

BLACKASH

BUSHFIRE CONSULTING

Bushfire Risk Assessment

Precincts 3c and 5

Oakdale West Industrial Estate

Prepared for

Goodman Property Services (Aust.) Pty Ltd



Version 1.2

27 October 2022

Project Name:	Oakdale West Estate – Precincts 3c and 5
Site Details	Oakdale West Estate
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1. Summary

Table 1 is a summary of compliance with relevant documents and approaches to limit bushfire attack and meet the requirements of the NSW planning framework for new development in Bushfire Prone Areas.

Table 1: Summary

Planning for Bushfire Protection 2019 Classification	"Other" commercial/ industrial
Location	3c - Lot 108 DP126310. 5 - Lot 111 DP1262310
Local Government Area	Penrith
Can this proposal comply with AS3959, 2018	AS3959, 2018 does not apply as a DTS Provision
Does this development comply with the requirements of <i>Planning for Bushfire Protection 2019</i>?	YES
Does this development comply with the Aims and objectives of <i>Planning for Bushfire Protection 2019</i>?	YES
Is referral to the NSW RFS required?	NO

Assessment Framework	<input checked="" type="checkbox"/> <i>Planning for Bushfire Protection 2019</i>
	<input checked="" type="checkbox"/> Meets the deemed to satisfy provisions
	<input type="checkbox"/> Alternate solution/ performance-based assessment

2. Introduction

Blackash Bushfire Consulting has been engaged by Goodman Property Services (Aust.) Pty Ltd (Goodman) to provide a Bushfire Hazard Assessment report to support a Development Application (DA) for the construction of Precincts 3c and 5 at the Oakdale West Estate (OWE).

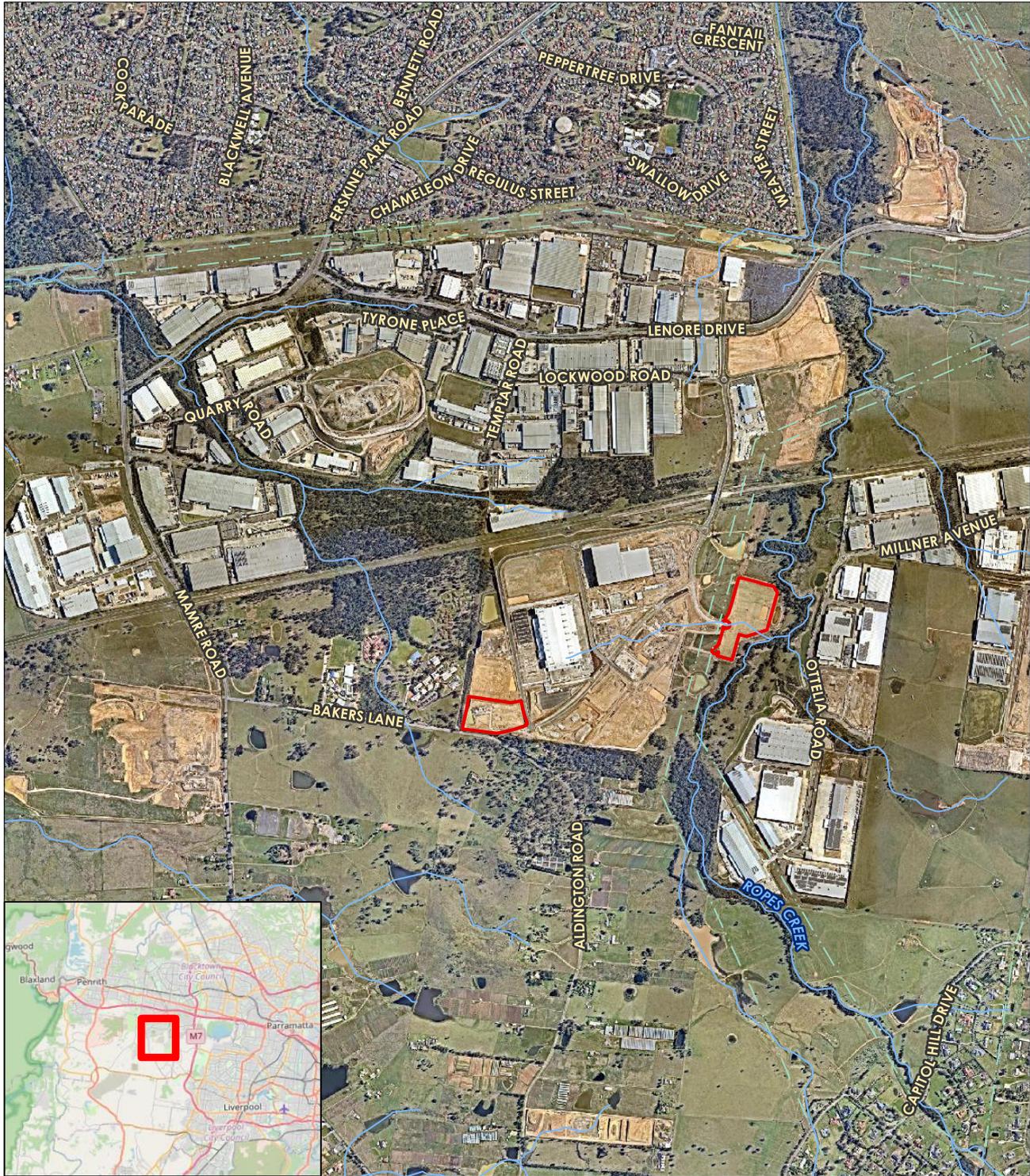
The site is shown in Figure 1 and is part of the larger OWE which comprises 154 hectares of land within the Western Sydney Employment Area [WSEA] and is owned by a Joint Venture (JV) between Goodman and Brickworks Limited (Brickworks, parent company of the Austral Brick Company Pty Ltd).

The OWE was approved as a State Significant Development for the staged development of the land for warehousing and distribution uses.

The site is mapped as bushfire prone land and bushfire has been a key consideration in the design process. Commercial and industrial development is designated as “other” development in PBP 2019. As “other” development, a key issue for the proposal will be meeting the aim and objectives of *Planning for Bushfire Protection* and the performance requirements for commercial and industrial development.

The proposed warehouse buildings are required to respond and implement an appropriate level of bushfire protection measures, as per *Planning for Bushfire Protection 2019* (PBP 2019). This report will demonstrate that an appropriate combination of protection measures has been considered and provided.

This assessment has been prepared by Corey Shackleton, Principal Bushfire & Resilience (FPAA BPAD Level 3 Certified Practitioner No. BPD-L3-34603) who is recognised by the NSW RFS as qualified in bushfire risk assessment and have been accredited by the Fire Protection Association of Australia as a suitably qualified consultant to undertake alternative solution proposals.



Legend

-  Watercourse
-  Electricity Transmission Line
-  Subject Land



Date: 15/02/2022



Coordinate System: GDA 1994 MGA Zone 56
Imagery: © Nearmap

Figure 1: Site Location

3. Legislative Framework

The site is identified as 'bushfire prone land' (see Figure 2) for the purposes of Section 10.3 of the *Environmental Planning and Assessment Act, 1979* (EPA Act) and the legislative requirements for development on bushfire prone lands are applicable.

All development on bushfire prone land must consider and comply with PBP 2019. However, industrial development has considerable flexibility, and the nature of the development often results in the structures providing a higher degree of bushfire resistance than required by the NSW RFS.

As "other" development, the proposed industrial development is addressed through demonstrating compliance with the aim and objectives of PBP.

Under the building classification system within the *National Construction Code* (NCC), Class 5 to 8 buildings include offices, shops, factories, warehouses, public car parks and other commercial and industrial facilities. The NCC does not provide for any bushfire specific performance requirements for these particular classes of building. As such the *Australian Standard for Construction of Buildings in Bushfire Prone Areas* (AS 3959) and the NASH Standard are not considered as a set of 'deemed to satisfy' provisions. However, compliance with AS 3959 and NASH should be considered when meeting the aims and objectives of PBP.

Whilst bushfire is not captured in the NCC for Class 5-8 buildings, PBP 2019¹ articulates the following objectives which will be applied in relation to access, water and services, and emergency and evacuation planning:

- *to provide safe access to/from the public road system for firefighters providing property protection during a bush fire and for occupant egress for evacuation;*
- *to provide suitable emergency and evacuation (and relocation) arrangements for occupants of the development;*
- *to provide adequate services of water for the protection of buildings during and after the passage of bush fire, and to locate gas and electricity so as not to contribute to the risk of fire to a building; and*
- *provide for the storage of hazardous materials away from the hazard wherever possible.*

¹ Planning for Bushfire Protection 2019 (p. 76)

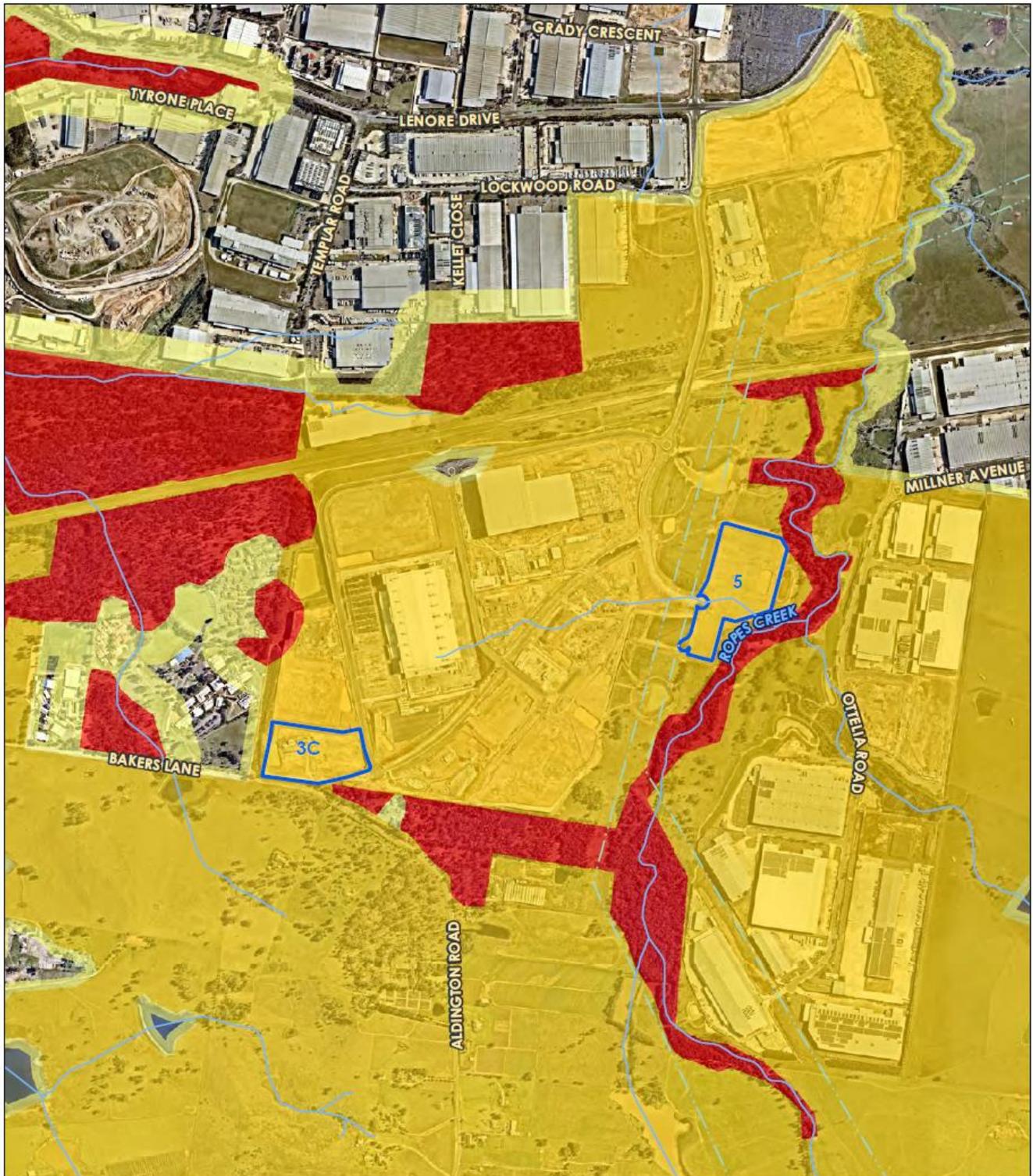
The general fire safety construction provisions (of the NCC) are taken as acceptable solutions however construction requirements for bushfire protection will need to be considered on a case-by-case basis.

4. Bushfire Prone Land

Bushfire prone land maps provide a trigger for the development assessment provisions and consideration of sites that are bushfire prone.

Bushfire prone land (BFPL) is land that has been identified by council, which can support a bushfire or is subject to bushfire attack. Bushfire prone land maps are prepared by local council and certified by the Commissioner of the NSW RFS.

Figure 2 shows the Bushfire Prone Land Map for the two precincts. The extract from the Penrith Bushfire Prone Map shows that the sites and the surrounding land is predominately Category 2 Bushfire Prone Vegetation, except for a narrow band of Category 1 to the southeast of Precinct 5. All the vegetation within the OWE has since been cleared as part of the OWE development.



Legend

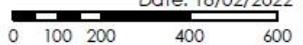
-  Watercourse
-  Vegetation Category 1
-  Vegetation Category 2
-  Electricity Transmission Line
-  Subject Land

Bushfire Prone Land

-  Vegetation Buffer



Date: 18/02/2022



Coordinate System: GDA 1994 MGA Zone 56
Imagery: © Nearmap

Figure 2: Bushfire Prone Land Map

5. The Proposal

The Concept design for the OWE (Figure 3) was developed in consideration of a comprehensive constraint's analysis of the site, with particular reference to riparian lands, vegetation and flooding. The OWE Masterplan was approved through an SSD process, which included proposed Precincts 3c and 5.

Precinct 3c

The Precinct 3c proposal (Figure 4) includes the construction of 2 warehouses as described below:

- Warehouse 3C1
 - Warehouse spanning 4,270 sqm
 - Two level office 400 sqm office
 - 4 x on grade doors with 20m awning
 - 2 x recessed docks with 3m awning
 - 36m hardstand for truck manoeuvring
 - Separate car and truck entry / exit

- Warehouse 3C2
 - Warehouse spanning 15,000 sqm
 - Two level office 1,000 sqm office
 - 7 x on grade doors with 20m awning
 - 4 x recessed docks with 3m awning
 - 40m hardstand for truck manoeuvring
 - Separate car and truck entry / exit

The Precinct 3c development includes a total of 19,270 sqm of warehouse space and 1,400 sqm of office space, totalling 20,670 sqm. To facilitate the above development, minor modifications are required to the eastern retaining wall on the site.

Precinct 5

The Precinct 5 proposal (Figure 5) includes the construction of 2 warehouses as described below:

- Warehouse 5A
 - Warehouse spanning 25,915 sqm
 - Two level office 614 sqm
 - 2 x 100sqm dock offices
 - 2 x 20 sqm gate houses

- 16 x on grade doors with 20m awning
 - 16 x recessed docks with 3m awning
 - 38m hardstand for truck manoeuvring
 - Separate car and truck entry / exit
- Warehouse 5B
 - Warehouse spanning 4,661 sqm
 - Two level office 400 sqm
 - 3 x on grade doors with 20m awning
 - 2 x recessed docks with 3m awning
 - 58m hardstand for truck manoeuvring
 - Separate car and truck entry / exit

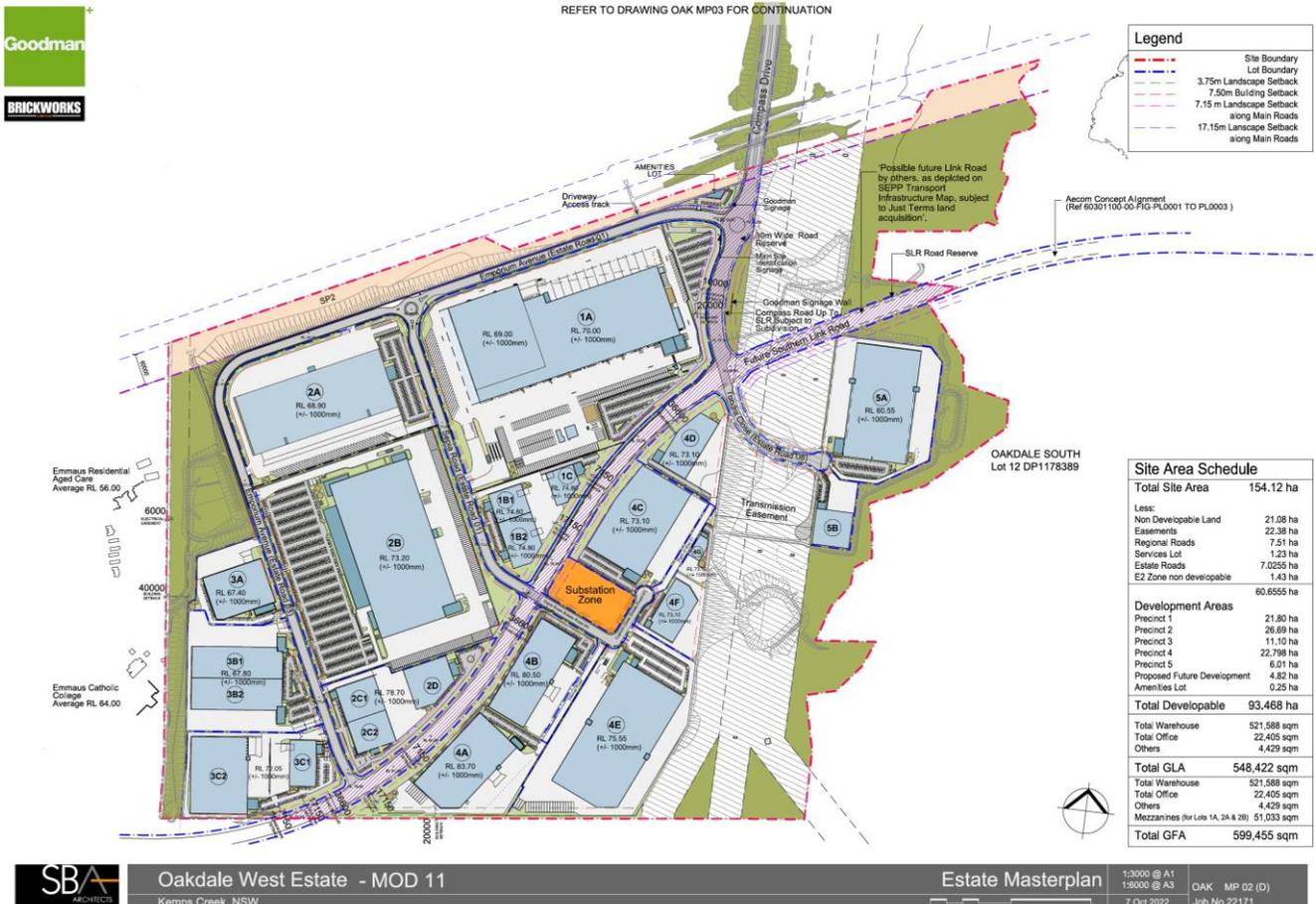


Figure 3: Oakdale West Estate Concept Masterplan

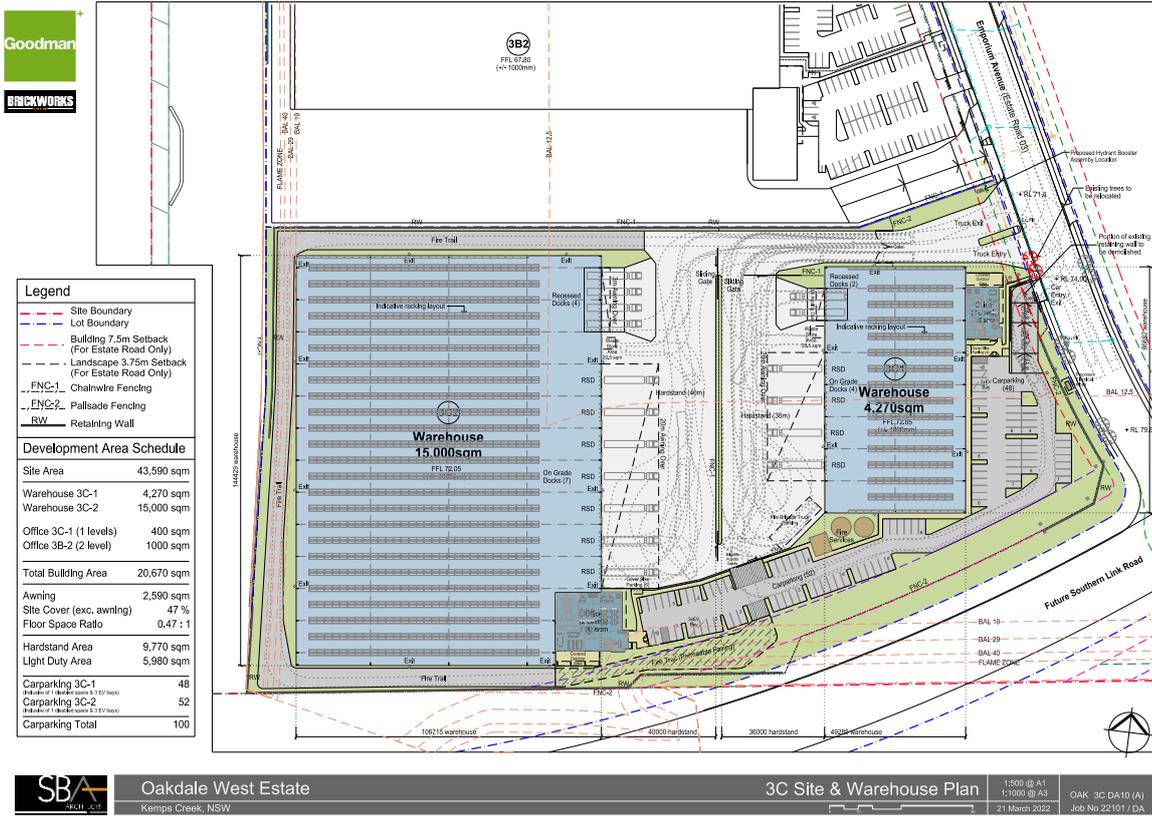


Figure 4: Proposed Precinct 3c Development

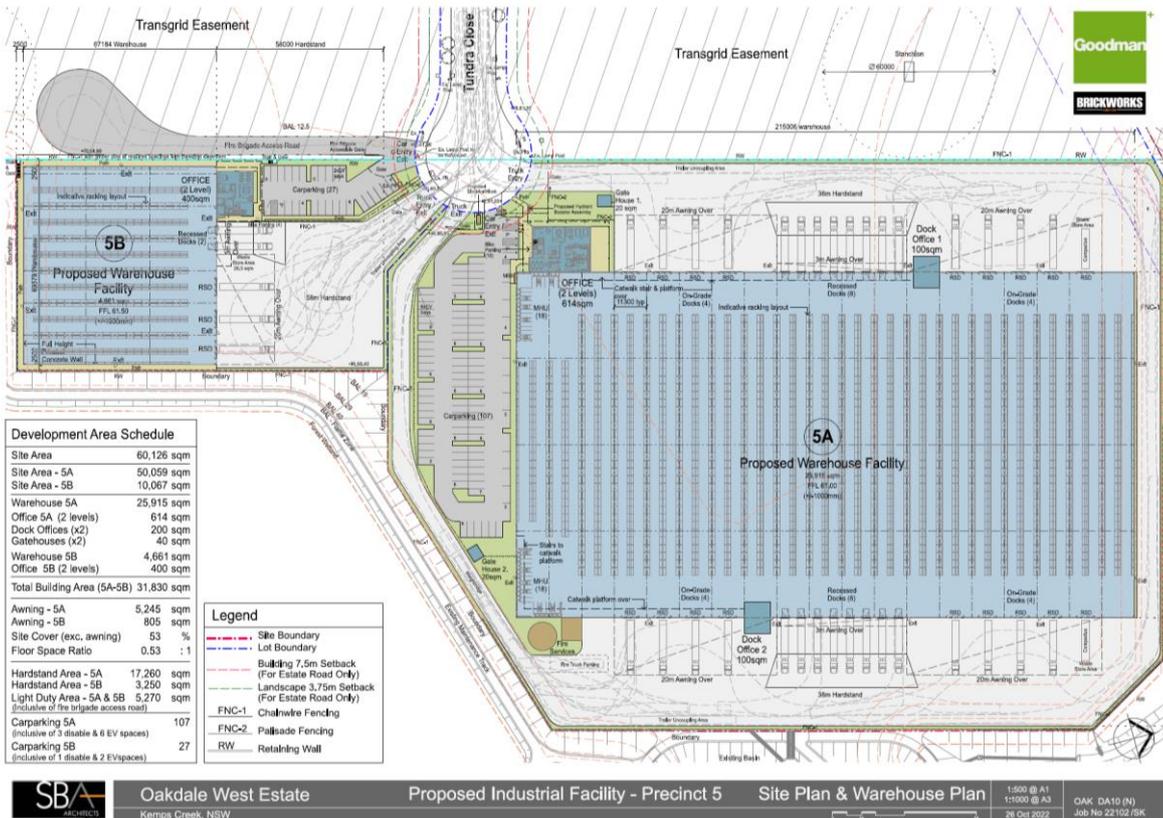


Figure 5: Proposed Precinct 5 Development

6. Site Assessment Methodology

The Bushfire Assessment Report is based on a desktop and site assessment of the site utilising the following resources:

- *Planning for Bushfire Protection* (NSW RFS, 2019);
- Aerial mapping;
- Site inspection; and
- Detailed GIS analysis.

This assessment is based on mapping of vegetation formations and slope assessment in accordance with PBP 2019. The methodology used in this assessment is in accordance with PBP 2019 and is outlined in the following sections.

6.1. Bushfire Hazard

An assessment of the bushfire hazard is necessary to determine the application of bushfire protection measures such as Asset Protection Zone (APZ) locations and dimensions and future building levels.

The vegetation formations (bushfire fuels) and the topography (effective slope) combine to create the bushfire threat that may affect bushfire behaviour at the site, and which determine the planning and building response of PBP 2019.

6.2. Fire Weather

The fire weather is dictated by PBP 2019 and assumes a credible worst-case scenario and an absence of any other mitigating factors relating to aspect or prevailing winds. The site has a Fire Danger Index (FDI) of 100 as per PBP 2019.

6.3. Vegetation

Predominant Vegetation is classified by structure or formation using the system adopted by Keith (2004) and by the general description using PBP 2019. Vegetation types give rise to radiant heat and fire behaviour characteristics.

The predominant vegetation is determined over a distance of at least 140 metres in all directions from the proposed site boundary or building footprint on the development site. Where a mix of vegetation types exist, the type providing the greater hazard is said to predominate.

The land around the site is identified as bushfire prone land (see Figure 2) and is made up of a mixture of Coastal Valley Grassy Woodland (south of Precinct 3c) and Coastal Floodplain Forest (East of Precinct 5) vegetation communities (see Figures 6 and 7). The remainder of the surrounding areas are managed/ non hazard areas.

6.4. Slopes Influencing Bushfire Behavior

The 'effective slope' influencing fire behaviour approaching the sites has been assessed in accordance with the methodology specified within PBP 2019. This is conducted by measuring the worst-case scenario slope where the vegetation occurs over a 100 m transect measured outwards from the development boundary or the existing/ proposed buildings.

The slopes within and adjoining both precincts are mild and generally fall downslope from the sites (Figure 6 and 7).



Legend

- Contour - 2m
- Subject Land
- Vegetated Mound
- Woodland
- Forest

Vegetation Formation



Date: 22/03/2022

0 25 50 100 150
Metres

Coordinate System: GDA 1994 MGA Zone 56
Imagery: © Nearmap

Figure 6: Vegetation and Slope Precinct 3c.



Legend

- | | |
|---|--|
|  Watercourse | Vegetation Formation |
|  Contour - 2m |  Forested Wetland |
|  Electricity Transmission Line | |
|  Subject Land | |

N



Date: 18/02/2022



Metres

Coordinate System: GDA 1994 MGA Zone 56
Imagery: © Nearmap

Figure 7: Vegetation and Slope Precinct 5.

6.5. Asset Protection Zones

An Asset Protection Zone (APZ) is a buffer zone between a bush fire hazard and buildings. The APZ is managed progressively to minimise fuel loads and reduce potential radiant heat levels, flame, smoke and ember attack. The appropriate APZ distance is based on vegetation type, slope and the nature of the development.

The APZ can include roads or properties managed to be consistent with APZ standards set out in RFS document *Standards for Asset Protection Zones*. The APZ provides a fuel-reduced, physical separation between buildings and bush fire hazards is a key element in the suite of bush fire measures and dictates the type of construction necessary to mitigate bushfire attack.

PBP 2019 requires APZs for commercial and industrial development to provide a defensible space and minimises material ignition. APZs are shown in Figure 8 and 9 and are compliant with PBP 2019.

The site will be managed and maintained to prevent the spread of a bushfire towards the building and to prevent the spread of fire onto or from the site in accordance with section 63 of the *Rural Fires Act 1997* (RF Act). The area around the buildings is cleared and maintained to mineral earth or non-combustible surfaces and is not a fire hazard.

Tables 2 and 3 below provide a summary of the APZ for proposed precincts 3c and 5 respectively. Figures 8 and 9 provide a depiction of the APZ.

Table 2: APZ Assessment – Precinct 3c.

Direction	Slope	Vegetation	Flame Zone Width	APZ Proposed
North	NA	No hazard	NA	NA
East	NA	No hazard	NA	NA
South	3° Upslope	Coastal Valley Grassy Woodlands	7 metres	19 metres
West	0-5° Downslope	Woodland	7.5 metres	8.5 metres

Table 3: APZ Assessment – Precinct 5.

Direction	Slope	Vegetation	Flame Zone Width	APZ Proposed
North	Level	Coastal Floodplain Forest	7 metres	>10 metres
East	Level	Coastal Floodplain Forest	7 metres	>10 metres
South	Level	Coastal Floodplain Forest	7 metres	>10 metres
West	NA	No hazard	NA	NA

6.5.1. Radiant Heat Modelling

Detailed radiant heat modelling has been undertaken for the site due to the unique nature of the site. Table 2 below is a summary of the key inputs, while the detailed outputs can be seen in Appendix 2.

To create conservatism in the APZ design, slopes have been rounded up to the nearest degree.

Table 4 and 5 is a summary of the key inputs and Appendix 2 contains the detailed outputs/results.

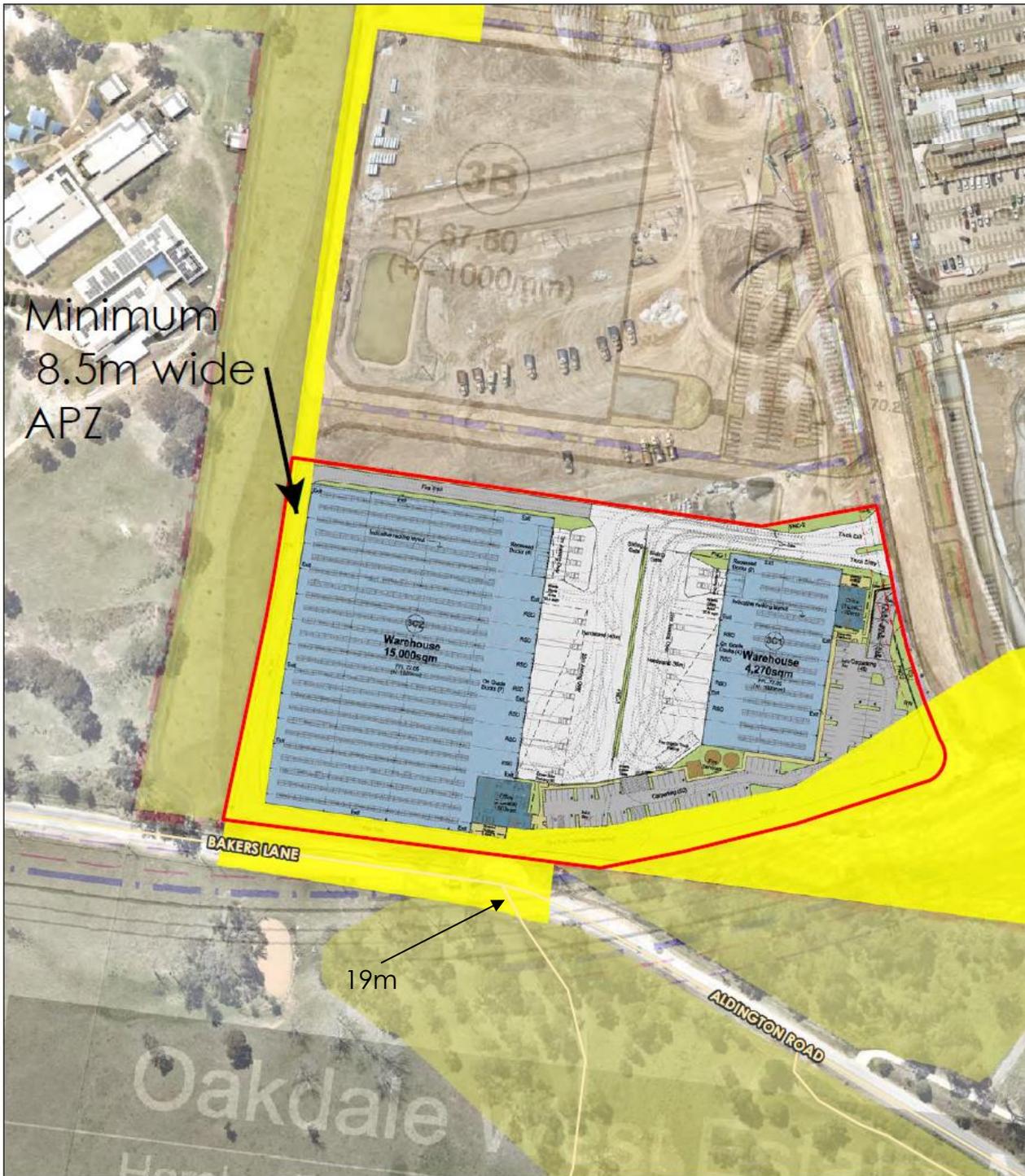
Table 4: Specific Modelling details Precinct 3c.

Direction	Slope	Vegetation	Short Fire Run	Min APZ Provided	Radiant Heat
South	3° Up	Coastal Valley Grassy Woodland	NA	19 metres	13.74kW/m ²
West	5° Down	Coastal Valley Grassy Woodlands	30 metres	8.5 metres	20.75kW/m ²

Table 5: Specific Modelling details Precinct 5.

Direction	Slope	Vegetation	Short Fire Run	Min APZ Required	Radiant Heat
North	Level	Coastal Floodplain Forest	NA*	10 metres	25.96kW/m ²
East	Level	Coastal Floodplain Forest	NA*	10 metres	25.96kW/m ²
South	Level	Coastal Floodplain Forest	NA*	10 metres	25.96kW/m ²

**Note: While the use of a Short Fire Run in the modelling is appropriate, it has not been used and provides for an additional level of conservatism and therefore redundancy on the design.*



Minimum
8.5m wide
APZ

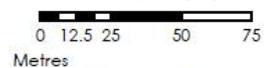
19m

Legend

- Subject Land
- Asset Protection Zone
- Vegetation Formation**
- Woodland

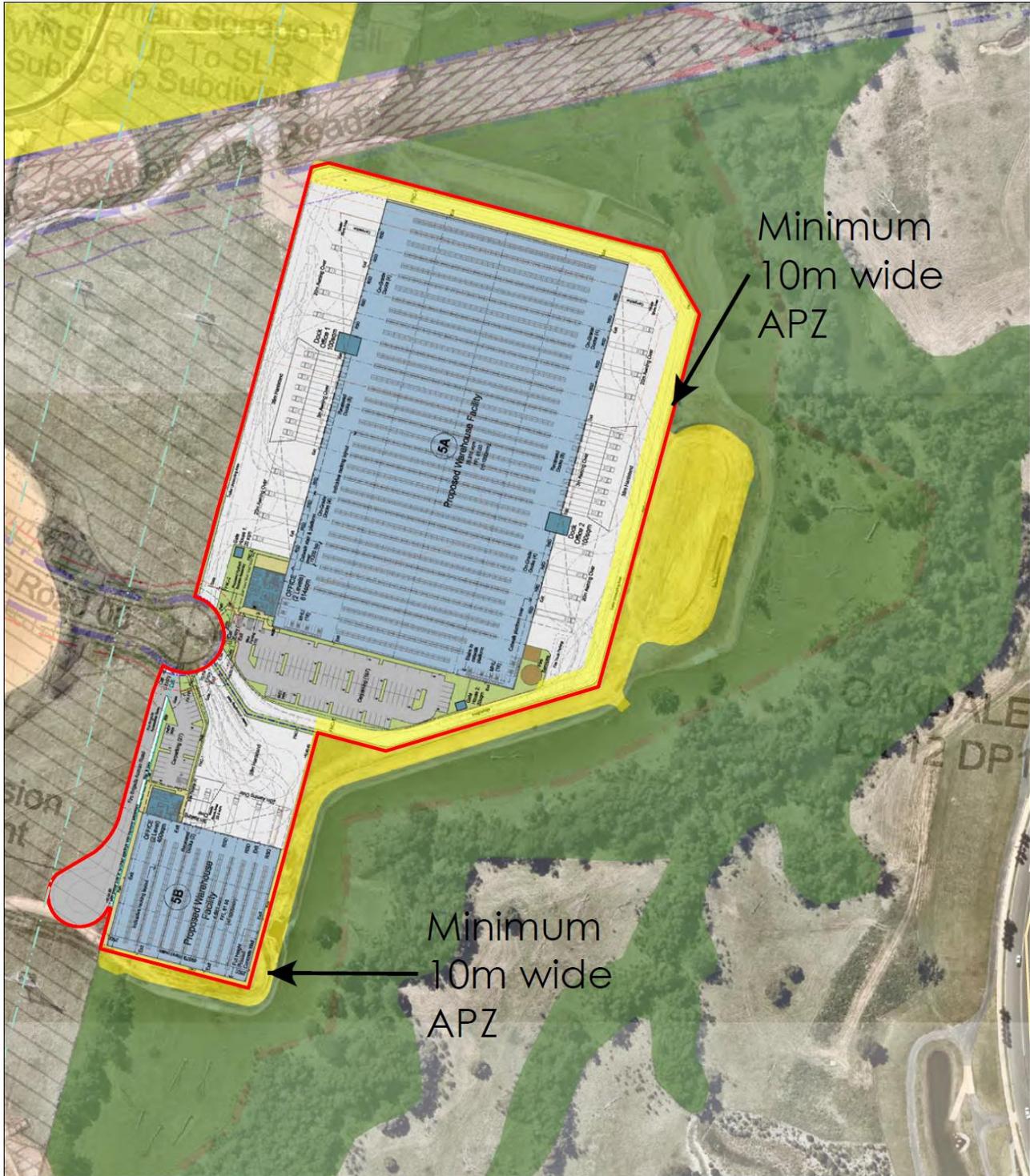


Date: 22/03/2022



Coordinate System: GDA 1994 MGA Zone 56

Figure 8: Asset Protection Zones – Precinct 3c



Legend

- Electricity Transmission Line
- Subject Land
- Asset Protection Zone
- Vegetation Formation**
- Forest



Date: 27/10/2022



Metres

Coordinate System: GDA 1994 MGA Zone 56

Figure 9: Asset Protection Zones – Precinct 5

6.6. Bushfire Attack Levels

The Bushfire Attack Level (BAL) is a means of measuring the severity of a buildings or sites potential exposure to ember attack, radiant heat and direct flame contact. In the Building Code of Australia, the BAL is used as the basis for establishing the requirements for construction to improve protection of building elements.

The Bushfire Attack Levels to the site (Tables 5 and 6) have been calculated through site specific radiant heat modelling. As "Other" development, the development must comply with objective 3 of PBP 2019 which requires that the development:

3. Provide appropriate separation between a hazard and buildings, which, in combination with other measures, prevent the likely fire spread to buildings.

Asset Protection Zones (see section 6.5) will be provided around the development that will include perimeter roads and hardstand areas. The buildings will be constructed to meet the relevant requirements of AS3959-2018 as identified through the radiant heat modelling consistent with the methodology in PBP 2019.

The building requirements for design and construction vary according to the bushfire attack level for the building. The building requirements for each BAL are set out in *Australian Standard: 3959 Construction of buildings in bushfire-prone areas 2009 (AS3959)*.

Detailed BAL mapping has been undertaken for the site (see Figures 10 and 11) based on specific radiant heat modelling as described in section 6.5.1 (see Appendix 3). Tables 6 and 7 (below) provide a summary of the key modelling inputs across the precincts and Figures 10 and 11 depict the BAL as mapped across the precincts. The Bushfire Attack Levels have been determined based on the site assessment methodology in PBP 2019.

Table 6: Bushfire Attack Levels – Precinct 3c.

Direction	Slope	Vegetation	APZ Proposed	BAL
North	NA	No hazard	NA	See Figure 10*
East	NA	No hazard	NA	See Figure 10*
South	3° Upslope	Coastal Valley Grassy Woodlands	>19 metres	See Figure 10*
West	0-5° Downslope	Coastal Valley Grassy Woodlands	>8.5 metres	See Figure 10*

*Note: The extent of the BAL for the building is depicted in detail in Figure 10.

Table 7: Bushfire Attack Levels – Precinct 5.

Direction	Slope	Vegetation	APZ Proposed	BAL
North	Level	Coastal Floodplain Forest	>10 metres	See Figure 11*
East	Level	Coastal Floodplain Forest	>10 metres	See Figure 11*
South	Level	Coastal Floodplain Forest	>10 metres	See Figure 11*
West	NA	No hazard	NA	See Figure 11*

*Note: The extent of the BAL for the building is depicted in detail in Figure 11.

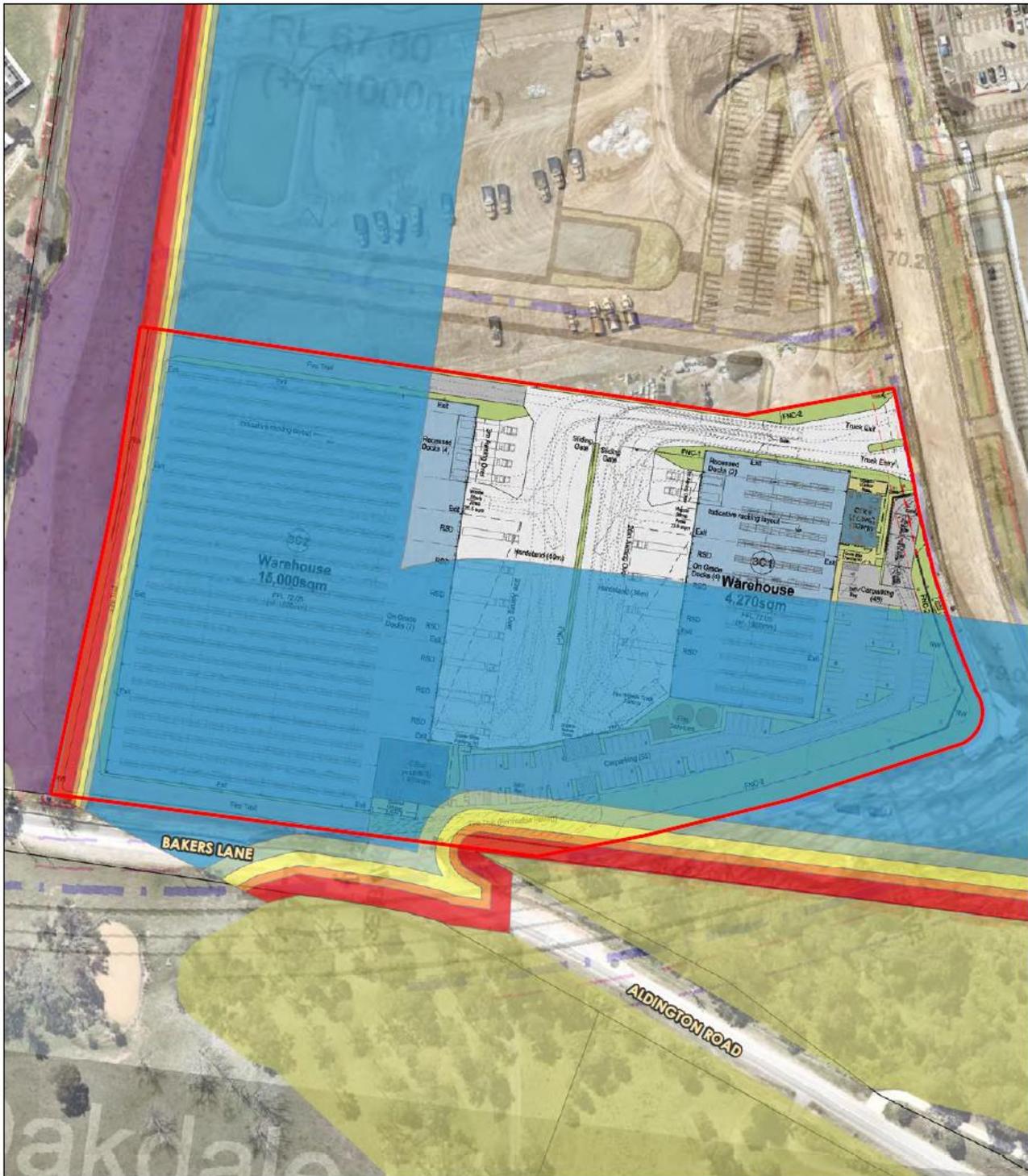
6.6.1. Application of AS3959 (2018)

Construction must comply with the corresponding Bushfire Attack Level (BAL) as shown in Figures 10 and 11.

The application of each BAL is as defined on Figures 10 and 11 and not broadly applied across the entire elevation/building. The construction must comply with corresponding sections of the Australian Standard AS3959-2018 *Construction of buildings in bush fire-prone areas* or NASH Standard (1.7.14 updated) *National Standard Steel Framed Construction in Bushfire Areas – 2014* as appropriate, and Section 7.5 of *Planning for Bush Fire Protection 2019*.

The construction for the remainder of the proposed buildings not denoted with a BAL in Figures 10 and 11 is greater than 100 metres from any bushfire hazard. Consistent with AS3959, construction greater than 100 metres from a bushfire hazard is classified as BAL-Low. AS3959 describes BAL-Low as “*There is insufficient risk to warrant specific construction requirements*”. Therefore, the construction for the remainder of the proposed building not denoted with a BAL in Figures 10 and 11, is appropriately BAL-Low.

The construction of the buildings in this manner complies with *Planning for Bush Fire Protection 2019* and the National Construction Code (NCC).



Legend

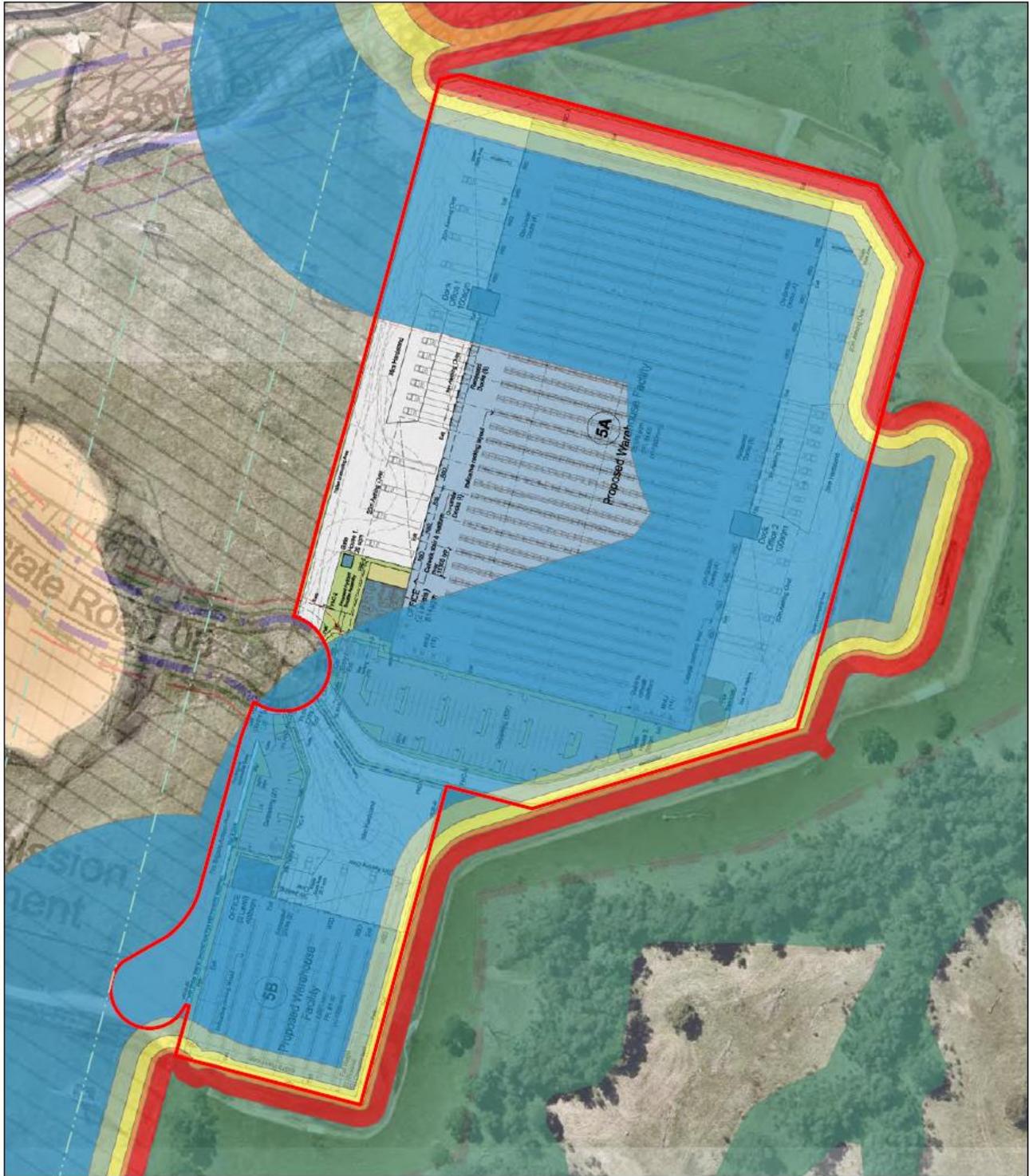
 Subject Land	Bushfire Attack Level (BAL)	 BAL - 19
 Lot	 BAL - Flame Zone	 BAL - 12.5
Vegetation Formation	 BAL - 40	
 Vegetated Mound	 BAL - 29	
 Woodland		

N
DKGIS
Date: 22/03/2022

0 12.5 25 50 75
Metres

Coordinate System: GDA 1994 MGA Zone 56

Figure 10: Bushfire Attack Levels – Precinct 3c

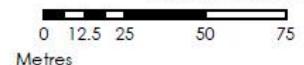


Legend

- | | | |
|-------------------------------|------------------------------------|------------|
| Electricity Transmission Line | Bushfire Attack Level (BAL) | BAL - 19 |
| Subject Land | BAL - Flame Zone | BAL - 12.5 |
| Vegetation Formation | BAL - 40 | |
| Forested Wetland | BAL - 29 | |



Date: 27/10/2022



Coordinate System: GDA 1994 MGA Zone 56

Figure 11: Bushfire Attack Levels – Precinct 5

7. Access

PBP 2019 requires that the design of access roads enables safe access and egress for people attempting to leave the area at the same time that emergency service personnel are arriving to undertake firefighting operations.

Figure 3 shows the OWE Masterplan which includes the access to the site.

Vehicular access to the proposed Oakdale West Estate will be provided in the north-eastern part of the site, providing a link north to Lenore Drive and the broader external road network.

This road and the proposed internal access roads will be constructed to provide heavy rigid and articulated vehicle access to each of the proposed precincts. This internal road network provides suitable access for fire-fighting appliances like NSW RFS Category 1 Tankers and Fire & Rescue NSW Composite and Aerial Appliances.

The precinct designs provide for access around each of the proposed buildings and to the adjoining low risk bushfire prone vegetation.

Given the comprehensive nature of the road design, access complies with the requirements of PBP 2019.

8. Water Supply and Utilities

PBP 2019 (p. 47) requires that adequate services of water for the protection of buildings during and after the passage of a bush fire, and to locate gas and electricity so as not to contribute to the risk of fire to a building.

Suitable water supply arrangements will be provided for firefighting that meet the NSW RFS requirements. A reticulated water supply for potable water supply and fire hydrants will be provided to the site. The fire-fighting water supply to the proposed building shall comply with the Building Code of Australia [BCA] and A.S. 2419.1 – 2005.

Both Precincts will be provided with a ring-main to the hazard side of the building, complete with Millcock Valves fitted with Stortz Coupling and Blanking Cap.

9. Emergency Management Arrangements

Emergency management arrangements will be demonstrated through a separate Bushfire Emergency Management and Evacuation Plan which will be provided prior to occupation that will include triggers for closing the site and what to do in the event of a bushfire emergency.

10. Assessment Against the Aim and Objectives of PBP

All development on Bushfire Prone Land needs to comply with the aim and objectives of PBP. Table 6 shows the compliance with PBP.

Table 6: Compliance with Aim & Objectives of PBP

Aim	Meets Criteria	Comment
The aim of PBP is to use the NSW development assessment system to provide for the protection of human life (including fire fighters) and to minimise impacts on property from the threat of bushfire, while having due regard to development potential, onsite amenity and the protection of the environment.	Yes	Landscaping, defensible space, access and egress, emergency risk management and construction standards are in accordance with the requirements of PBP and the aims of PBP have been achieved.
Objectives	Meets Criteria	Comment
Afford occupants of any building adequate protection from exposure to a bushfire.	Yes	The development provides opportunity for all occupants to be shielded from any external bushfire. Construction material will comply with the relevant AS3959 requirements.
Provide for a defensible space to be located around buildings.	Yes	Defensible space is provided on all sides of the proposed building.
Provide appropriate separation between a hazard and buildings, which, in combination with other measures, prevent the likely fire spread to buildings.	Yes	The building is separated from the forest vegetation and is provided APZs and commensurate construction in accordance with AS3959.
Ensure that safe operational access and egress for emergency service personnel and occupants is available.	Yes	The site has direct access to public roads, and access and egress for emergency vehicles and evacuation is adequate. A perimeter road is provided around the building. The development provides for the movement of heavy articulated trucks about the site.
Provide for ongoing management and maintenance of bushfire protection measures.	Yes	The site will be managed by Goodman including all APZ and landscaping in accordance with PBP.
Ensure that utility services are adequate to meet the needs of firefighters.	Yes	Utility services are adequate to meet the needs of firefighters (and others assisting in bushfire fighting).

The suite of bushfire protection measures provided for the proposed development satisfies the objectives for buildings of Class 5-8 under the NCC as identified in section 8.3.1 of PBP 2019.

11. Recommendations

The following recommendations are made to ensure the Oakdale West Estate is provided with adequate bushfire protection in accordance with PBP:

Recommendation 1: At the commencement of building works and in perpetuity, Asset Protection Zones shall be established and maintained on the precincts as per Figures 8 and 9. The APZ shall be established and maintained as an inner protection area as outlined within *Planning for Bushfire Protection 2019* and the NSW RFS document '*Standards for Asset Protection Zones*'.

Recommendation 2: Fire hydrants are provided in accordance with Building Code of Australia E1.3, AS2419.1:2005, including the ring main complete with Millcock Valves fitted with Stortz Coupling and Blanking Cap.

Recommendation 3: The construction shall comply with the National Construction Code (2019), Australian Standard AS 3959:2018, Construction of buildings in bush fire-prone areas and/or NASH Standard (1.7.14 updated), National Standard Steel Framed Construction in Bushfire Areas – 2014, and Section 7.5 of Planning for Bush Fire Protection 2019 on a prescriptive (deemed to satisfy and/or acceptable solution) basis and/or performance basis to the extent identified in Figures 10 and 11.

12. Conclusion

The Bushfire Hazard Assessment to support a Development Application (DA) for the construction of Precincts 3c and 5 at the Oakdale West Estate (OWE).

The site is on bushfire prone land. Commercial and industrial development is designated as “other” development in PBP 2019. As “other” development, the proposed development has considerable flexibility, and the nature of the development often results in the structures providing a higher degree of bushfire resistance than that specified by PBP and AS3959.

The proposed new buildings within Precincts 3c and 5 can respond and implement an appropriate level of bushfire protection measures, as per PBP 2019.

This Report is a Bush Fire Hazard Assessment that provides the required information to assist Penrith City Council in determining compliance in accordance with the aims and objectives of *Planning for Bushfire Protection 2019*.



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B.Sc., Grad. Dip. (Design for Bushfire Prone Areas)
Fire Protection Association of Australia BPAD Level 3 - 34603



Appendix 1 References

Australian Building Codes Board Building Code of Australia Volumes 1&2

Councils of Standards Australia AS3959 (2018) – Australian Standard Construction of buildings in bushfire-prone areas

Keith, David (2004) – Ocean Shores to Desert Dunes – The Native Vegetation of New South Wales and the ACT. The Department of Environment and Climate Change

NSW Rural Fire Service (2015) Guide for Bushfire Prone Land Mapping.

NSW Rural Fire Service (RFS). 2006. Planning for Bushfire Protection: A Guide for Councils, Planners, Fire Authorities, Developers and Home Owners. Australian Government Publishing Service, Canberra.

NSW Rural Fire Service (RFS). 2019. Planning for Bushfire Protection: A Guide for Councils, Planners, Fire Authorities, Developers and Home Owners.

NSW Government (1979) Environmental Planning and Assessment Act 1979. NSW Government Printer.

Appendix 2: Radiant Heat Modelling Outputs (APZ)

Forest/Woodland - FDF & SFR Calculation page:
Fire run specifics:

Common and bushfire behaviour contributor inputs:
Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph
Average Canopy Height: Metres Fire weather district: FDI
Average elevated fuel height: Metres Flame temperature: Kelvin
Distance to vegetation: Metres Target elevation of receiver: Metres
Effective slope: Degrees Ambient temperature: Kelvin
Site slope: Degrees SFR fire run length: Metres
IF nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**
Wind Speed: kph Wind speed: kph
Default elevation of receiver: Metres Default elevation of receiver: Metres
FDF Flame Angle: Degrees SFR Flame Angle: Degrees
FDF Flame Length: Metres SFR Flame Height: Metres
FDF Intensity: kW/m SFR Intensity: kW/m
FDF FROS: kph SFR FROS: kph
FDF Flame transmissivity: kW/m SFR Flame transmissivity: kW/m
FDF View Factor: SFR View Factor: Calculated SFR Head Width: Metres
SFR fire run length: Metres
Approx. SFR travel time: min/sec

FDF Radiant Heat: 13.74 kW/m² **SFR Radiant Heat: 0.00 kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:
tph = tonnes per hectare m/h = metres per hour K = Kelvin
kW/m = Kilowatts per metre FROS = Forward rate of Spread min = minutes
kW/m² = Kilowatts per metre squared kph = kilometres per hour sec = seconds
HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 3c – Min APZ (South)

Forest/Woodland - FDF & SFR Calculation page:
Fire run specifics:

Common and bushfire behaviour contributor inputs:
Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph
Average Canopy Height: Metres Fire weather district: FDI
Average elevated fuel height: Metres Flame temperature: Kelvin
Distance to vegetation: Metres Target elevation of receiver: Metres
Effective slope: Degrees Ambient temperature: Kelvin
Site slope: Degrees SFR fire run length: Metres
IF nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**
Wind Speed: kph Wind speed: kph
Default elevation of receiver: Metres Default elevation of receiver: Metres
FDF Flame Angle: Degrees SFR Flame Angle: Degrees
FDF Flame Length: Metres SFR Flame Height: Metres
FDF Intensity: kW/m SFR Intensity: kW/m
FDF FROS: kph SFR FROS: kph
FDF Flame transmissivity: kW/m SFR Flame transmissivity: kW/m
FDF View Factor: SFR View Factor: Calculated SFR Head Width: Metres
SFR fire run length: Metres
Approx. SFR travel time: min/sec

FDF Radiant Heat: 47.52 kW/m² **SFR Radiant Heat: 20.75 kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:
tph = tonnes per hectare m/h = metres per hour K = Kelvin
kW/m = Kilowatts per metre FROS = Forward rate of Spread min = minutes
kW/m² = Kilowatts per metre squared kph = kilometres per hour sec = seconds
HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 3c – Min APZ (West)

Forest/Woodland - FDF & SFR Calculation page:
Fire run specifics:

Common and bushfire behaviour contributor inputs:
Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph
Average Canopy Height: Metres Fire weather district: FDI
Average elevated fuel height: Metres Flame temperature: Kelvin
Distance to vegetation: Metres Target elevation of receiver: Metres
Effective slope: Degrees Ambient temperature: Kelvin
Site slope: Degrees SFR fire run length: Metres
IF nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**
Wind Speed: kph Wind speed: kph
Default elevation of receiver: Metres Default elevation of receiver: Metres
FDF Flame Angle: Degrees SFR Flame Angle: Degrees
FDF Flame Length: Metres SFR Flame Height: Metres
FDF Intensity: kW/m SFR Intensity: kW/m
FDF FROS: kph SFR FROS: kph
FDF Flame transmissivity: kW/m SFR Flame transmissivity: kW/m
FDF View Factor: SFR View Factor: Calculated SFR Head Width: Metres
SFR fire run length: Metres
Approx. SFR travel time: min/sec

FDF Radiant Heat: 25.96 kW/m² **SFR Radiant Heat: 0.00 kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:
tph = tonnes per hectare m/h = metres per hour K = Kelvin
kW/m = Kilowatts per metre FROS = Forward rate of Spread min = minutes
kW/m² = Kilowatts per metre squared kph = kilometres per hour sec = seconds
HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 5 – Min APZ (North, East and South)

Appendix 3: Radiant Heat Modelling Outputs (BAL Mapping)

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

DFD Flame Angle: Degrees SFR Flame Angle: Degrees

DFD Flame Length: Metres SFR Flame Height: Metres

DFD Intensity: kW/m SFR Intensity: kW/m

DFD FROS: kph SFR FROS: kph

DFD Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

DFD View Factor: SFR View Factor:

Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

DFD Radiant Heat: 39.04 kW/m² **SFR Radiant Heat: 0.00 kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = Kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = Kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 3C (South) – BAL-40

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

DFD Flame Angle: Degrees SFR Flame Angle: Degrees

DFD Flame Length: Metres SFR Flame Height: Metres

DFD Intensity: kW/m SFR Intensity: kW/m

DFD FROS: kph SFR FROS: kph

DFD Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

DFD View Factor: SFR View Factor:

Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

DFD Radiant Heat: 26.79 kW/m² **SFR Radiant Heat: 0.00 kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = Kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = Kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 3C (South) – BAL-29

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

DFD Flame Angle: Degrees SFR Flame Angle: Degrees

DFD Flame Length: Metres SFR Flame Height: Metres

DFD Intensity: kW/m SFR Intensity: kW/m

DFD FROS: kph SFR FROS: kph

DFD Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

DFD View Factor: SFR View Factor:

Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

DFD Radiant Heat: 17.69 kW/m² **SFR Radiant Heat: 0.00 kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = Kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = Kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 3C (South) – BAL-19

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

DFD Flame Angle: Degrees SFR Flame Angle: Degrees

DFD Flame Length: Metres SFR Flame Height: Metres

DFD Intensity: kW/m SFR Intensity: kW/m

DFD FROS: kph SFR FROS: kph

DFD Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

DFD View Factor: SFR View Factor:

Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

DFD Radiant Heat: 12.30 kW/m² **SFR Radiant Heat: 0.00 kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = Kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = Kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 3C (South) – BAL-12.5

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

FDF Flame Angle: Degrees SFR Flame Angle: Degrees

FDF Flame Length: Metres SFR Flame Height: Metres

FDF Intensity: kW/m SFR Intensity: kW/m

FDF FROS: kph SFR FROS: kph

FDF Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

FDF View Factor: SFR View Factor: Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

FDF Radiant Heat: kW/m² **SFR Radiant Heat: kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 5 – BAL-40

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

FDF Flame Angle: Degrees SFR Flame Angle: Degrees

FDF Flame Length: Metres SFR Flame Height: Metres

FDF Intensity: kW/m SFR Intensity: kW/m

FDF FROS: kph SFR FROS: kph

FDF Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

FDF View Factor: SFR View Factor: Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

FDF Radiant Heat: kW/m² **SFR Radiant Heat: kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 5 – BAL-29

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

FDF Flame Angle: Degrees SFR Flame Angle: Degrees

FDF Flame Length: Metres SFR Flame Height: Metres

FDF Intensity: kW/m SFR Intensity: kW/m

FDF FROS: kph SFR FROS: kph

FDF Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

FDF View Factor: SFR View Factor: Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

FDF Radiant Heat: kW/m² **SFR Radiant Heat: kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 5 – BAL-19

Forest/Woodland - FDF & SFR Calculation page:

Fire run specifics:

Common and bushfire behaviour contributor inputs:

Predominant vegetation:

Surface & Elevated Fuel Load: tph Overall fuel load: tph

Average Canopy Height: Metres Fire weather district: FDI

Average elevated fuel height: Metres Flame temperature: Kelvin

Distance to vegetation: Metres Target elevation of receiver: Metres

Effective slope: Degrees Ambient temperature: Kelvin

Site slope: Degrees SFR fire run length: Metres

Nominal head width: Metres

Outputs - Fully Developed Fire (FDF) **Outputs - Developing Fire Run (DFR)**

Wind Speed: kph Wind speed: kph

Default elevation of receiver: Metres Default elevation of receiver: Metres

FDF Flame Angle: Degrees SFR Flame Angle: Degrees

FDF Flame Length: Metres SFR Flame Height: Metres

FDF Intensity: kW/m SFR Intensity: kW/m

FDF FROS: kph SFR FROS: kph

FDF Flame transmissivity: kW/m SFR Flame transmissivity: kW/m

FDF View Factor: SFR View Factor: Calculated SFR Head Width: Metres

SFR fire run length: Metres

Approx. SFR travel time: min/sec

FDF Radiant Heat: kW/m² **SFR Radiant Heat: kW/m²**

Input cells Locked output cells

Glossary of abbreviations/terms:

tph = tonnes per hectare m/h = metres per hour K = Kelvin
 kW/m = kilowatts per metre FROS = Forward rate of Spread min = minutes
 kW/m² = kilowatts per metre squared kph = kilometres per hour sec = seconds
 HFD = Horizontal Flame Depth FF = Flank Fire min/sec = minutes and seconds
 LRV = Low Risk Vegetation SFR = Short Fire Run

Precinct 5 – BAL-12.5