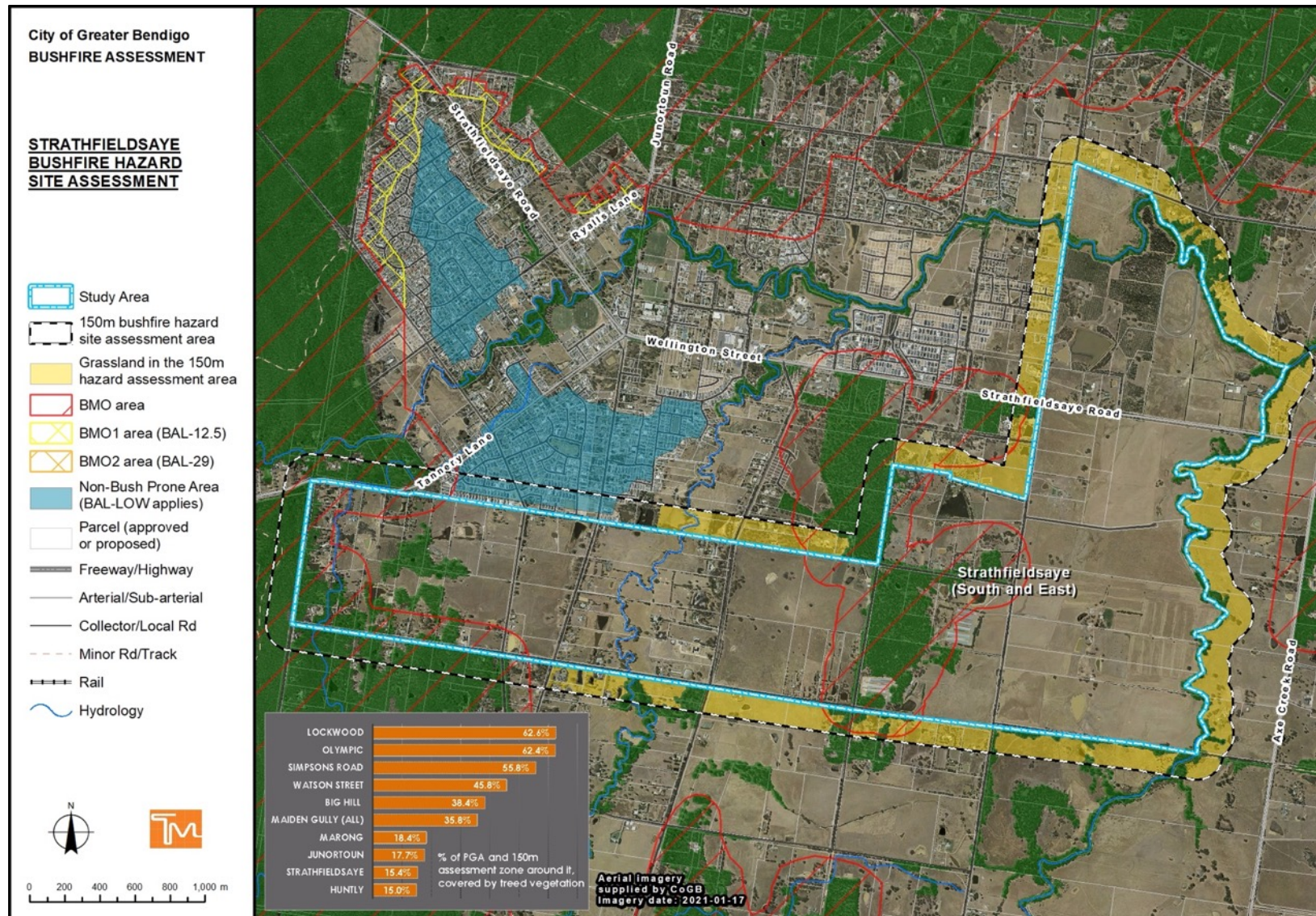
**Map 18 – Olympic
Bushfire Hazard
Site Assessment
Plan**



**Map 19 –
Simpsons Rd and
Watson St Bushfire
Hazard Site
Assessment Plan**



**Map 20 –
Strathfieldsaye
Bushfire Hazard
Site Assessment
Plan**



9.2 Excluded vegetation and non-vegetated areas

Areas of low threat vegetation and non-vegetated areas can be excluded from classification and be deemed non-hazardous in accordance with Section 2.2.3.2 of AS 3959-2018, if they meet one or more of the following criteria:

- (a) *‘Vegetation of any type that is more than 100 m²¹ from the site.*
- (b) *Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified vegetation.*
- (c) *Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified vegetation.*
- (d) *Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified vegetation.*
- (e) *Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.*
- (f) *Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops),*

cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTES:

- 1 *Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).*
- 2 *A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees' (Standards Australia, 2020).*

All areas not shown as Woodland or Grassland in the BHSA maps are likely either low threat or non-vegetated.

²¹ 150 m in BMO areas.

10 Risk analysis

10.1 FFMVic analysis

To inform the strategic growth planning being undertaken by CoGB, Forest Fire Management Victoria (FFMVic) undertook spatial mapping of bushfire risk across the LGA (FFMVic, 2022).

The mapping, and advice that accompanied it, is based on the spatial extent of vegetation and the fuel hazard it potentially poses. Therefore, it correlates with the pattern of BMO coverage in the LGA but is 'significantly more conservative' than the BMO, based on the following rationale/criteria underpinning the mapping.

Box–Ironbark Forest EVC

- *'Buffered out to 500 m in areas east of this vegetation type. Consistent with the BMO.*
- *Buffered out to 150 m in areas west of this vegetation type.*
- *Explanation: no particularly heavy ember shedding tree species in this vegetation type.*
- *Red Stringybark is assumed to be <20% of tree cover in these areas' (FFMVic, 2022).*

Heathy Dry Forest EVC

- *'Buffer out to 1000 m areas east of this vegetation type.*
- *Buffer out to 150 m areas west of this vegetation type.*

- *Assumption for this vegetation type is that Red Stringybark (*Eucalyptus macrorhyncha*) is assumed to be >50% canopy cover.*
- *Explanation: this is due to the potential for heavy/dense ember showers coming from Red Stringybark trees that are a dominant part of this forest type' (FFMVic, 2022).*

N.B. the Box Ironbark Forest EVC comprises approximately half of the total area of EVCs within and up to 1 km around the PGAs, whereas Heathy Dry Forest EVC comprises less than 2% of the total EVC area within 1 km and this EVC only occurs in proximity to the Lockwood Road, Olympic Parade, and to a lesser extent, Big Hill PGAs (see Map 10).

For areas where dwellings could be located on a slope/hill above forest with a slope greater than 10°, a buffer of 1 km from the forest applies (FFMVic, 2022).

The following three resultant classes of bushfire risk are defined in the mapping:

1. ***'High Bushfire Risk –public land interface (unmanageable):*** *Areas surrounding public land native vegetation. These areas fall within the BMO and/or the buffer according to perceived bushfire risk. Dense housing settlements are not recommended for these areas*

as it is considered that bushfire risk is difficult to effectively mitigate in these areas.

2. **High Bushfire Risk – private land interface (may be manageable):** Areas surrounding private land native vegetation. Bushfire risk is considered similar in these areas as for public land and so dense housing settlements would only be suitable if the fuels from this vegetation could be managed. Potential for management of bushfire fuels represented by this vegetation is not known at this time and consequently, risk represented by this vegetation is considered the same as for public land without any mitigation.
3. **Moderate Bushfire Risk – private land not forested:** Bushfire risk in these areas is considered moderate (as for grasslands and scattered trees with little understorey) and manageable. Therefore, with appropriate adherence to planning requirements dwellings are likely to be able to easily achieve the BAL 12.5 requirement' (FFMVic, 2022).

The mapping of these three risk classes within and at least 5 km around the PGAs is shown in Map 21. Overlaid on the mapping is the regional house loss risk modelling that was undertaken for the Loddon Mallee Bushfire Management Strategy (DELWP, 2020b), as discussed in Section 3.1 of this report.

Table 8 - Percentage of PGA land area in each FFMVic risk class

Potential Growth Area	% Freehold High Risk Land	% Freehold Moderate Risk Land	% Public High Risk Land
Marong	7.7%	91.9%	0.3%
Huntly	14.3%	69.4%	16.3%
Strathfieldsaye	25.0%	69.0%	6.0%
Maiden Gully (all)	78.2%	9.4%	12.4%
Big Hill	14.6%	1.6%	83.7%
Simpsons Road	3.2%	0.0%	96.8%
Olympic	5.4%	0.0%	94.5%
Junortoun	7.1%	0.0%	92.9%
Watson Street	15.1%	0.0%	84.9%
Lockwood	0.0%	0.0%	100.0%

The percentage of PGA land area in each of the three FFMVic risk classes as shown in Map 21, is presented in Table 8. The data is sorted according to the PGA with the largest area of land in the least risk class (i.e. Freehold Moderate Risk), giving a 'comparative risk indicator' for each PGA. Therefore, generally the comparative risk ranking is from lesser risk PGAs at the top of the table to higher risk PGAs at the bottom of the table.

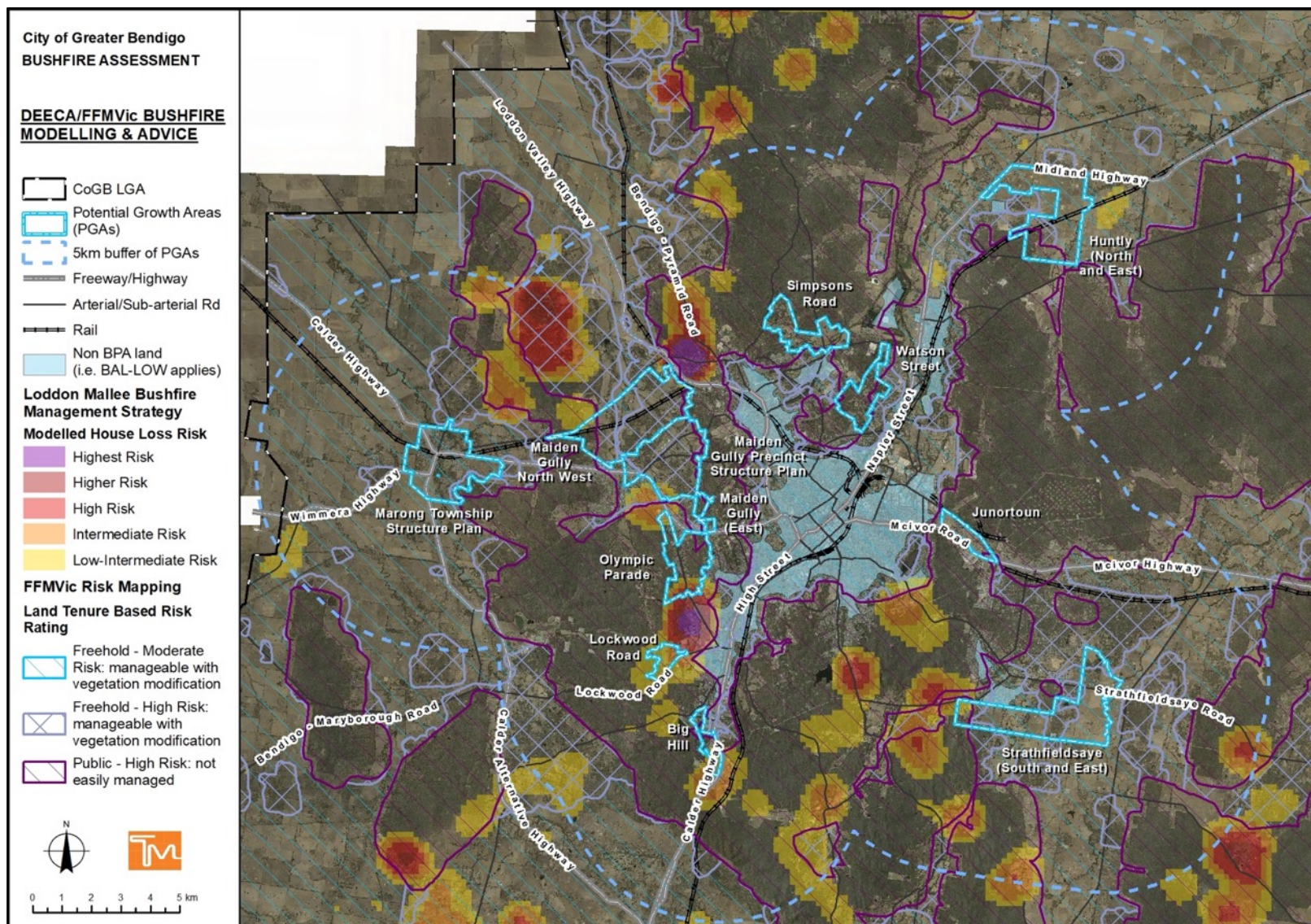
Accordingly, Marong PGA, with the highest proportion of its total land area in the least risk class (Moderate Risk Freehold Land), has the least comparative risk. Conversely, it also has the lowest proportion of its total land area in the highest risk class (High Risk Public Land).

Hence, according to the FFMVic risk classes, Marong, Huntly and Strathfieldsaye are lesser risk PGAs; and Big Hill, Olympic Parade, Lockwood Road, Watson Street, Junortoun and Simpsons Road are all higher risk PGAs, all with over 80% of their land area in the highest risk 'High Risk Public Land' class.

The Maiden Gully PGAs as a group, have the highest (almost 80%) proportion of land area in the high risk freehold land class. Accordingly, the ability of development in the Maiden Gully precincts to mitigate risk, is significantly influenced by the extent to which vegetation on private land can be removed and/or managed in a low threat state in perpetuity.

Note, the FFMVic mapping and modelling is not definitive, e.g. some areas of land not designated as a BPA are shown as high risk public land areas with a high probability of house loss. Rather, they should be seen as one of several useful indicators of comparative (relative) risk.

**Map 21 –
DEECA/FFMVic risk
modelling**



10.2 Clause 13.02-1S Bushfire Planning analysis

10.2.1 BAL safety thresholds

An assessment has been undertaken of the ability of each PGA to meet key settlement planning safety thresholds for BAL and RHF exposure based on development setbacks from hazardous vegetation.

The safety thresholds the analysis is based on are defined in the following key settlement planning strategies:

- *‘Directing population growth and development to low risk locations, being those locations assessed as having a radiant heat flux of less than²² 12.5 kilowatts/square metre under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018).*
- *Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire.*
- *Not approving any strategic planning document, local planning policy, or planning scheme amendment that will result in the introduction or intensification of development in an area that has, or will on completion have, more than a BAL-12.5 rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018)’ (Greater Bendigo Planning Scheme, Cl. 13.02-1S).*

²² Note that this strategy is to ensure RHF is less than 12.5 kW/m² (author’s emphasis). The third strategy above stipulates a maximum BAL-12.5 construction standard (which requires that RHF not exceed 12.5 kW/m²). It is assumed the intent of both strategies is to

The results are shown in Maps 22 - 30 as the following two layers:

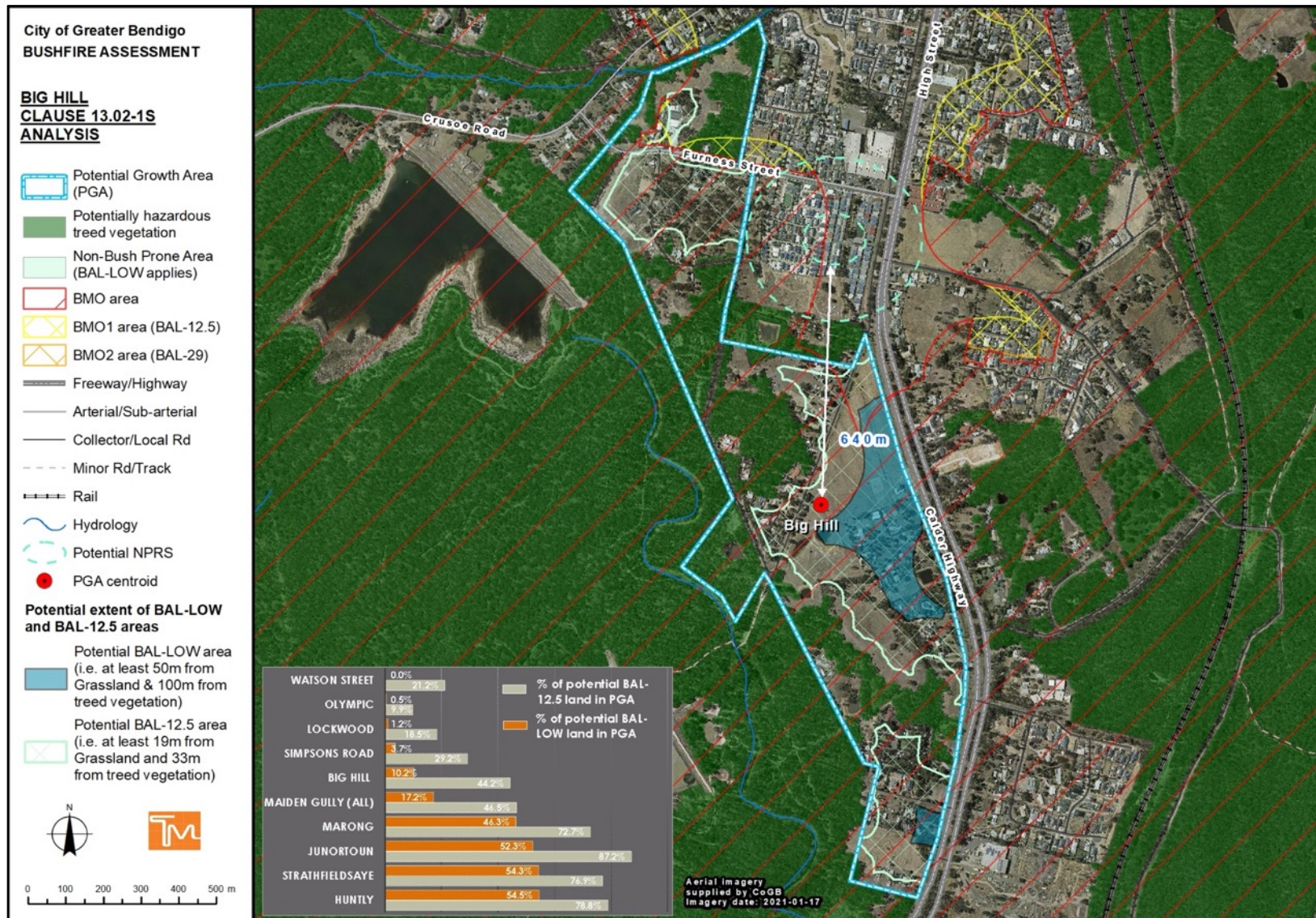
1. Potential ‘low risk’ areas where BAL-12.5 development could occur, that is, where RHF is calculated to not exceed 12.5 kW/m², i.e. at least 33 m from Woodland and 19 m from Grassland in the 150 m assessment zones around the PGAs.
2. Potential BAL-LOW areas where human life may be better protected from the effects of bushfire, i.e. land at least 50 m from Grassland and 100 m from Woodland.

Note that these areas have been defined as buffers (setbacks) from the potentially classifiable vegetation identified in the Bushfire Hazard Site Assessment Plans (Maps 12 - 20). This does not include Grassland within the PGAs as it assumed under future development/growth scenarios, Grassland within the study areas can be rendered low threat or non-vegetated by development.

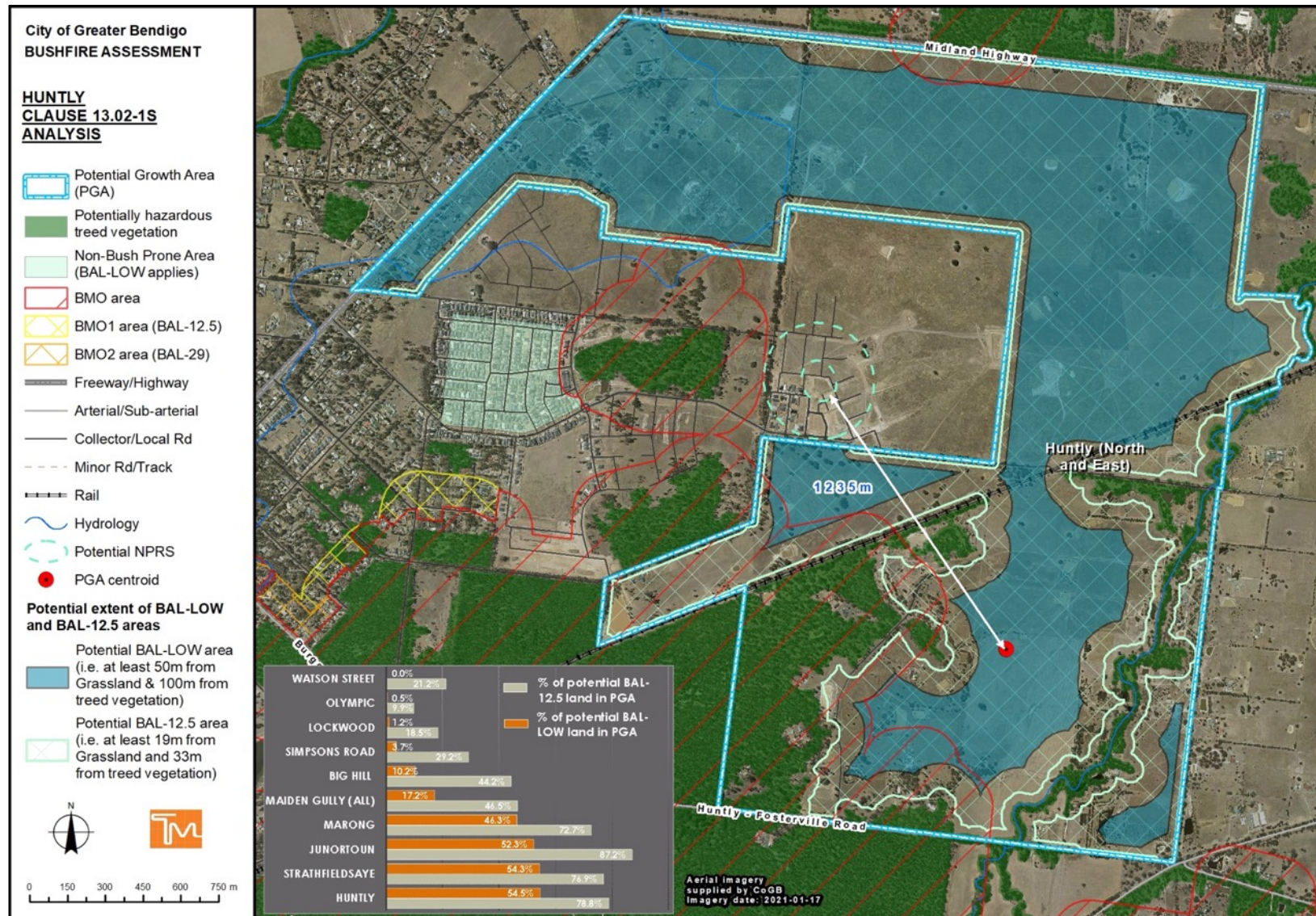
Further, areas of Woodland less than 20 m wide and less than 0.25 ha in area, and not within 20 m of other classified vegetation, have been excluded from the buffering, as they are likely able to be deemed low threat in accordance with the criteria for low threat vegetation in Section 2.2.3.2 of AS 3959-2018 (see Section 9.2 of this report).

ensure that BAL-12.5 is a maximum construction standard for settlement planning, which is consistent with the wording of the latter strategy and the criteria and setback distances for BAL-12.5 in AS 3959-2018.

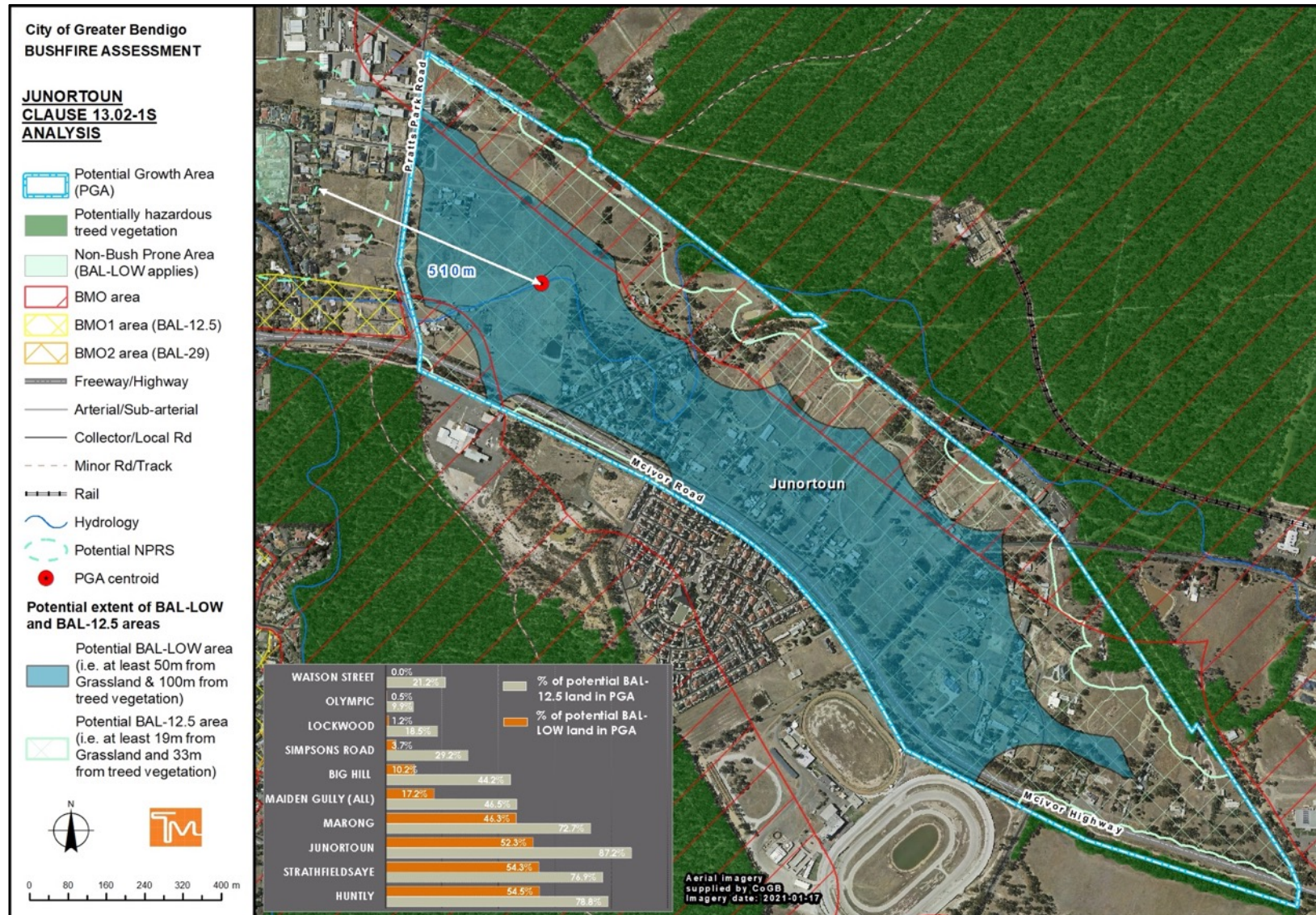
Map 22 – Big Hill
Clause 13.02-1S
BAL analysis



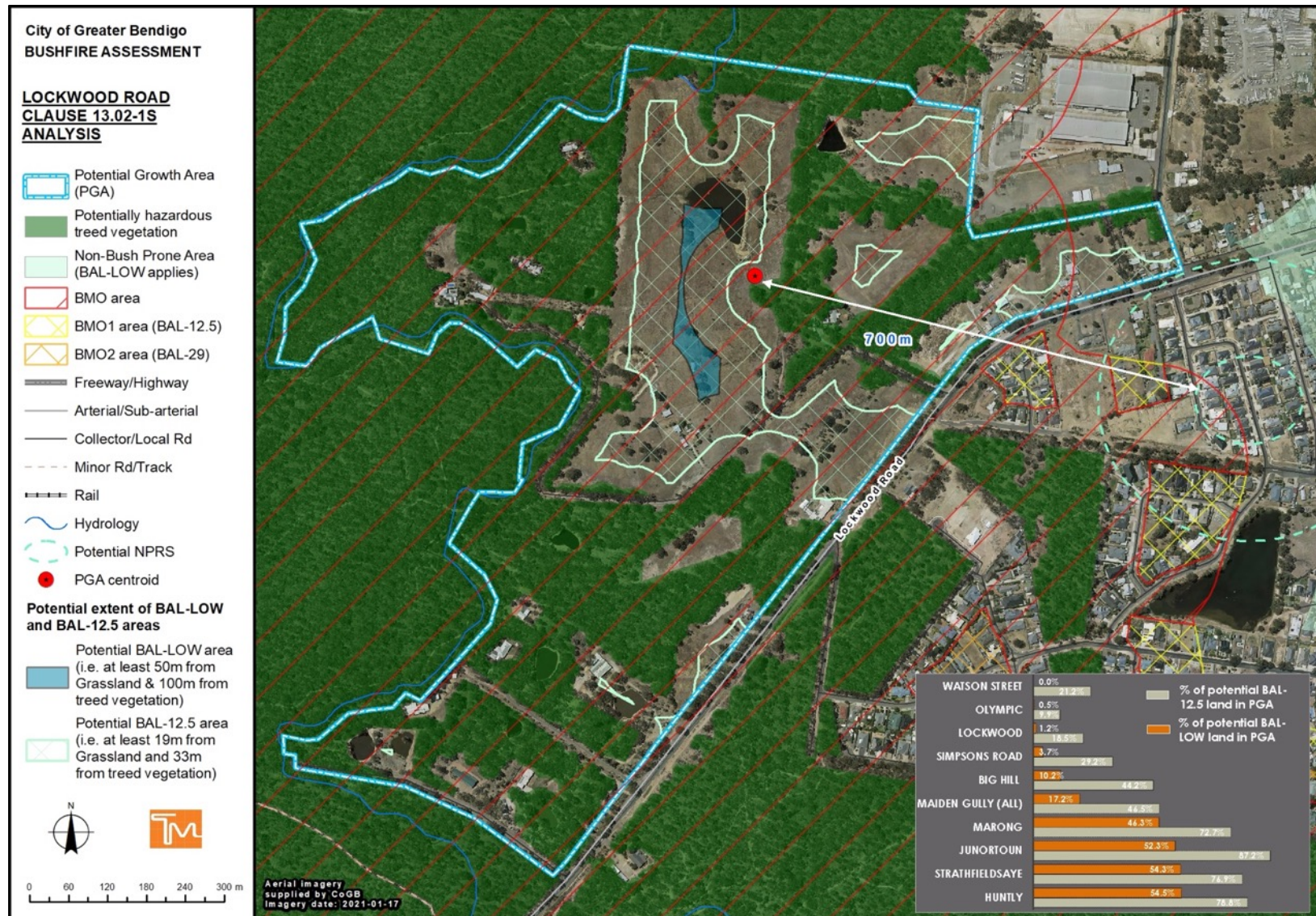
Map 23 – Huntly
Clause 13.02-1S
BAL analysis



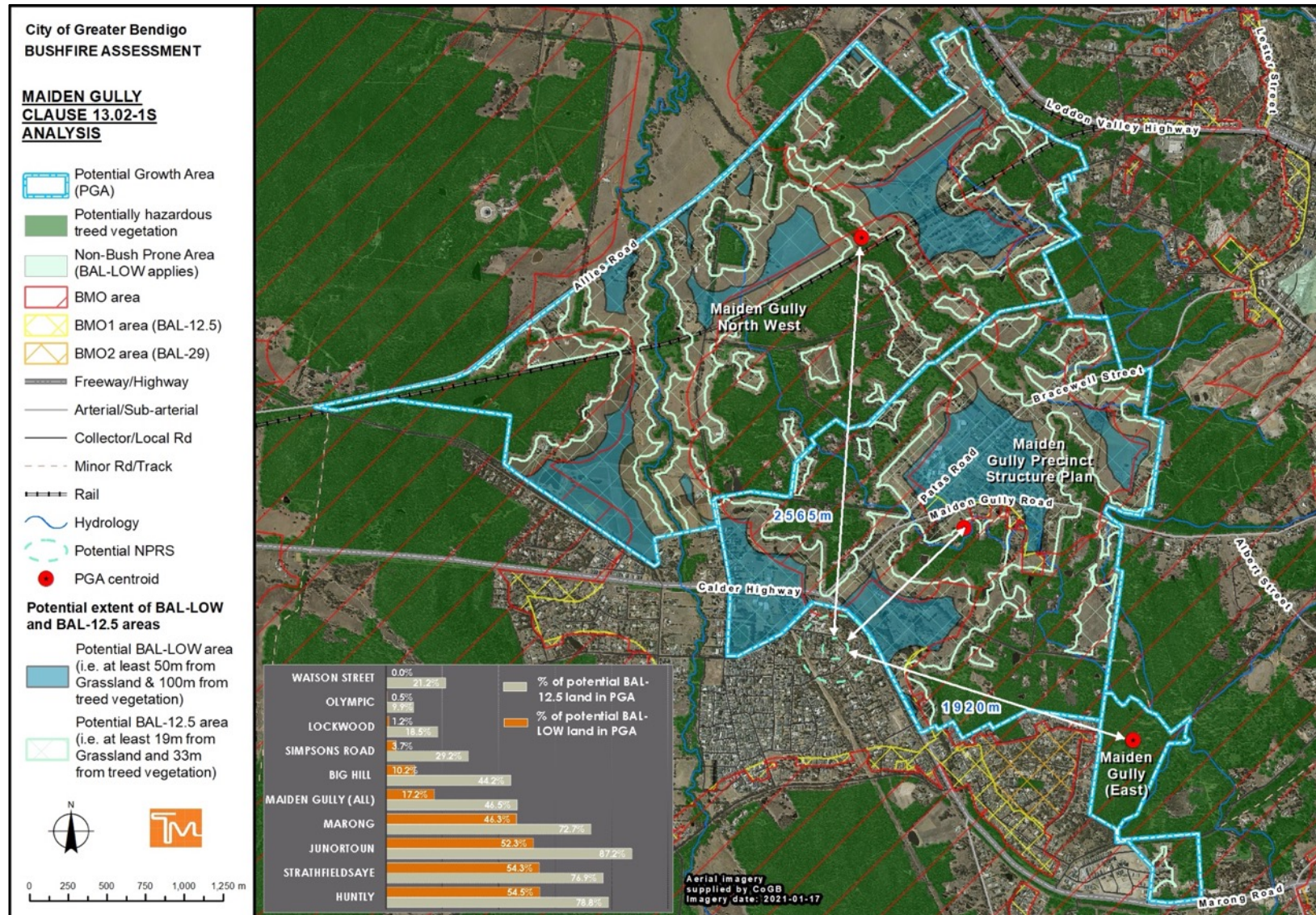
**Map 24 –
Junortoun Clause
13.02-1S BAL
analysis**



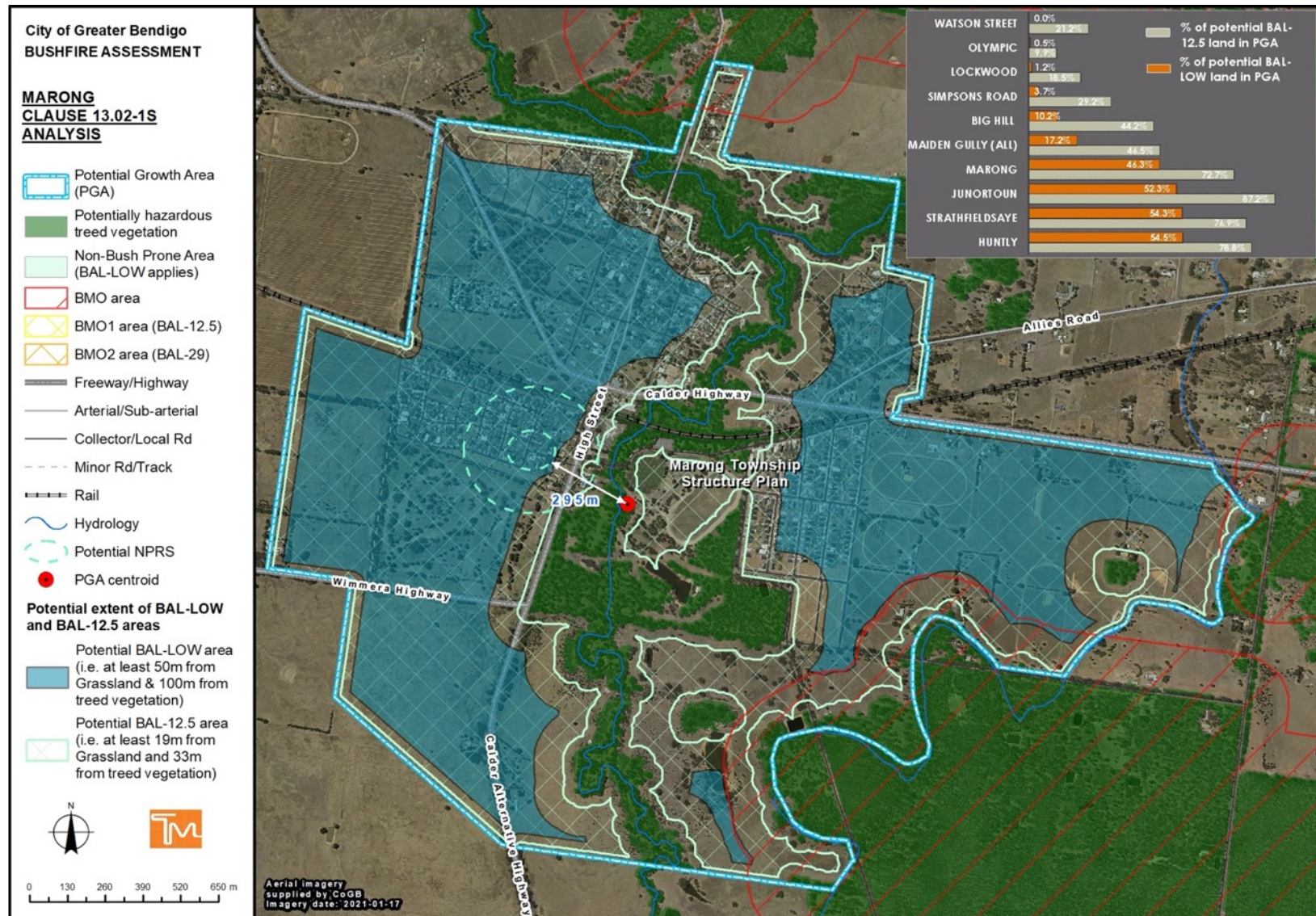
**Map 25 –
Lockwood Clause
13.02-1S BAL
analysis**



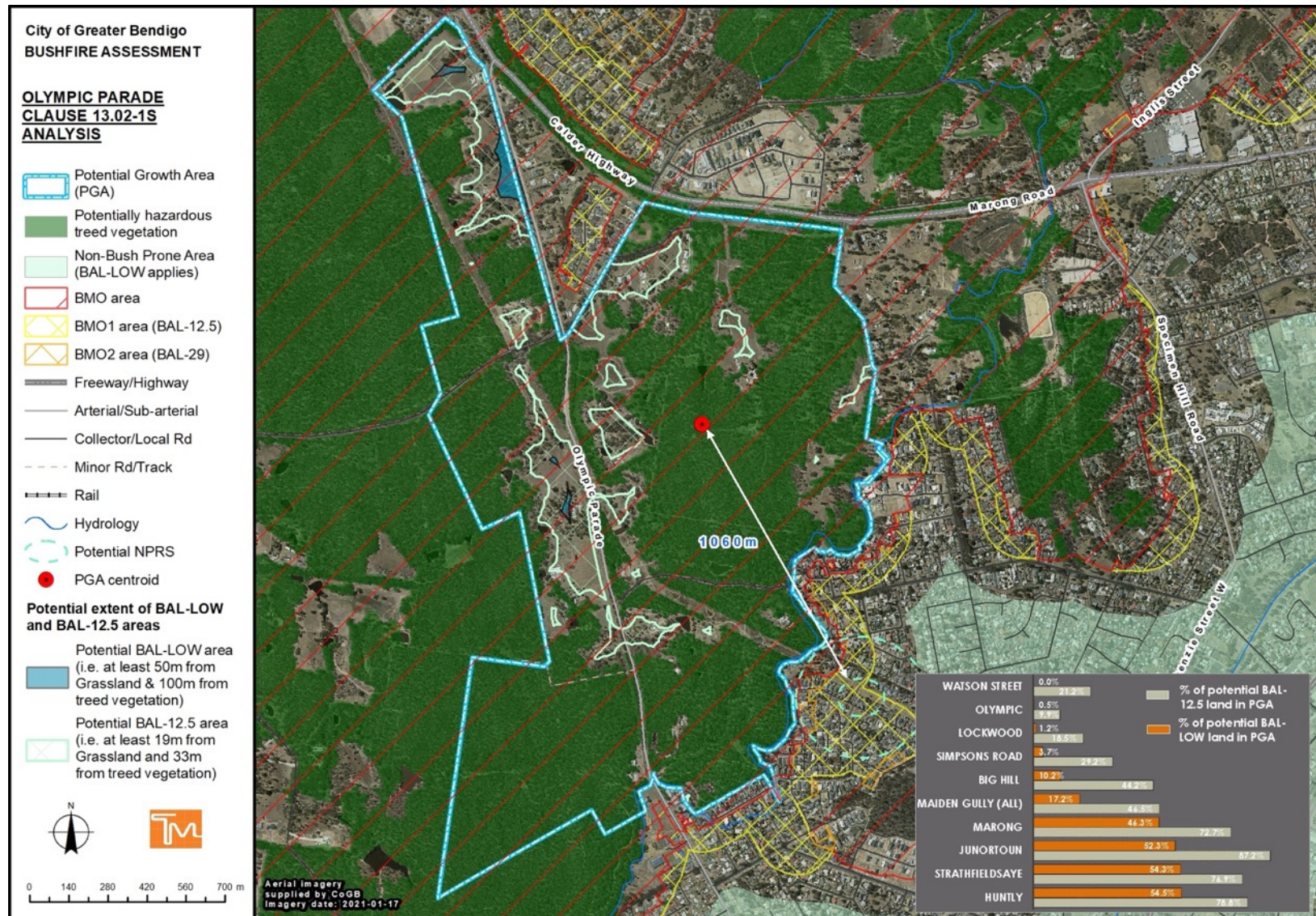
Map 26 – Maiden Gully Clause 13.02-1S BAL analysis



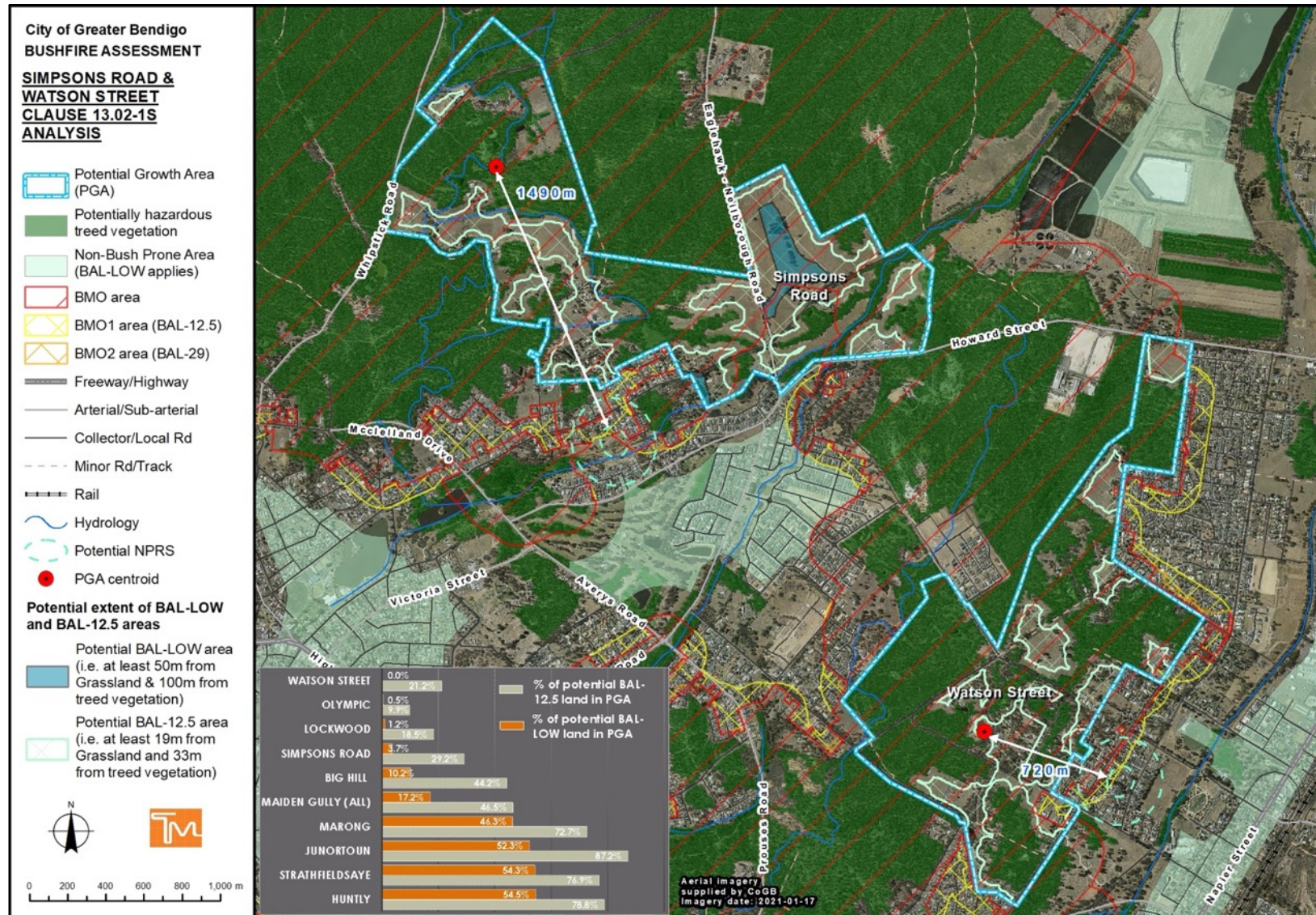
Map 27 – Marong
Clause 13.02-1S
BAL analysis



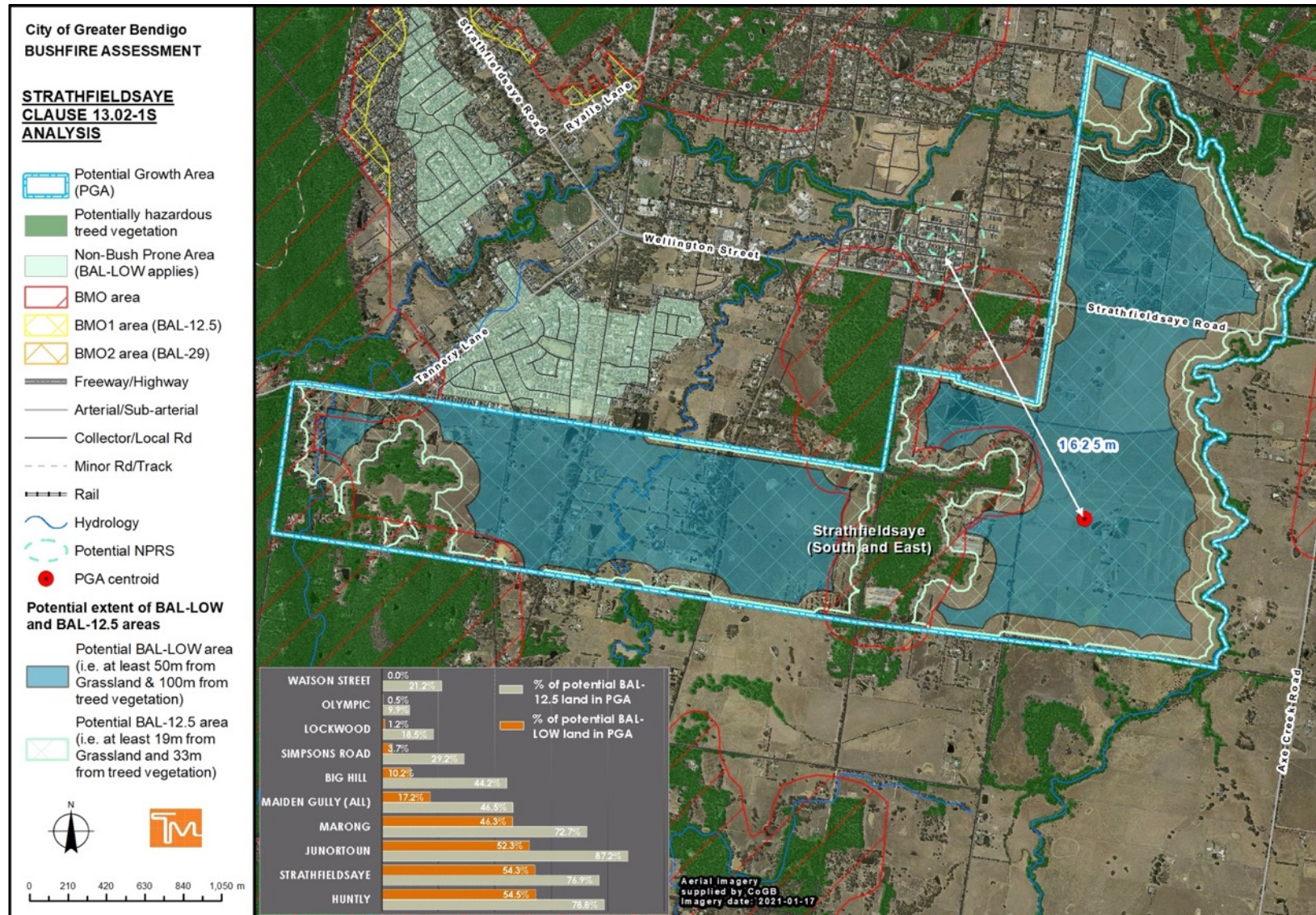
**Map 28 – Olympic
Clause 13.02-1S
BAL analysis**



**Map 29 –
Simpsons Road
and Watson Street
Clause 13.02-1S
BAL analysis**



**Map 30 –
Strathfieldsaye
Clause 13.02-1S
BAL analysis**



10.2.2 Bushfire scenarios and egress to safer areas

In addition to directing population growth and development to low risk locations, Clause 13.02-1S states that human life must be protected by ensuring the availability of, and safe access to, areas where human life can be better protected from the effects of bushfire (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

An assessment was made of the ability of the PGAs, or land around them, to provide relative safety from bushfire. This includes assessing credible bushfire scenarios applicable to each PGA, and identifying an existing location nearby where RHF would not exceed 1 kW/m^2 . This is a safety threshold tolerable for long periods of time for people with no protective clothing (bare skin) (Butler, 1969 in Sullivan *et al.*, 2001).

Based on AS 3959-2018 design fire conditions, this requires a low threat or non-vegetated area setback at least 150 m from Woodland. A 150 m setback also ensures RHF will not exceed 2 kW/m^2 based on the more conservative design fire conditions²³ and acceptable RHF safety threshold for a Neighbourhood Safer Place (NSP)/Place of Last Resort in the open (CFA, 2020). The assessment is based on an area equivalent to a standard senior football oval, 165 m by 135 m (DLGSC, 2023), being considered large enough to provide shelter. Maps 21 - 29 show the location of this nearest place of relative safety (NPRS) that meets these criteria in proximity to each PGA, as a central oval area surrounded by the 150 m setback distance (doughnut shaped polygon).

The distance shown is measured as a straight-line to the NPRS from the centroid (deepest point) in each PGA, i.e. the point farthest from all PGA boundaries. Whilst this is a relatively crude measure, it assists as a guide for comparing of the ability of each PGA to provide access to a safer location of minimum size. The NPRS shown may not be the best or closest site for the PGA.

The following assessment summarises the availability of access/egress associated with potential bushfire scenarios considered most likely to threaten a PGA, under the design fire conditions assumed in the BMO/AS3959 model i.e. a 100 m wide, fully developed fire, moving towards a location at a quasi-steady state rate of spread under Catastrophic fire weather conditions (FDI/FBI 100).

The characteristics of each PGA are summarised and a subjective, overall rating for access/egress availability is provided, as either 'Very Good', 'Good', 'Fair', 'Poor' or a hybrid of two ratings.

Big Hill

Big Hill PGA could be exposed to a large and intense bushfire approach from multiple directions, including those of highest risk i.e. from the north-northwest, west or south-west. Long fire runs of more than 5 km are possible from the north-west. Spotting could 'leap frog' over the PGA and ignite forest to the east, with the long narrow site potentially

²³ Including a flame temperature of 1200 K and FFDI 120.

exposed to flame contact, radiant heat, embers and significant smoke from all directions except a narrow north-north-eastern corridor.

Big Hill is the fifth lowest ranked, in terms of potential to result in BAL-12.5 and BAL-LOW areas. Only approximately 10% of its area is likely able to be rated BAL-LOW.

The site has, however, access to a low threat GRZ area just over 600 m away. Approximately 1 km to the north via the Calder Highway, there is access to non-BPA land and central Bendigo. Overall, access to an area of relative safety is rated as 'Good'.

Huntly

Huntly could be threatened by a large, fast moving grassfire from the west, north or, less credibly, the east. A bushfire could also approach through forest to the south-west. The fire history shows several fires have occurred to the north-west of Bendigo Creek just over 2 km away (see Map 9).

The LDRZ and GRZ land to the north-west has some potential to moderate the approach of any grassfire and Huntly has good access to the developing residential area that the PGA encompasses. The Midland Highway provides egress to Bendigo to the south-west or alternative locations out of the area to the north-east.

Huntly is the top ranked of all PGAs in terms of potential to result in BAL-12.5 and BAL-LOW areas. Overall, the PGA is rated as having 'Very Good' access to areas of relative safety.

Junortoun

Junortoun is exposed to large tracts of forest on public land to the north-north-east, east and south-south-west. Similarly to Big Hill, the long narrow site is potentially exposed to flame contact, radiant heat, embers and significant smoke, but generally only to the north-east where forest abuts the site.

Of all the PGAs, due to the lack of classified vegetation within (and immediately abutting) the PGA, Junortoun is the third highest ranked in potential to result in BAL-12.5 and BAL-LOW areas.

Access to a low threat GRZ area is available just over 500 m away to the north-west, and there is access to non-BPA land and central Bendigo within 1 km to the west-north-west. Overall, access to an area of relative safety is rated as 'Good' as, whilst safer areas are nearby, they are largely only in one direction.

Lockwood Road

As with Big Hill, the Lockwood Road PGA could be exposed to a large and intense bushfire approach from multiple directions, including those of highest risk i.e. from the north-northwest, west or south-west. Long fire runs of more than 5 km are possible from the north-west. The site is

potentially exposed to flame contact, radiant heat, embers and significant smoke from all directions except the top eastern-most corner.

Lockwood is the third lowest ranked, in terms of potential to result in BAL-12.5 and BAL-LOW areas. Only just over 1% of its area is likely able to be rated BAL-LOW.

The site has somewhat good access to a low threat GRZ area 700 m away and further to the north-east there is access to non-BPA land and central Bendigo. Overall, access to an area of relative safety is rated as 'Good' but access/egress is constrained somewhat.

Maiden Gully

Maiden Gully PSP and Maiden Gully NW PGAs are both exposed to a potential bushfire approaching through forest/woodland from the north-west, north, north-east or, less threateningly, the east.

The Maiden Gully PSP PGA is, however, a lesser risk location than the Maiden Gully NW PGA, as it is less exposed to long fire runs through remnant treed vegetation to the north-west, and has better access to larger, low threat areas to its west and south-west.

Large tracts of remnant vegetation generally only adjoin the PGAs to the north-west and east but long fire runs of more than 5 km are possible from the north and north-west of the Maiden Gully NW PGA. The central Maiden Gully PSP PGA, is buffered or protected from a westerly or south-westerly approach by the GRZ area in these directions.

The risk associated with a large bushfire impacting the Maiden Gully PGAs is significantly influenced by the resultant vegetated state of the PGAs under future growth scenario/s. The existing patchwork of native vegetation could allow fire to penetrate deep within and across the PGAs. Concentrated urban-residential development could, however, create large low threat areas of relative safety. Alternatively, lower density development with good vegetation controls to manage vegetation in a low threat state could result in a similar outcome.

Maiden Gully (as a whole) is mid-ranked in terms of potential to result in BAL-12.5 and BAL-LOW areas, but this is dependent on the extent to which vegetation can be managed under a growth scenario.

Egress is generally good to the GRZ areas to the west, especially for the Maiden Gully PSP PGA. To get to central Bendigo to the east, travel would be through areas of hazardous remnant vegetation. Overall, access to an area of relative safety is rated as 'Fair' but it varies according to the PGA and location within it.

Marong

Marong is exposed to a bushfire approach through forest vegetation from the north, north-east, and south-east, with large tracts of forest in these directions resulting in potentially long fire runs. The largest areas of contiguous forest are, however, in the generally lesser threat north-east and south-east directions, and generally only smaller areas directly abut the PGA's northern boundary.

In other directions the PGA could be threatened by a large grassfire, especially in the highest threat west, north-west and south-west directions.

Good urban design with hard non-vegetated edges, including perimeter roads along the western, north-western and south-western interfaces of the PGA should be able to acceptably mitigate the grassfire risk and enable people to move several blocks away to access safer locations. Whilst there is no non-BPA land close to the PGA, and Bendigo is approximately 10 km away to the east, Marong can provide more than one central area of relative safety and under a growth scenario non-BPA land could be created. Marong is fourth ranked in terms of potential to result in BAL-12.5 and BAL-LOW areas.

Overall, access to an area(s) of relative safety is rated as 'Good'.

Olympic Parade

As with the Lockwood Road PGA (and Big Hill) Olympic Parade could be exposed to a large and intense bushfire approach from multiple directions, including those of highest risk i.e. from the north-northwest, west or south-west. Long fire runs of more than 5 km are possible from the west and north-west although Maiden Gully provides somewhat of a 'buffer' to the north. The site is, however, potentially exposed to flame contact, radiant heat, embers and significant smoke from all directions except to a lesser extent from the east.

Olympic is the second lowest ranked, in terms of potential to result in BAL-12.5 and BAL-LOW areas, with only 0.5% of its area likely able to be rated BAL-LOW.

The site has fair access to low threat GRZ areas abutting the site to the south-east and to the north-east. Access to non-BPA land and central Bendigo is to the south-east. Overall, access to an area of relative safety is rated as 'Fair'.

Simpsons Road and Watson Street

Due to their similar locations and somewhat similar characteristics these two PGAs are described together.

Both PGAs could be impacted by a large intense bushfire from the highest risk directions i.e. the west, north and north-west. Simpsons Road, being to the north-west, is at a significantly higher risk and has a long complex interface directly abutting forest vegetation on multiple boundaries. It has a relatively short southern edge that directly abuts low threat GRZ land.

Watson Street, being further to the south-east, is a lower risk location and almost entirely abuts low threat GRZ land along its south-western, southern and eastern boundaries.

Both PGAs are low rated in terms of being able to result in low threat land. Overall, access to an area(s) of relative safety for Simpsons Road is rated as 'Fair to Poor', whilst Watson Street is rated as 'Good'.

Strathfieldsaye

Similarly to Marong and Huntly, Strathfieldsaye is somewhat of an ‘outlier’ PGA to the Bendigo urban area. The PGA also shares similar bushfire characteristics, being predominantly exposed to grassfire hazard and to a lesser extent a forest fire hazard. The western end of the PGA in particular is vulnerable to bushfire, due to the abutting tracts of forest to the west (reflected in the BMO coverage to the west) and a relatively small area in the centre of the PGA.

Strathfieldsaye has the benefit of a relatively large area of GRZ and LDRZ land abutting most of its northern and western (for the eastern part of the PGA) boundaries. To the south and east, a grassfire threat is the main potential bushfire risk scenario.

It is ranked second most highly, behind Huntly, in being potentially able to create BAL-LOW and BAL-12.5 development areas. Overall, access to an area(s) of relative safety is rated as ‘Very Good’.

10.3 PGA comparative ranking and analysis summary

This section provides a summary of the analysis. It presents a number of assessment attributes for each PGA, ranking them according to the favourability or suitability of the attribute for (or against) potential urban growth. A higher ranking (i.e. lower rank number) is indicative that a PGA may be comparatively more suitable for development than a PGA with a lower ranking.

It is important to note that the ranking does not consider other constraints to development such as flooding, buffer distances to incompatible land uses, availability of supporting infrastructure and the like.

A summary table of all the PGA rankings has then been compiled as a simple sum of all the ranking ‘scores’, as an ‘overall ranking’ table.

It is also important to note that the ranking is based only on some metrics available as outcomes of the analysis. It does not consider every attribute relevant to bushfire risk and so should not be seen as definitive. It is a simplified comparative ranking tool only, as a guide to assist in deciding where, if anywhere, growth might be directed, from a bushfire safety perspective only.

Further, note that the ranking does not consider the weighting of an attribute more than another in its importance for bushfire safety. Therefore, caution is required in interpreting the individual and overall table rankings as some attributes have more significance for bushfire safety/risk than others.

10.3.1 Attribute ranking

Clause 13.02-1S BAL analysis

Based on the analysis and mapping in Maps 21 - 29, Table 9 summarises the extent of BAL-12.5 and BAL-LOW land, potentially able to be created within each PGA, as a proportion of its total land area. Whilst the BAL-

12.5 and BAL-LOW results are similar in ranking, as a BAL-LOW area is considered likely safer than a BAL-12.5 area, the table ranks the PGAs preferentially according to the % of potential BAL-LOW land rather than % of potential BAL-12.5 land.

Huntly PGA is ranked most favourably, with over half of its area potentially able to meet the criteria for BAL-LOW, and almost 80% of its area likely to meet the BAL-12.5 safety threshold for settlement planning.

Table 9 – Ranking based on BAL-12.5 and BAL-LOW analysis

Ranking	Potential Growth Area	% of Potential BAL-12.5 within PGA	% of potential BAL-LOW within PGA
1	Huntly	78.8%	54.5%
2	Strathfieldsaye	76.9%	54.3%
3	Junortoun	87.2%	52.3%
4	Marong	72.7%	46.3%
5	Maiden Gully (all)	46.5%	17.2%
6	Big Hill	44.2%	10.2%
7	Simpsons Road	29.2%	3.7%
8	Lockwood	18.5%	1.2%
9	Olympic	9.9%	0.5%
10	Watson Street	21.2%	0.0%

Egress to a safer location

A summary ranking of the Clause 13.02-1S access/egress analysis in Section 10.2.2 is provided in Table 10.

Table 10 – Ranking based on egress analysis

Ranking	Potential Growth Area	Egress to a safer location
1	Huntly	Very Good
1	Strathfieldsaye	Very Good
2	Big Hill	Good
2	Junortoun	Good
2	Marong	Good
2	Watson Street	Good
2	Lockwood	Good
3	Maiden Gully (all)	Fair
3	Olympic	Fair
4	Simpsons Road	Fair to Poor

Potentially hazardous treed vegetation in and around PGAs

Based on the site assessment analysis in Section 9.1, the % area of 'potentially hazardous' treed vegetation, within and up to 150 m around each PGA, is shown in Table 11.

Table 11 – Ranking based on treed vegetation coverage

Ranking	Potential Growth Area	% area covered by treed vegetation within and up to 150m around PGA
1	Huntly	15.0%
2	Strathfieldsaye	15.4%
3	Junortoun	17.7%
4	Marong	18.4%
5	Maiden Gully (all)	35.8%
6	Big Hill	38.4%
7	Watson Street	45.8%
8	Simpsons Road	55.8%
9	Olympic	62.4%
10	Lockwood	62.6%

Huntly ranks most favourably, as it has no more than 15% of its area, and the 150 m site assessment zone around it, covered by potentially hazardous treed vegetation i.e. Woodland. However, Strathfieldsaye, Junortoun and Marong have similarly relatively low levels of exposure to Woodland i.e. all less than 20% coverage.

The results may or may not also correlate with the potential of an area to avoid and minimise native vegetation removal and biodiversity impacts associated with growth and development in the PGA.

BMO or BMO Schedule coverage

Using the BMO mapping as a surrogate for hazard exposure, the % area of each PGA that is covered by the BMO or a Schedule to the BMO is presented in Table 12.

Table 12 – Ranking based on BMO/BMO Schedule coverage

Ranking	Potential Growth Area	% area of BMO within PGA
1	Marong	8.1%
2	Huntly	19.4%
3	Strathfieldsaye	19.6%
4	Junortoun	29.9%
5	Maiden Gully (all)	64.0%
6	Big Hill	91.5%
7	Simpsons Road	92.1%
8	Lockwood	97.5%
9	Watson Street	99.3%
10	Olympic	100.0%

Marong ranks most favourably according to this metric, within only 8.1% of its area covered by the BMO.

FFMVic risk mapping

Table 13 shows the FFMVic risk rankings for each PGA, according to the FFMVic criteria and mapping presented in Section 10.1. The ranking is according to the PGA with the largest area of land in the least risk class (i.e. Freehold Moderate Risk).

Marong PGA, with the highest proportion of its total land area in the least risk class (Moderate Risk Freehold Land), ranks most favourably. It also has the lowest proportion of its total land area in the highest risk class (High Risk Public Land) (see Section 10.1).

Table 13 – Ranking based on land area in FFMVic risk classes

Ranking	Potential Growth Area	% Freehold High Risk Land	% Freehold Moderate Risk Land	% Public High Risk Land
1	Marong	7.7%	91.9%	0.3%
2	Huntly	14.3%	69.4%	16.3%
3	Strathfieldsaye	25.0%	69.0%	6.0%
4	Maiden Gully (all)	78.2%	9.4%	12.4%
5	Big Hill	14.6%	1.6%	83.7%
6	Simpsons Road	3.2%	0.0%	96.8%
7	Olympic	5.4%	0.0%	94.5%
8	Junortoun	7.1%	0.0%	92.9%
9	Watson Street	15.1%	0.0%	84.9%
10	Lockwood	0.0%	0.0%	100.0%

Neighbourhood hazard exposure

Table 14 ranks the PGAs according to the results of the neighbourhood hazard analysis presented in Section 8.3.

Table 14 – Ranking based on neighbourhood hazard exposure

Ranking	Potential Growth Area	% of PGA with 0% (Nil) exposure	% of PGA with >0-13% (Low) exposure	Total of both exposure classes
1	Strathfieldsaye	42%	28%	70%
2	Huntly	41%	28%	69%
3	Junortoun	26%	40%	66%
4	Marong	40%	19%	59%
5	Maiden Gully (all)	5%	20%	25%
6	Big Hill	0%	8%	8%
7	Simpsons Road	0%	3%	3%
8	Watson Street	0%	1%	1%
9	Lockwood Road	0%	1%	1%
10	Olympic Parade	0%	0%	0%

The ranking is based on the total percentage (sum of the percentages) of the land area within each PGA that has 'Nil' exposure and the % area that is in the 'Low' exposure class i.e. '>0 to 13%' of its land area exposed to hazardous treed vegetation.

Strathfieldsaye, Huntly, Junortoun and Marong all rank favourably with over 50% of their land areas in the least risk classes, and to a lesser extent Maiden Gully with 25% land area in the least risk classes.

10.3.2 Overall summary ranking

Table 15 - Overall summary ranking by PGA

Sum of Ranked Results	Potential Growth Area	Ranked Result According To Each Attribute						Colour legend for ranked attributes (comparative suitability for growth)
		% of potential BAL-LOW within PGA	% area covered by treed vegetation within and up to 150m around PGA	% area of BMO within PGA	% FFMVic Freehold Moderate Risk Land in PGA	% of PGA with 0 to 13% neighbourhood hazard exposure	Egress to a place of relative safety	
9	Huntly	1	1	2	2	2	1	More suitable ↑ 1 2 3 4 5 6 7 8 9 10 ↓ Less suitable
12	Strathfieldsaye	2	2	3	3	1	1	
16	Marong	4	4	1	1	4	2	
23	Junortoun	3	3	4	8	3	2	
27	Maiden Gully (all)	5	5	5	4	5	3	
31	Big Hill	6	6	6	5	6	2	
39	Simpsons Road	7	8	7	6	7	4	
45	Watson Street	10	7	9	9	8	2	
47	Lockwood Road	8	10	8	10	9	2	
48	Olympic Parade	9	9	10	7	10	3	

Table 15 presents an overall summary ranking score for the PGAs, based on simply summing the rankings (scores 1-10) for the six metrics presented in the assessment.

The comparative ranking indicates the more suitable PGAs for potential growth and development towards the top of the table, with the less suitable PGAs towards the bottom of the table i.e. it shows Huntly and Marong and Strathfieldsaye as being comparatively better suited to development, according to the ranked attributes, and Watson Street, Simpsons Road, Lockwood Road and Olympic Parade as less suitable.

It is reiterated that the ranking is based on some metrics available as outcomes of the analysis. It does not consider every attribute relevant to bushfire risk and so should not be seen as definitive. It is a simplified comparative ranking tool only, as a guide to assist in deciding to where growth might be directed, from a bushfire safety perspective only.

Further, the ranking does not consider the weighting of one attribute more than another in its importance for bushfire safety i.e. it assumes all attributes are equally significant in influencing bushfire safety and risk, which may not be the case.

SECTION 3: PLANNING & DESIGN RESPONSE

This section identifies how the urban growth in the PGAs can respond appropriately to the bushfire hazard analysis and risk assessment in the previous section. Specifically, it reviews the ability of development in the PGAs to satisfy:

- DTP guidance for settlement planning at the bushfire interface, i.e. *Design Guidelines for Settlement Planning at the Bushfire Interface* (DELWP, 2020a);
- CFA general principles for strategic and settlement planning; and
- The objective and strategies of Clause 13.02-1S *Bushfire Planning*.

11 Design Guidelines for Settlement Planning at the Bushfire Interface

This section identifies how development can incorporate DTP guidance for settlement planning and bushfire. The section structure follows the *Design Guidelines for Settlement Planning at the Bushfire Interface* (DELWP, 2020a).

11.1 Settlement form and structure

11.1.1 Considering the bushfire hazard in directing growth

Clause 13.02-1S requires the protection of human life be prioritised and that population growth and development must identify the bushfire hazard, assess the risk and direct growth to low risk areas, with safe access to locations where human life can be better protected from bushfire (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

The State Planning Policy for bushfire does not explicitly require that settlement growth be directed to areas of least risk, rather that it be directed to areas of low risk, which are defined by a key settlement planning strategy at Clause 13.02-1S as ‘...those locations assessed as having a radiant heat flux of less than 12.5 kilowatts/square metre under AS 3959-2018 *Construction of Buildings in Bushfire-prone Areas* (Standards Australia, 2018)’ ((Greater Bendigo Planning Scheme, Cl. 13.02-1S).

The analysis in Section 10 shows that over 70% of the Huntly, Strathfieldsaye, Junortoun and Marong PGAs, and almost half of the Maiden Gully PGAs, can potentially meet this RHF safety threshold²⁴ and, therefore, be deemed low risk locations. Based on the 'All upslopes and flat land' slope class, this requires a minimum 33 m setback of development from Woodland areas and a minimum 19 m setback from any areas of classified Grassland around (or within) the PGAs.

Additionally, over half of the Huntly, Strathfieldsaye and Junortoun PGAs, and almost half of the Marong PGA, is likely to be able to meet the definition of a BAL-LOW area. There are no evident obstacles to future development providing good access to these areas within the PGAs.

The landscape risk analysis and assessment of the fuel hazard posed by the vegetation, fire weather and topography beyond the 150 m site assessment zone around the study areas, demonstrates that fire behaviour in the surrounding landscape is not likely to be extreme. Whilst the risk to each PGA varies, including where the development is sited within the PGAs, the BAL-LOW and BAL-12.5 areas are comparatively low risk.

Overall, the hazard and resultant bushfire risk are not considered significant enough to preclude development in the lesser risk parts of the PGAs; and with bushfire responsive urban design, the existing planning and building controls are considered adequate to mitigate the risk.

Therefore, if the development layout responds to the bushfire risk and future buildings are setback sufficiently from hazardous vegetation it is considered the risk can be deemed to be acceptable for at least some growth in numerous, if not all PGAs. However, as summarised in Section 10.3, some are comparatively lesser risk locations than others and, therefore, are better suited for growth.

11.1.2 The distribution of land uses in the settlement

Terramatrix is aware that potential place-based plans, or future urban structures, have been prepared for the Maiden Gully Precinct Structure Plan area and the Marong PGA. However, review of those plans is not within the scope of this assessment.

Generally, any 'vulnerable uses'²⁵ should be directed to least risk central parts of the PGAs, which are those outside the BPA, have very good access to places of relative safety, or that could potentially achieve BAL-LOW.

11.1.3 Lot sizes in settlement layout

Smaller lot sizes can offer bushfire safety advantages if the lot size is small enough that it creates a 'dense' urban area that contains only low threat vegetation and non-vegetated areas, with a resultant limited potential for bushfire to spread through it. March *et al.* (2011) found that lot size

²⁴ Which is commensurate with a BAL-12.5 construction standard.

²⁵ Considered to be Class 9a health-care buildings, Class 9b early childhood centres, primary or secondary schools and Class 9c residential care buildings.

influenced both the level of bushfire penetration into the urban fringe at Bendigo on Black Saturday 2009 and the likelihood of house loss²⁶:

- Semi-rural (>4,000 m²) lots – 95% area burnt and 35% houses destroyed
- Large residential (800-3,999 m²) lots – 47% area burnt and 23% houses destroyed
- Residential (<799 m²) lots – 16% area burnt and 5% houses destroyed (March *et al.*, 2011).

March *et al.* (2011) concluded that the small residential lots acted as a barrier to fire penetration as there was much greater fragmentation of bushfire fuels by non- or low-flammability features, such as domestic use areas, driveways, paths, roads, cultivated gardens etc. The semi-rural (>4,000 m²) lots offered no such advantage, and the performance of the large residential (800-3,999 m²) lots was closer to the semi-rural than to the residential lots. Site coverage was also a significant influence on outcomes in that study. Lots unaffected by fire penetration had an average site coverage of 37%, while those with property damage had 24% average site coverage, and lots where dwellings were destroyed had an average site coverage of 19% (March *et al.*, 2011).

Conversely, studies have found a correlation between house loss in a bushfire and proximity to other houses, due to the potential for heavy ‘urban’ fuels to increase flame, radiant heat and ember attack on adjacent or nearby dwellings (Price and Bradstock, 2013; Blanche and Leonard, 2005).

The guidelines consider that in interface areas lot sizes between 800 m² and 1,200 m² provide a good balance between the risk of larger lots retaining more vegetation within a residential area, and smaller lots providing an increased risk of house-to-house ignitions or increased house losses from ember attack due to the higher housing density (DELWP, 2020a).

To this end, average lot densities of approximately 1,000 m² should be considered in PGA locations directly adjacent to a bushfire hazard, in accordance with the guidelines and to provide separation between dwellings (a minimum 10 m separation is recommended). Higher density conventional residential lots should be concentrated more centrally within the identified BAL-12.5 parts of the PGAs.

It is also desirable to consider the need for vegetation controls or guidelines to be applied to any areas with an interface with a bushfire hazard, to ensure vegetation on larger lots is maintained as low threat. e.g. planning controls or structure plan requirements could specify that vegetation within 150 m of an identified hazard be managed in accordance with the defensible space requirements of Table 6 to Clause 53.02-5. This is considered especially desirable in the Maiden Gully PGAs, which have the highest (almost 80%) proportion of land area in the FFMVic ‘high risk freehold land’ class. Accordingly, the ability of development in the Maiden Gully precincts to mitigate risk is significantly influenced by the extent to which vegetation can be removed and/or managed in a low threat state in perpetuity.

²⁶ A total of 58 dwellings were destroyed.

This measure will help minimise the risk for fire spread into and within the PGAs but is likely not needed in conventional density areas (e.g. UGZ, TZ, GRZ, NRZ or MUZ) within those PGAs most suitable to direct growth to, i.e. especially Huntly, Strathfieldsaye and Marong. These more intensively developed zones typically result in smaller lot sizes that comprise only non-vegetated and low threat cultivated garden or lawn areas.

11.1.4 Vegetated areas within a settlement

Vegetated areas to be permanently retained (e.g. as conservation reserves which may pose a tree/shrub hazard, or drainage reserves that could pose a lesser grassland hazard), should be identified in growth/development plans and setbacks from them defined to facilitate adjacent BAL-12.5 development. Note that ‘managed’ drainage reserves would be low threat such that no setback is required.

Note that some vegetated areas may be able to be designed to meet one or more of the small patch or narrow strips criteria for exclusion as non-hazardous vegetation, and therefore be deemed ‘low threat’ (see Section

²⁷ The setback distance is measured from the edge of the classified vegetation to the external wall of the building, or for parts of the building that do not have external walls (including carports, verandas, decks, landings, steps and ramps), to the supporting posts or columns. The following parts of a building are excluded:

- a) Eaves and roof overhangs.
- b) Rainwater and domestic fuel tanks.
- c) Chimneys, pipes, cooling or heating appliances or other services.

9.2) with no need for a development setback or where a lesser development setback can apply.

It likely that any local parks and sports reserves will comprise only managed grassland and low threat landscaped areas from which no setbacks would be required. Accordingly, it is desirable to locate these features at the interface with a hazard if possible.

11.2 The settlement interface

11.2.1 Applying the required development setbacks

As previously identified, to satisfy key settlement planning strategies of Clause 13.02-1S, future dwellings and other buildings requiring a BAL (see Section 2.2), must be sufficiently setback²⁷ from classified vegetation to enable a BAL-12.5 construction standard. These strategies aim to strengthen the resilience of settlements and communities and prioritise protection of human life, including by:

- *‘Directing population growth and development to low risk locations, being those locations assessed as having a radiant heat flux of less than 12.5 kilowatts/square metre²⁸ under AS 3959-*

d) Unroofed pergolas.

e) Sun blinds (Standards Australia, 2020).

²⁸ Note that the first strategy is to ensure RHF is less than 12.5 kW/m² (author’s emphasis). The second strategy stipulates a maximum BAL-12.5 construction standard (which requires that RHF not exceed 12.5 kW/m²). It is assumed the intent of both strategies to ensure that BAL-12.5 is a maximum construction standard for settlement planning, which

2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018).

- *Not approving any strategic planning document, local planning policy, or planning scheme amendment that will result in the introduction or intensification of development in an area that has, or will on completion have, more than a BAL-12.5 rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018)’ (Greater Bendigo Planning Scheme, Cl. 13.02-1S).*

The BAL-12.5 setbacks potentially required in response to Grassland and Woodland, based on the site hazard assessments in Section 9, and determined using the simple Method 1 procedure of AS 3959-2018, are shown in Table 16 below.

Table 16 – Potentially applicable building-vegetation setbacks for BAL-12.5

Vegetation	Slope class	Vegetation setback distance (defendable space ²⁹)
Grassland	All upslopes and flat land	19 m
Woodland		33 m

is consistent with the wording of the latter strategy and the criteria and setback distances for BAL-12.5 in AS 3959-2018.

Maps 20 - 26 show the BAL-12.5 setbacks that would be required for future dwellings within the study area from Woodland and Grassland vegetation.

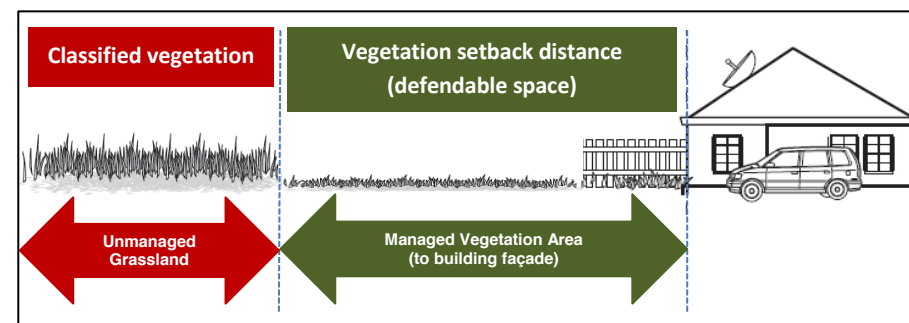


Figure 7 - Example of building-classified vegetation setback (adapted from CFA, 2013). Roads, pathways and shared trails etc. can be sited within the setback.

11.2.2 Designing the settlement interface

Lots in interface areas should ideally be lower density residential lots of 800 m² to 1,200 m², as discussed in Section 11.1.3 above. This is especially desirable for any interface areas on or close to a northern, north-western or western interface (and to a lesser extent the south-west), as these are areas of higher hazard based on the most likely directions of approaching fire under elevated fire danger conditions.

²⁹ Defined at Clause 73.01 as ‘An area of land around a building where vegetation is modified and managed to reduce the effects of flame contact and radiant heat associated with bushfire’ (Greater Bendigo Planning Scheme, Cl. 73.01).

11.2.3 Designing access and egress

Perimeter roads are a highly desirable design feature; to achieve or contribute to BAL setbacks, separate future development from hazardous vegetation with a ‘hard’ non-vegetated edge and facilitate property protection and fire fighting (see Figure 8).

Perimeter roads should be incorporated along the boundaries of growth areas and any patches of hazardous vegetation to contribute to separation from adjacent residential areas. This is especially important along any interface with creek corridors, and as with lot sizes above, especially desirable for any interface areas on or close to a northern, north-western or western interface. Planning controls or growth/development plans should include this as a requirement.

There should be no obstacles to future subdivision providing appropriate access/egress within PGAs for emergency vehicles and residents via a conventional residential road network in accordance with the requirements for roads in residential subdivisions at Clause 56.06.

Additionally, roads should comply with the CFA’s *Design Requirements, Vehicle Access and Water Supply Requirements in Residential Developments* (CFA 2022).

The road layout should provide at least two access and egress routes to BAL-LOW areas.

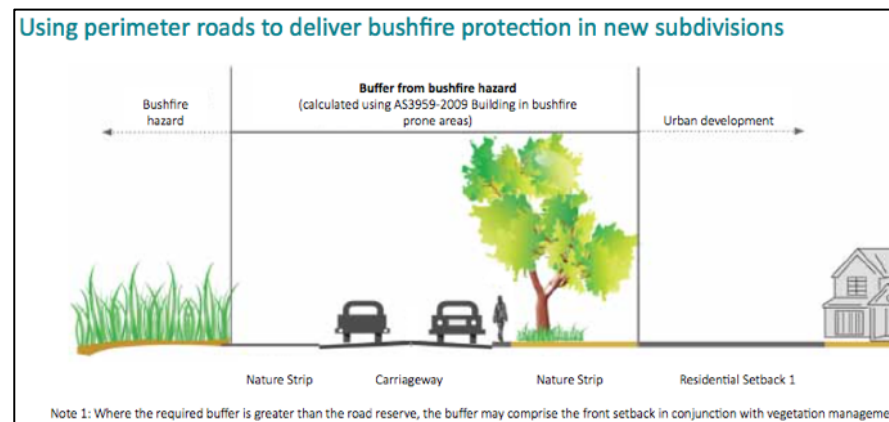


Figure 8 - Illustration of a perimeter road to provide required development setbacks (DELWP, 2015)

11.3 Bushfire protection measures across a settlement

11.3.1 Vegetation management

All landscaping of road reserves, communal areas and other managed open space in growth areas should be low threat. Additionally, locating any low threat open space areas at the periphery of development areas, between dwellings and any hazardous vegetation, can contribute to development setbacks.

The Municipal Fire Management Plan (MFMP), or other appropriate plan, could specify ongoing management standards for any other areas, such as road reserves, that are required to be maintained in a low threat state. Any review and future version of the MFMP should note any other

bushfire protection measures that are implemented for growth areas if they require ongoing maintenance.

Any retarding basins or WSUD features may be non-vegetated or low threat if they will have open water or reliably wet areas with little or no vegetation. However, larger, seasonally inundated wetlands or WSUD features that may be dry and vegetated during the fire danger period, could comprise classifiable Grassland (or higher hazard vegetation if they have shrubs and/or trees).

A guideline could be included in growth/development plans for landscape design and plant selection in open spaces, including waterways and drainage corridors that ensures a low risk of bushfire, i.e. comprise low threat vegetation in accordance with AS 3959-2018.

As identified above, a requirement in the planning controls or growth/development plans could also specify that vegetation within 150 m of an identified hazard be managed in accordance with the defendable space requirements of Table 6 to Clause 53.02-5.

11.3.2 Building construction standards

Growth/development plans should incorporate setbacks from hazardous vegetation based on the minimum BAL-12.5 that applies in a BPA. The development setbacks required for BAL-12.5 in response to the Grassland and Woodland are provided in Table 16 above.

11.3.3 Fences and other localised fuel sources

It is desirable to discourage, restrict or prohibit the use of combustible fences such as non-bushfire resistant timber fences and brush fences, especially in interface parts of PGAs.

Accordingly, a guideline, or requirement, could be proposed for all fencing adjoining fire hazard areas to be of non-combustible materials.

12 Clause 13.02-1S Bushfire planning

The objective of the state bushfire planning policy is *'To strengthen the resilience of settlements and communities to bushfire through risk-based planning that prioritises the protection of human life'* (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

The applicable strategies stipulated in Clause 13.02-1S that can contribute to satisfying the objective, are identified below and a summary assessment of how PGA development can respond to each of them is provided.

12.1 Protection of human life strategies

Priority must be given to the protection of human life.

Prioritising the protection of human life over all other policy considerations.

The analysis of the four landscape-scale severe fire characteristics in Section 7.2, shows the PGAs are not at high risk of extreme fire behaviour. Bushfire behaviour can credibly be expected to be within the AS 3959/BMO design fire conditions.

Overall, based on the broader and local landscape hazard analysis and assessments in Sections 7 and 8, the land beyond 150 m around the PGAs accords with either BMO Broader Landscape Types 2 or 3,

depending on the PGA and the location of development within it (see Sections 7.4 and 8, and Map 11).

The dominant hazard in the 1 km local and 400 m neighbourhood landscape areas (as well as within the 150 m site assessment areas) is Grassland or Woodland, with potentially some small patches of higher hazard Forest (see Sections 8.1 and 9.1, and Maps 10 and 12 - 20).

The topography in the landscape is likely not a significant influence on bushfire behaviour and, therefore, not an appreciable contributor to the risk within the PGAs (see Section 6 and Map 3).

Accordingly, it is considered that the protection of human life can be achieved by bushfire responsive guidance for layout and design of development in growth/development plans, and compliance with the applicable planning and building controls that relate to bushfire. That is, BMO and BMO schedule compliance for development in those parts of the PGAs and compliance with building regulations for construction in parts of the PGAs designated as BPAs.

Depending on the extent and pattern of proposed new urban growth, parts of most PGAs could meet criteria for excision from the BPA following development, and some areas may be appropriate for application of the BMO1 or BMO2 (see Section 2.1.6).

Directing population growth and development to low risk locations and ensuring the availability of, and safe access to, areas where human life can be better protected from the effects of bushfire.

The risk analysis in Section 10 identifies a range of attributes for each PGA. It identifies the locations of lowest risk of exposure to areas of hazard and, therefore, those that are the least risk and most favourable to direct growth to.

The overall summary ranking of this risk analysis is provided in Table 15, which identifies that the three most suitable PGAs that can be considered low risk locations are Huntly, Marong and Strathfieldsaye. Junortoun and Maiden Gully PGAs, or at least parts of them, are also likely to be suitable for at least some growth and development, noting that:

- Whilst Junortoun has very good potential for BAL-12.5 and BAL-LOW development, its narrow shape and location in the landscape between large tracts of forest to the north and south-south-east, requires careful consideration for siting and layout of development.
- Given the comparatively higher cover of native vegetation on private land within Maiden Gully, the ability of development in the Maiden Gully PGAs to mitigate risk, is significantly influenced by the extent to which vegetation can be removed and/or managed in a low threat state in perpetuity.

Watson Street, Simpsons Road, Lockwood Road and Olympic Parade PGAs are, comparatively, the least favourable locations to direct

growth to from a bushfire perspective. Big Hill is also somewhat unfavourable.

Reducing the vulnerability of communities to bushfire through consideration of bushfire risk in decision-making at all stages of the planning process.

This report provides the basis for incorporating bushfire risk into decision making associated with planning for growth. DTP settlement planning guidance for bushfire interface areas has been considered in Section 11, to inform the preparation of any growth or development plans.

The CFA provide principles to guide strategic planning and the consideration of and response to bushfire risk:

- *‘Direct development to locations of lower bushfire risk.*
- *Carefully consider development in locations where there is significant bushfire risk that cannot be avoided.*
- *Avoid development in locations of extreme bushfire risk.*
- *Avoid development in areas where planned bushfire protection measures may be incompatible with other environmental objectives.*
- *Design out risk and for reduction, resilience and response’ (CFA, 2023).*

As identified above, the locations of comparably lesser risk are identified in this assessment. The identification of environmental values

that might be adversely affected by development is not within the scope of this study.

DTPs bushfire interface guidelines, as identified in Section 11, provide principles for designing out risk and for reduction, resilience and response. This assessment enables the CFA's principles for strategic planning to be integrated into any growth and development plans, to increase community resilience and reduce vulnerability.

12.2 Bushfire hazard identification and assessment strategies

Clause 13.02-1S-1 requires that the bushfire hazard be identified, and appropriate risk assessment be undertaken.

Applying the best available science to identify vegetation, topographic and climatic conditions that create a bushfire hazard.

This report identifies the potential hazards in accordance with the commonly accepted methodologies of the BMO/AS 3959-2018 and, as appropriate, additional guidance provided in *Planning Practice Note 64 Local planning for bushfire protection* (DELWP, 2015), *Planning Advisory Note 68 Bushfire State Planning Policy Amendment VC140* (DELWP, 2018) and *Planning Permit Applications – Bushfire Management Overlay, Technical Guide* (DELWP, 2017).

Additional hazard analysis, based on peer reviewed scientific literature, has been included in the assessment to inform the consideration of risk

at the landscape scale beyond 150 m around the study areas, and the ability of the proposal and study areas to create land that can be low risk and BAL-LOW, i.e. where the risk can be deemed to be mitigated to an acceptable level such that human life is acceptably protected from bushfire impacts.

The type and extent of potentially hazardous vegetation within and around the PGAs has been identified and classified at the site and neighbourhood scales. The classification is based on the anticipated long-term state of the vegetation, aerial imagery, site assessment, analysis of modelled EVCs present, published guidance on vegetation assessment for bushfire purposes and experience with the fuel hazard posed by the vegetation types that occur within the region.

Publicly available contour data for the area was obtained, including a 10 m DEM, which provided the basis for assessment of the topography and identification of potentially applicable slope classes.

In relation to climatic conditions and fire weather, the AS 3959-2018 default FFDI 100/GFDI 130 benchmark used in the Victorian planning and building system, has been applied as discussed in Section 5.

Additional analysis of the wind direction, frequency and strength on days of elevated fire danger was also undertaken as presented in Section 5.2.

Considering the best available information about bushfire hazard including the map of designated bushfire prone areas prepared under the Building Act 1993 or regulations made under that Act.

The extent of BPA coverage has been considered (see Section 2.2) and is shown in the mapping. This is based on the most recent BPA mapping for Victoria, which was gazetted 20th April 2023.

Applying the Bushfire Management Overlay in planning schemes to areas where the extent of vegetation can create an extreme bushfire hazard.

BMO coverage has been considered and reflects current mapping in the Greater Bendigo Planning Scheme. The extent of coverage of the PGAs by the BMO and Schedules 1 and 2 to the BMO is provided in Figure 2 and shown in Maps 12 - 20.

Based on the analysis presented in Section 8.3 and Map 11, the BMO coverage is generally considered appropriate.

Subject to the extent and pattern of development proposed and any proposed vegetation removal³⁰, it is likely that the BMO1 or BMO2 schedules (which facilitate BAL-12.5 and BAL-29 development respectively) could be extended to some parts of the PGAs that are currently covered by the BMO parent provision e.g. potentially Huntly, Strathfieldsaye, Marong, Junortoun and Maiden Gully.

³⁰ TerraMatrix is not aware of any locations in the PGAs that may be subject to permitted vegetation removal.

Considering and assessing the bushfire hazard on the basis of:

- **Landscape conditions - meaning the conditions in the landscape within 20 kilometres and potentially up to 75 kilometres from a site;**
- **Local conditions - meaning conditions in the area within approximately 1 kilometre from a site;**
- **Neighbourhood conditions - meaning conditions in the area within 400 metres of a site; and**
- **The site for the development.**

The hazard has been assessed and described at the broader landscape, local, neighbourhood and site scales.

The characteristics of the landscape, out to at least 20 km around the sites, have been considered in accordance with guidance about assessing risk for planning scheme amendments provided in the Planning Advisory Note 68 (DELWP, 2018) and Planning Practice Note 64 (DELWP, 2015).

Local and neighbourhood conditions have been assessed at distances of 1 km and 400 m around the PGAs (see Map 10 and Map 11).

At the site scale, a 150 m assessment area has been applied around the study area. The site assessment follows the BMO and AS 3959-2018 methodology for classifying vegetation and topography (see Maps 12 - 20).

Consulting with emergency management agencies and the relevant fire authority early in the process to receive their recommendations and implement appropriate bushfire protection measures.

It is anticipated that the CFA/FRV will be provided with this assessment report for their review and feedback.

Ensuring that strategic planning documents, planning scheme amendments, planning permit applications and development plan approvals properly assess bushfire risk and include appropriate bushfire protection measures.

DTP advisory and practice notes, Clause 13.02-1S and the planning and building controls invoked by the BMO and BPA coverage, specify the general requirements and standards for assessing the risk. These have been applied in this report supplemented by additional hazard analysis based on peer reviewed scientific literature.

Potential bushfire protection measures have been identified commensurate with the risk. Relevant regional bushfire plans and strategies have been identified, reviewed and incorporated into this assessment where appropriate (see Section 3).

Not approving development where a landowner or proponent has not satisfactorily demonstrated that the relevant policies have been addressed, performance measures satisfied or bushfire protection measures can be adequately implemented.

The risk can be deemed to be acceptably mitigated such that development can proceed if the objective and strategies of Clause 13.02-1S, the DTP settlement planning guidelines, and compliance with BPA and BMO measures are successfully implemented as identified in this report. These can be incorporated into bushfire requirements and guidelines in growth and development plans.

With BPA (or BMO) compliance, and bushfire responsive siting and layout of development, including good access/egress to BAL-LOW areas, appropriate bushfire protection measures can be adequately implemented.

12.3 Settlement planning strategies

Settlement planning must strengthen the resilience of settlements and communities and prioritise protection of human life.

Directing population growth and development to low risk locations, being those locations assessed as having a radiant heat flux of less than 12.5 kilowatts/square metre under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018).

Applicable distances for dwellings and other development to be setback from classifiable vegetation, such that RHF is calculated to not exceed 12.5 kW/m² and where, therefore, BAL 12.5 buildings could potentially be sited, have been identified (see Section 10.2 and Maps 22 - 30). These are locations at least 19 m from Grassland around the PGAs and 33 m from patches of classifiable Woodland.

Ensuring the availability of, and safe access to, areas assessed as a BAL-LOW rating under AS 3959-2018 Construction of Buildings in Bushfire-prone Areas (Standards Australia, 2018) where human life can be better protected from the effects of bushfire.

The existing locations where human life can be better protected from the effects of bushfire are the existing low threat, developed areas within or adjacent to the PGAs (see Maps 22 - 30).

Maps 22 - 30 also identify potential BAL-LOW areas within the PGAs, which are at least 100 m from classifiable Woodland patches and 50 m from Grassland around the PGAs.

Good access to these areas needs to be assured and there are no apparent obstacles to this being achievable.

Once developed with reliably low threat and non-vegetated areas, parts of some PGAs can likely meet the criteria for future excision from the BPA, creating more easily accessible areas of relative safety from bushfire attack for future residents.

Ensuring the bushfire risk to existing and future residents, property and community infrastructure will not increase as a result of future land use and development.

Achieving no net increase in risk to existing and future residents, property and community infrastructure, through the implementation of bushfire protection measures and where possible reduce bushfire risk overall.

Growth and development in the PGAs should not result in an increase in risk to existing or future residents, their property or community infrastructure. The risk to existing residents may in fact be reduced by the development of additional low threat or non-vegetated land that would accompany development within a PGA.

Assessing and addressing the bushfire hazard posed to the settlement and the likely bushfire behaviour it will produce at a landscape, settlement, local, neighbourhood and site scale, including the potential for neighbourhood-scale destruction.

As identified previously, this report appropriately assesses and addresses the risk at a range of scales.

Assessing alternative low risk locations for settlement growth on a regional, municipal, settlement, local and neighbourhood basis.

The PGAs comprise multiple alternative locations that have been assessed as part of this study. This includes assessment of BMO landscape risk typologies and bushfire characteristics in and around the

PGAs to 20 km. Detailed comparative assessment of potential locations where growth might be directed is presented in Section 10.

Not approving any strategic planning document, local planning policy, or planning scheme amendment that will result in the introduction or intensification of development in an area that has, or will on completion have, more than a BAL-12.5 rating under AS 3959-2018.

If the setback distances from hazardous vegetation identified in this report are implemented, then development will be able to achieve BAL setbacks commensurate with nothing higher than BAL-12.5 construction. Maps 22 - 30 show where BAL-12.5 development could potentially occur within the PGAs.

12.4 Areas of high biodiversity conservation value

Ensure settlement growth and development approvals can implement bushfire protection measures without unacceptable biodiversity impacts by discouraging settlement growth and development in bushfire affected areas that are of high biodiversity conservation value.

The identification of environmental values that might be adversely affected by development is not within the scope of this study.

12.5 Use and development control in a Bushfire Prone Area

Clause 13.02-1S requires that ‘In a bushfire prone area designated in accordance with regulations made under the Building Act 1993, bushfire risk should be considered when assessing planning applications for the following uses and development:

- Subdivisions of more than 10 lots
- Accommodation
- Child care centre
- Education centre
- Emergency services facility
- Hospital
- Indoor recreation facility
- Major sports and recreation facility
- Place of assembly
- Any application for development that will result in people congregating in large numbers’ (Greater Bendigo Planning Scheme, Cl. 13.02-1S).

It further states that:

‘When assessing a planning permit application for the above uses and development:

- Consider the risk of bushfire to people, property and community infrastructure.
- Require the implementation of appropriate bushfire protection measures to address the identified bushfire risk.

- *Ensure new development can implement bushfire protection measures without unacceptable biodiversity impacts' (Greater Bendigo Planning Scheme, Cl. 13.02-1S).*

There are no apparent barriers for future development applications that trigger this use and development control strategy, complying with the applicable bushfire planning and building controls.

13 Conclusion

All the PGAs are declared Bushfire Prone Areas (BPA) and have at least partial Bushfire Management Overlay (BMO) coverage, which indicates there are areas within all of them that could potentially be exposed to significant fire behaviour.

To help delineate the extent to which the PGAs could be subject to significant fire behaviour, in accordance with the bushfire hazard identification and assessment strategies in Clause 13.02-1S, the hazard posed by vegetation, topographic and climatic conditions has been assessed at a range of scales, including in and around each PGA, and in the broader surrounding landscape for at least 20 km.

The landscape risk analysis and assessment of the fuel hazard posed by the vegetation, fire weather and topography beyond 150 m around the study areas, demonstrates that fire behaviour is not likely to be extreme.

Accordingly, if a development layout responds to the bushfire risk and future buildings are setback sufficiently from hazardous vegetation it is considered the risk can be deemed to be acceptable for at least some growth in numerous, if not all PGAs. However, some are comparatively lesser risk locations than others and, therefore, are better suited to growth.

Analysis of weather data on days of elevated fire danger shows a dominance of northerly and north-westerly winds, with westerly and

south-westerly winds also occurring but less frequently, on days of when FFDI is greater than or equal to 50 (i.e. generally when the fire danger rating is Extreme or Catastrophic). The wind data shows that the PGAs are least likely to be exposed to direct bushfire attack from the east, south or south-east, which is typical of most locations in Victoria.

The northern and western interfaces of the PGAs are, therefore, generally at higher risk than more easterly and southerly parts.

Four landscape-scale bushfire characteristics, where the pattern of topography and vegetation may interact with weather and atmospheric conditions to generate extreme bushfire behaviour, were assessed:

- Terrain Ruggedness
- Convective Strength
- Modelled House Loss Probability
- Ember-storm Potential (Drop Zone).

The analysis confirms that the PGAs are not likely to experience extreme fire behaviour, and hence, it is considered bushfire behaviour can be expected to be generally within the BMO/AS3959 design fire conditions.

This conclusion is generally supported by FFMVic bushfire behaviour and house loss modelling for the Loddon Mallee Bushfire Management Strategy, which shows that all of the PGAs are comparatively least risk

locations in the region for potential house loss under catastrophic conditions, except for:

- The westernmost corner of the Strathfieldsaye PGA, which is a 'Low-Intermediate' risk location.
- Approximately the southern two-fifths of Big Hill PGA, which is a 'Low-Intermediate' and 'Intermediate' risk location.
- A small area towards the north-westernmost corner of Maiden Gully North West PGA, which is a 'Low-Intermediate' risk location, and another small area in the north-easternmost corner that is a 'Low-Intermediate' to 'High' risk location.
- An area in the south-west corner of the Maiden Gully Precinct Structure Plan PGA, which is rated as a 'Low-Intermediate' and 'Intermediate' risk location.
- All the Lockwood Road PGA is rated as a 'Low-Intermediate' and 'Intermediate' risk location.
- The Olympic Parade PGA has areas of 'Low-Intermediate' risk increasing to 'High' Risk in the south.

Overall, it is considered that the landscape around the PGAs is best characterised as BMO Broad Landscape Type 2 or 3, which is typical of BMO landscapes.

The topography in the landscape is unlikely to be a significant influence on bushfire behaviour, and therefore not an appreciable contributor to the risk within the PGAs.

For the purposes of determining BAL construction standards and defendable space/development setback distances, the applicable slope

class is likely to be 'All upslopes and flat land' for most, if not all, of the PGAs.

The hazard posed by vegetation at the local and neighbourhood scales around the PGAs was identified by delineating classified vegetation types from Ecological Vegetation Classes (EVCs).

The analysis reveals that 70% of the land area in and up to 1 km around the PGAs, potentially comprises an EVC. Just over half that area is Box Ironbark Forest, almost a third is Grassy Woodland, and a little less than 10% comprises Plains Grassy Woodland.

Analysis of EVC bioregional benchmarks shows all EVCs with at least 1% coverage of land within, and up to 1 km around the PGAs, are likely most appropriately classified in the AS 3959 Woodland group.

At the site scale, within 150 m of the PGAs the hazard comprises Grassland or Woodland vegetation. Lockwood Road and Olympic Parade have the highest exposure to Woodland (i.e. percentage of land in and up to 150m around them), closely followed by Simpsons Road and Watsons Street PGAs. Huntly, Strathfieldsaye, Junortoun and Marong have the least, with less than 20% treed vegetation cover in and within 150 m of them.

GIS neighbourhood hazard exposure analysis was undertaken to determine the relative risk (% exposure) of all parts of the study areas to hazardous areas of dense treed vegetation within 400 m to the north and west, and 150 m in other directions. That is, the *area of hazard* within 400

m to north and west, and 150 m to south and east, around 30 m x 30 m cells, was calculated and reported back to the subject cell, and then ranked as a percentage of total possible exposure.

The results of the analysis provide a comparative analysis of the hazard exposure for each PGA. It shows the percentage of land area within each PGA that has 'Nil' exposure or is in the 'Low' exposure class i.e. '>0-13%' of its land area exposed to hazardous treed vegetation.

It confirms that Olympic Parade, Lockwood Road, Simpsons Road and Watsons Street PGAs have the highest exposure to potentially hazardous treed vegetation, and Huntly, Strathfieldsaye, Junortoun and Marong PGAs the least.

The neighbourhood hazard analysis correlates well with BPA coverage and Clause 13.02-1S analysis of potential 'low risk' areas in each PGA where BAL-12.5 development could occur.

The mapping of the higher risk classes also correlates well with BMO coverage and potentially indicates areas which may be more, or less, suitable for BMO schedules.

An assessment was made of the ability of the PGAs to meet key settlement planning safety thresholds for BAL and RHF exposure, being:

- Potential 'low risk' areas where BAL-12.5 development could occur, that is, where RHF calculated to not exceed 12.5 kW/m² i.e. at least 33 m from patches of Woodland and 19 m from Grassland in the 150 m assessment zone around the PGAs.

- Potential BAL-LOW areas where human life may be better protected from the effects of bushfire, i.e. land at least 50 m from Grassland around the PGAs and 100 m from Woodland patches.

Over 70% of the Huntly, Strathfieldsaye, Junortoun and Marong PGAs, and almost half of the Maiden Gully PGAs, can potentially meet the 12.5 kW/m² RHF safety threshold and, therefore, be deemed low risk locations in accordance with Clause 13.02.1S.

Based on the 'All upslopes and flat land' slope class, this requires a minimum 33 m setback of development from Woodland areas and a 19 m minimum setback from any areas of classified Grassland around (or within) the PGAs.

Additionally, over half of the Huntly, Strathfieldsaye and Junortoun PGAs, and almost half of the Marong PGA, is likely to be able to meet the definition of a BAL-LOW area under the State Planning Policy AS 3959 criteria for BAL-LOW. There are no evident obstacles to future development providing good access to these areas within the PGAs.

The ability of development in the Maiden Gully PGAs to mitigate risk is significantly influenced by the extent to which vegetation can be removed and/or managed in a low threat state in perpetuity.

Whilst Junortoun has very good potential for BAL-12.5 and BAL-LOW development, its narrow shape and location in the landscape between large tracts of forest to the north and south-south-east, requires careful

consideration for siting and layout of development. 93% of its area is in the FFMVic high risk class of ‘Public High Risk Land’.

Big Hill, Watson Street, Simpsons Road, Lockwood Road and Olympic Parade PGAs are, comparatively, the least favourable locations to direct growth from a bushfire perspective.

Sum of Ranked Results	Potential Growth Area	Ranked Result According To Each Attribute						Colour legend for ranked attributes (comparative suitability for growth)
		% of potential BAL-LOW within PGA	% area covered by treed vegetation within and up to 150m around PGA	% area of BMO within PGA	% FFMVic Freehold Moderate Risk Land in PGA	% of PGA with 0 to 13% neighbourhood hazard exposure	Egress to a place of relative safety	
9	Huntly	1	1	2	2	2	1	More suitable ↑ 1 2 3 4 5 6 7 8 9 10 ↓ Less suitable
12	Strathfieldsaye	2	2	3	3	1	1	
16	Marong	4	4	1	1	4	2	
23	Junortoun	3	3	4	8	3	2	
27	Maiden Gully (all)	5	5	5	4	5	3	
31	Big Hill	6	6	6	5	6	2	
39	Simpsons Road	7	8	7	6	7	4	
45	Watson Street	10	7	9	9	8	2	
47	Lockwood Road	8	10	8	10	9	2	
48	Olympic Parade	9	9	10	7	10	3	

A summary of all the analysis was made based on the assessment attributes for each PGA. It ranked them according to the favourability or suitability of the attribute for (or against) potential urban growth. A higher ranking indicated that a PGA may be comparatively more suitable for development than a PGA with a lower ranking. The summary table of the PGA rankings that was compiled as a comparative ‘overall ranking’ is shown above.

The ranking indicates that comparatively, the most suitable PGAs for potential growth and development are Huntly, Marong and Strathfieldsaye. Development in Maiden Gully could be carefully considered, and to some extent Junortoun, although Junortoun has high exposure to hazardous vegetation on Public land.

Big Hill, Watson Street, Simpsons Road, Lockwood Road and Olympic Parade are comparatively less favourably suited to development.

Note in relation to the Maiden Gully and Junortoun PGAs:

- The development potential of the Maiden Gully PGAs is significantly influenced by the future vegetated state of these PGAs under a growth scenario/s. The existing patchwork of native vegetation could allow fire to penetrate deep within and across the PGAs. Concentrated urban-residential development could, however, create large low threat areas of relative safety. Alternatively, lower density development with good vegetation controls to manage vegetation in a low threat state could result in a similar outcome.
- Therefore, the ability of development in the Maiden Gully PGAs to mitigate risk is significantly influenced by the extent to which vegetation can be removed and/or managed in a low threat state in perpetuity.

Whilst Junortoun has very good potential for BAL-12.5 and BAL-LOW development, its narrow shape and location in the landscape between large tracts of forest to the north and south-south-east, requires careful consideration for siting and layout of development.

It is important to note that the ranking is based on only some metrics available as outcomes of the analysis. It does not consider every attribute relevant to bushfire risk and so should not be seen as definitive. It is a simplified comparative ranking tool only, as a guide to assist in deciding where, if anywhere, growth might be directed, from a bushfire safety perspective only.

Further, the ranking does not consider the weighting of one attribute more than another in its importance for bushfire safety, i.e. it assumes all

attributes are equally significant in influencing bushfire safety and risk, which may not be the case.

Generally, any 'vulnerable uses' should be directed to least risk central parts of the lower risk PGAs, which are those areas outside a BPA, have very good access to places of relative safety, or that could potentially achieve BAL-LOW.

Average lot densities of approximately 1,000 m² should be considered in PGA locations directly adjacent to a bushfire hazard, in accordance with DTP design guidelines for settlement planning on the bushfire interface, with the aim to provide a minimum 10 m separation between dwellings.

This is especially desirable for any areas on or close to a northern, north-western or western interface, as these are areas of higher hazard based on the most likely directions of approaching fire under elevated fire danger conditions.

Higher density conventional residential lots should be concentrated more centrally within the BAL-12.5 parts of PGAs.

It is also desirable to consider vegetation controls or guidelines for any areas with an interface with a bushfire hazard, to ensure vegetation is maintained as low threat. For example, planning controls or structure plan requirements could specify that vegetation within 150 m of an identified hazard be managed in accordance with the defensible space standards in Table 6 to Clause 53.02-5.

This is considered especially desirable in the Maiden Gully PGAs, which have the highest (almost 80%) proportion of land area in the FFMVic 'high risk freehold land' class.

This measure will assist to minimise the risk for fire spread into and within the PGAs but is likely not needed in conventional density areas (e.g. UGZ, TZ, GRZ, NRZ or MUZ) within those PGAs most suitable to direct growth to, i.e. especially Huntly, Strathfieldsaye and Marong. These more intensively developed zones typically result in smaller lot sizes that comprise non-vegetated and low threat cultivated garden or lawn areas.

Vegetated areas to be permanently retained (e.g. as conservation reserves or drainage reserves) and which may pose a tree/shrub or grassland hazard, should be identified in growth/development plans and setbacks from them defined to facilitate adjacent BAL-12.5 development.

It is presumed that any local parks and sports reserves will comprise only managed grassland and low threat landscaped areas from which no setbacks would be required.

Perimeter roads should be incorporated along the boundaries of growth areas and any patches of hazardous vegetation to contribute to separation from adjacent residential areas. This is especially important along any interface with any creek corridors, and any interface areas on or close to a northern, north-western or western interface. Planning controls or growth/development plans should include this as a requirement.

There should be no obstacles to future subdivision providing appropriate access/egress within PGAs for emergency vehicles and residents via a conventional residential road network in accordance with the requirements for roads in residential subdivisions at Clause 56.06. The road layout should provide at least two access and egress routes to BAL-LOW areas.

A guideline could be included in growth/development plans for landscape design and plant selection in open spaces, including waterways and drainage corridors that ensures a low risk of bushfire, i.e. comprises low threat vegetation in accordance with AS 3959-2018.

It is desirable to discourage, restrict or prohibit the use of combustible fences such as non-bushfire resistant timber fences and brush fences, especially in interface parts of PGAs. Accordingly, a guideline, or requirement, could be proposed for all fencing adjoining fire hazard areas to be of non-combustible materials.

Subject to the extent and pattern of development proposed and any proposed vegetation removal, it is likely that the BMO1 or BMO2 schedules (which facilitate BAL-12.5 and BAL-29 development respectively) could be extended to some parts of the PGAs that are currently covered by the BMO parent provision, e.g. potentially Huntly, Strathfieldsaye, Marong, Junortoun and Maiden Gully.

Overall, the risk to development in the PGAs can be deemed to be acceptably mitigated such that development can proceed, if the objective and strategies of Clause 13.02-1S, the DTP settlement planning guidelines, and compliance with BPA and BMO measures are successfully

implemented as identified in this report. These can be incorporated into bushfire requirements and guidelines in growth and development plans. With BPA (or BMO) compliance, and bushfire responsive siting and layout of development, including good access/egress to BAL-LOW areas, appropriate bushfire protection measures can be adequately implemented.

Once developed with reliably low threat and non-vegetated areas, parts of some PGAs can likely meet the criteria for future excision from the BPA, creating more easily accessible areas of relative safety from bushfire attack for existing and future residents.

14 Appendix - BALs & RHF

Bushfire Attack Level (BAL)	Risk Level	Construction elements are expected to be exposed to...	Comment
BAL-LOW	VERY LOW: There is insufficient risk to warrant any specific construction requirements but there is still some risk.	No specification.	At 4 kW/m ² pain to humans after 10 to 20 seconds exposure. Critical conditions at 10 kW/m ² and pain to humans after 3 seconds. Considered to be life threatening within 1 minute exposure in protective equipment.
BAL-12.5	LOW: There is risk of ember attack.	A radiant heat flux not greater than 12.5 kW/m ²	At 12.5 kW/m ² standard float glass could fail and some timbers can ignite with prolonged exposure and piloted ignition.
BAL-19	MODERATE: There is a risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to radiant heat.	A radiant heat flux not greater than 19 kW/m ²	At 19 kW/m ² screened float glass could fail.
BAL-29	HIGH: There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level of radiant heat.	A radiant heat flux not greater than 29 kW/m ²	At 29 kW/m ² ignition of most timbers without piloted ignition after 3 minutes exposure. Toughened glass could fail.
BAL-40	VERY HIGH: There is a much increased risk of ember attack and burning debris ignited by windborne embers, a likelihood of exposure to a high level of radiant heat and some likelihood of direct exposure to flames from the fire front.	A radiant heat flux not greater than 40 kW/m ²	At 42 kW/m ² ignition of cotton fabric after 5 seconds exposure (without piloted ignition).
BAL- FZ (Flame Zone)	EXTREME: There is an extremely high risk of ember attack and a likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front.	A radiant heat flux greater than 40 kW/m ²	At 45 kW/m ² ignition of timber in 20 seconds (without piloted ignition).

Adapted from Standards Australia (2020).

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