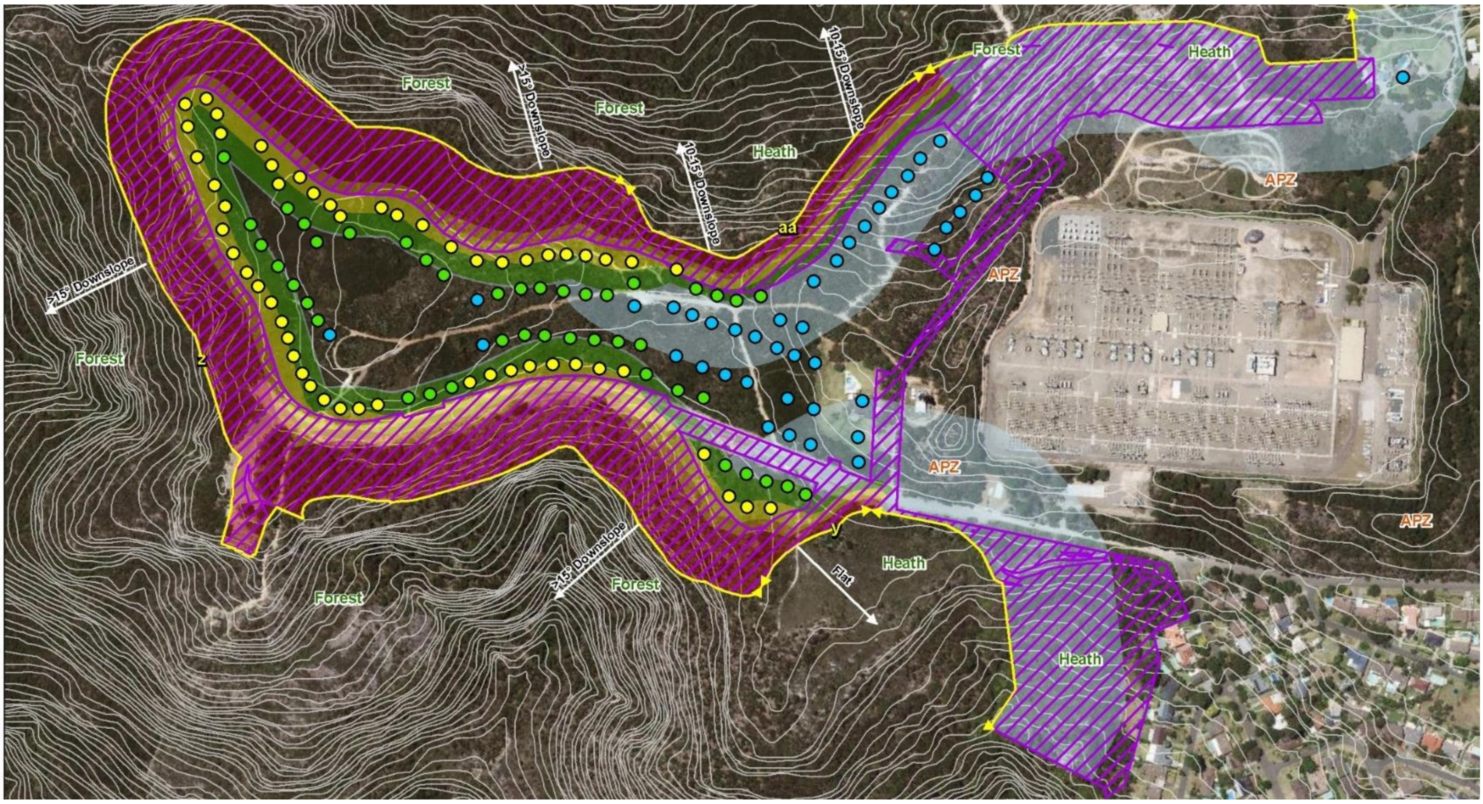
Ralston Avenue Belrose Planning Proposal: Review

Prepared for
RFS and Matthews Civil Pty Ltd

16 August 2017



Contents

1 Background

At a meeting between the proponent and the RFS on 7th July 2017 it was agreed that an independent bushfire expert review of the proposal would be considered.

Another meeting between RFS officers, Council and Rod Rose occurred on the 13th July 2017. Council and RFS communicated their concerns with the proposal at this meeting. It was agreed that the review focus on a comparison of the bushfire risk of the existing urban interface and a new urban interface established by the planning proposal.

The review of the planning proposal has been independently undertaken by Rod Rose. The report has not been edited or modified by any other party; including the RFS, Council, the proponent or any of the proponent consultants.

Rod Rose is a BPAD Level 3 Bushfire Consultant with over 23 years bushfire consulting experience in NSW and around Australia (see CV in **Appendix A**). Rod has managed over 1600 bushfires and is nationally recognised for his experience and expertise in bushfire protection planning, bushfire management planning, bushfire evacuation planning and fire ecology. He is also an expert in bushfire protection and risk for electricity infrastructure in NSW and is an approved bushfire auditor of such infrastructure by IPART.

Past bushfire assessment reports related to the proposal and the RFS response to these and a report by Blackash Bushfire Consulting have been reviewed. The site was inspected on 13th July 2017.

2 Methodology

This review does not specifically critique the bushfire protection assessments of other bushfire consultants, or the RFS or Council response to these. The review compares the existing bushfire risk of the urban-bushland interface with the bushfire risk of the interface resulting from the planning proposal. Wherever possible, objective assessment has been used to describe and analyse the risk between the proposed and existing interface.

The following risks are compared between the 'existing' and 'proposed' interface, see **Figures 1** and **2** and **Table 1**:

- Number of dwellings and occupants exposed to each BAL level;
    - Occupants are assumed as 2.6 per dwelling*
- Indicative BAL construction at existing interface;
- Number of houses exposed to BAL beyond their construction standard;
- Evacuation time available and number of dwellings and persons at risk;
- Extent of TransGrid sub-station, and telecommunication tower exceeding 10kW/m2;
- On-site refuge capacity and risk;
- Future ability to improve bushfire risk;

** occupant levels were assumed as 2.6 based on the 2016 Census for all dwellings*.

3 Assumptions

- Bushfire attack levels and fire spread predictions are based upon an FFDI 100, and unmanaged fuel in all vegetation types outside identified APZ
- Dwellings currently located at the urban interface are typically older housing stock and do not incorporate AS3959 building protection features. Based on a site inspection it is assumed 10% of existing dwellings are AS3959 compliant, however, this is likely to be a high estimate.
- RHF failure point for rubber and plastics is 10kW/m^2 and these components are part of the wiring and other vulnerable features within a sub-station and on telecommunication towers.

4 Limitations

The review has been conducted over a few weeks and in that time frame focused on primary bushfire risk matters. Other lesser risks, and contributions to risk, could be considered in a more detailed review, however, a reasonable indicator or relative risk is recognisable from the data considered.

Modelling of fire behaviour, short fire runs, Bushfire Attack Levels and the like each have limitations based upon input selections, data accuracy, model algorithms and other factors. If the data or outputs from any of the approaches used is to be used for a specific site e.g. dwelling, a more detailed approach is required. At this stage, however, the review is limited to a conceptual level analysis.

5 Results

Table 1 compares various bushfire risk criteria between the existing and proposed urban interface.

Table 1: Bushfire risk comparison of existing versus proposed urban interface

Criteria	Existing interface	Proposed interface	Comments
Dwellings/persons exposed to **BAL FZ**	7 (18 persons)	6 (16 persons)	The proposed interface does not significantly lower the number of buildings potentially within the flame zone; however, there is a lowering of the likelihood of bushfire attack resulting in a BAL FZ exposure. This is because the area of 'uninterrupted' fire catchment for the potential BAL FZ exposed buildings diminishes in the key NW and SW directions, and a smaller catchment means a lower: • probability of ignitions within the catchment; • number of fires reaching the interface; and • potential intensity of the fire at the interface. The length of fire run for a direct head fire attack for most of the BAL FZ exposed buildings is well over 3 km from most directions i.e. a large fire catchment, and a higher probability of major fire development.
Dwellings/persons exposed to **BAL 40**	2 (5)	2 (5)	As above
Dwellings/persons exposed to **BAL 29**	12 (31)	62 (161)	The proposed interface has an increased number of buildings exposed to BAL 29, however, all new buildings will be BAL 29 compliant. It is unlikely that more than 10% of the 12 buildings at the existing interface are BAL 29 compliant.
Dwellings/persons exposed to **BAL 19**	23 (60)	64 (166)	An increased number of buildings are exposed to BAL 19; however, all new buildings will be BAL 19 compliant. It is unlikely that more than 10% of the 23 buildings at the existing interface are BAL 19 compliant.
Dwellings/persons exposed to **BAL 12.5**	71 (185)	100 (260)	An increased number of buildings are exposed to BAL 12.5; however, all new buildings will be BAL 12.5 compliant. It is unlikely that more than 10% of the 71 buildings at the existing interface are BAL 12.5 compliant.
Non BAL-compliant dwellings at interface	104 (270)	87 (226)	Assumed 10% of the existing dwellings abutting the interface are BAL compliant. Non-compliance assumes no AS3959 modifications to the dwelling and includes non-compliance at BAL 12.5 and above.
Extent of Sydney east sub-station exposed to >10 kW/m^2	4.76 ha	2.80 ha	See Figure 1 and 2. Any plastics and rubber associated with transformers and switching etc exposed to >10kW/m2 will melt or burn. The proposal lowers the risk of substation failure, and options exist to eliminate it (see later in report).
RHF at base of Communications tower	76 kW/m2	76 kW/m2	Communications tower is at high risk of failure at RHF >10 kW/m^2 due to plastics and rubber exposures. The proposal reduces the RHF <10kW/m^2 in most locations however, some minor additional works would be required to lower it from all directions. The existing risk requires significant APZ across multiple land tenures.
Availability of community refuge	None	None proposed	A neighbourhood safer place is potentially feasible under the planning proposal; but is considered highly unlikely to be retrofitted to the existing urban interface.

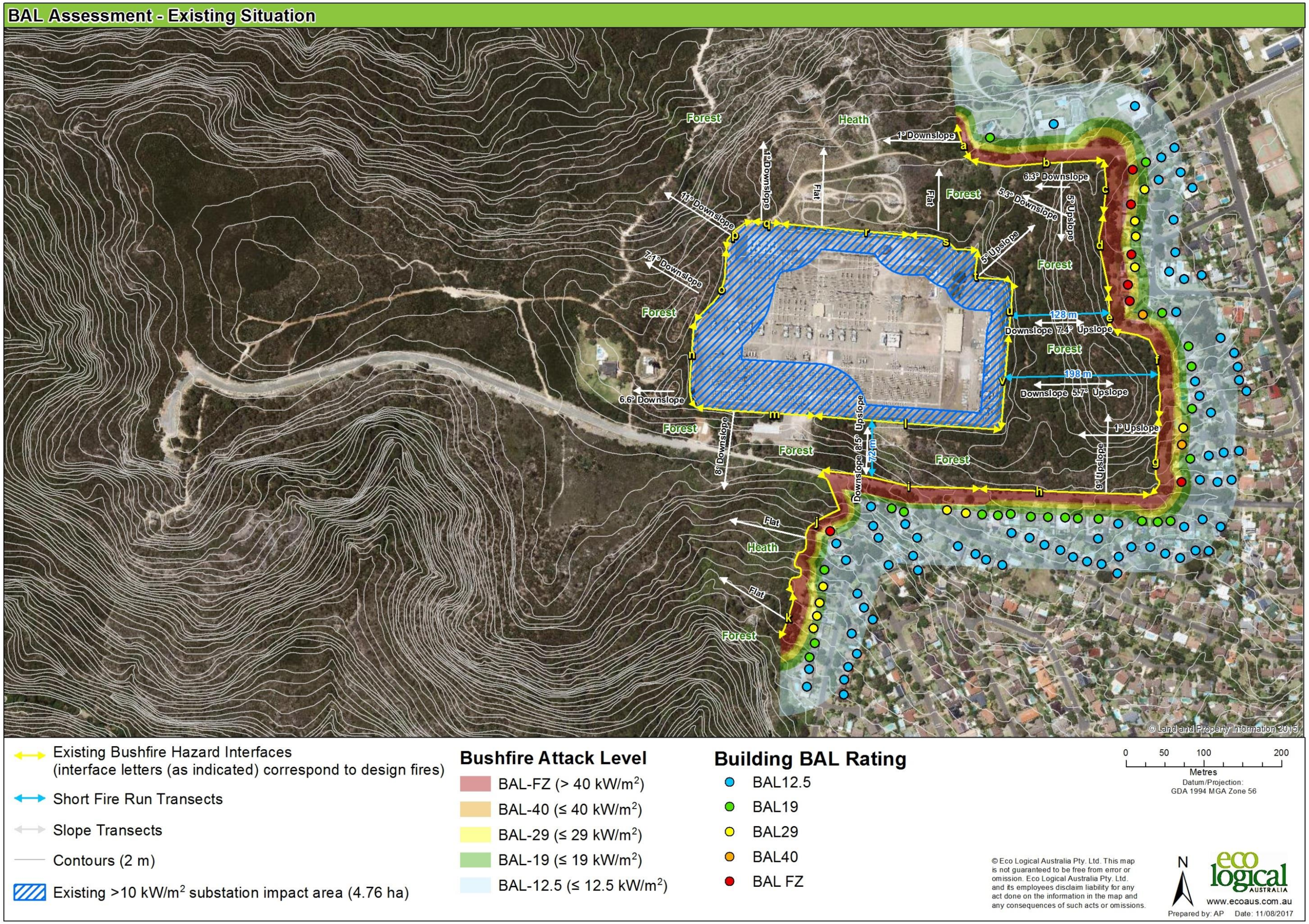


Figure 1: BAL Assessment – Existing Situation

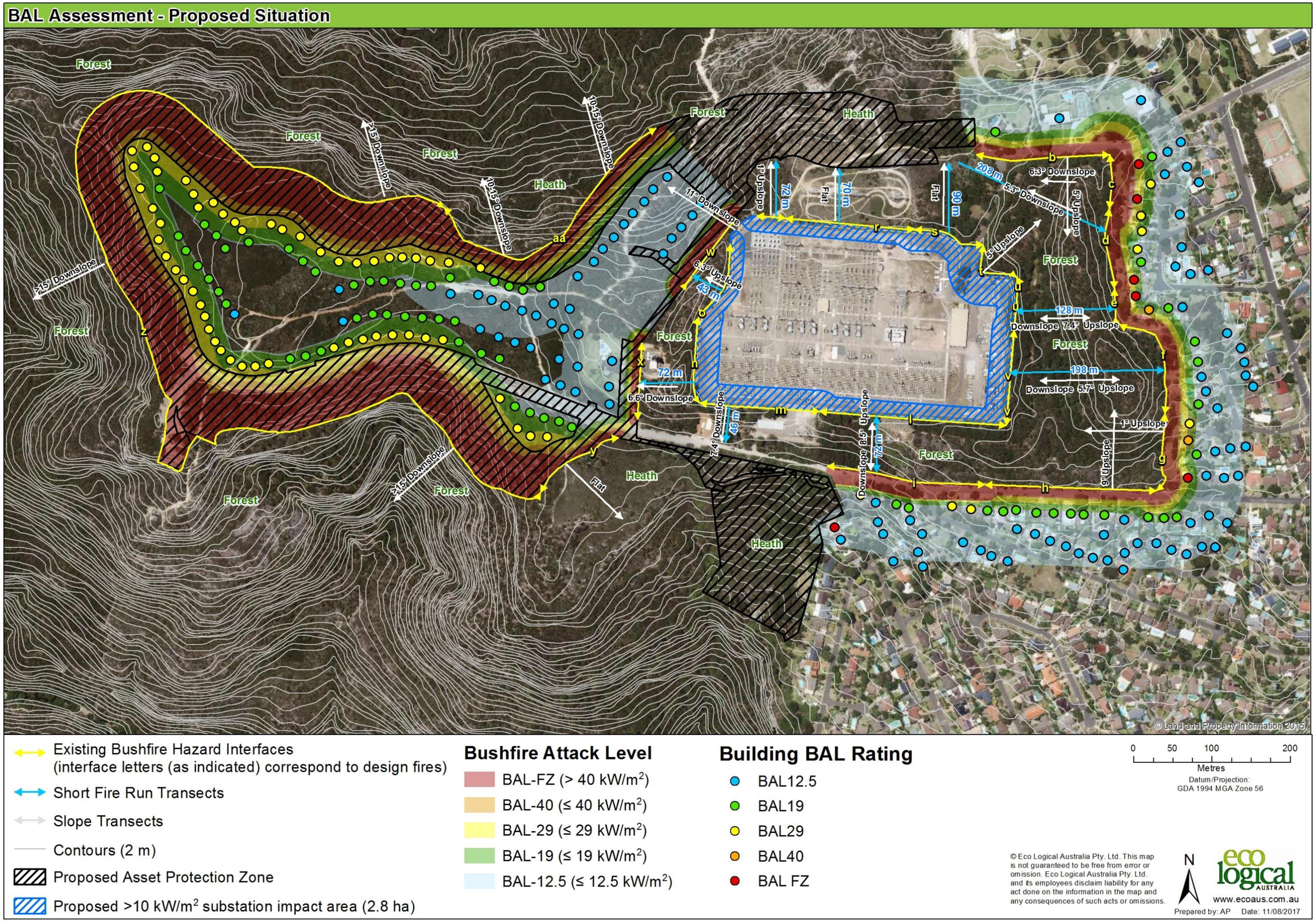


Figure 2: BAL Assessment – Proposed Situation

5.1 Evacuation risk

CSIRO's SPARK software has been used to calculate the travel time to impact the urban interface for two design fires (**Figure 3** and **4** shows these fires starting along Mona Vale Road). The fire arrival time is the time to reach the most north western part of the proposed development and the existing interface from ignition points of reasonable likelihood i.e. edge of a major road. As Planning for Bushfire Protection 2006 and most bushfire evacuation risk planning currently relies on offsite evacuation by multiple egress routes, the 'arrival time' for a bushfire attack under various weather events is a potential indicator of the feasibility of off-site evacuation.

Table 2 shows that under an FFDI 100 a fire from Mona Vale road would impact the proposed interface within 30 minutes and the existing interface within 42 minutes. These times are considered inadequate to safely and effectively evacuate either the existing or the proposed interfaces.

Table 3 shows that under an FFDI 55 (i.e. the FFDI value RFS previously used) a fire from Mona Vale road would impact the proposed interface within 57 minutes and the existing interface within 84 minutes. These are also inadequate times for early evacuation.

The design fires (any many similar scenarios) are considered possible over the next 50 years or so. Therefore, with evacuation unsafe or not feasible under benchmark weather conditions, on-site refuging is the primary risk and a higher risk than off-site evacuation. There is no neighbourhood safer place considered suitable for use within these timeframes for the existing interface although one may be feasible in the proposal.

Under the design fires it is estimated that 104 buildings (or 270 people) on the existing interface would not have adequate BAL construction for onsite refuging and there would be a high risk of loss of life and building destruction. Within the proposal all new dwellings are designed to withstand a bushfire attack under an FFDI 100.

Table 2: Design Fire #1: Mona Vale Road ignition under FDI 100

Location	331333, 6268686 (GDA 1994 Z56)
10 m Wind Speed (km/h)	37 km/h
Wind Direction	NW
Air Temp (ºC)	40
Relative Humidity (%)	4.3
Curing Level (%)	100
Heath Height Average (m)	2
Fire Hazard Rating (Surface)	3
Fire Hazard Rating (Near-surface)	3
Time to impact **proposed interface**	30 minutes
Time to impact **existing interface**	40 minutes

Table 3: Design Fire #2: Mona Vale Road ignition under FDI 55

Location	331333, 6268686 (GDA 1994 Z56)
10 m Wind Speed (km/h)	30 km/h
Wind Direction	NW
Air Temp (ºC)	35
Relative Humidity (%)	11.6
Curing Level (%)	100
Heath Height Average (m)	2
Fire Hazard Rating (Surface)	3
Fire Hazard Rating (Near-surface)	3
Time to impact **proposed interface**	57 minutes
Time to impact **existing interface**	84 minutes

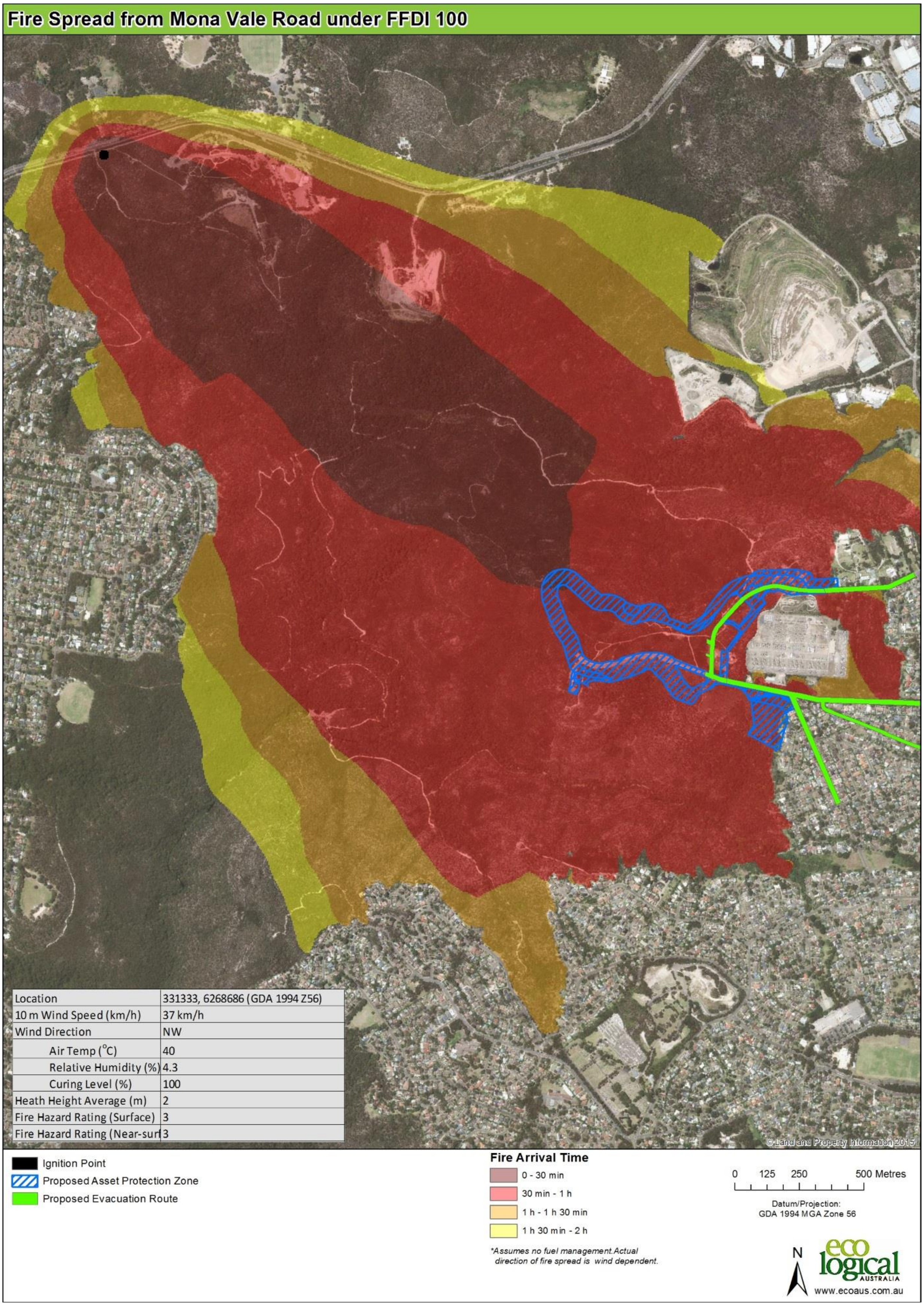


Figure 3: Fire Spread from Mona Vale Road under FFDI 100

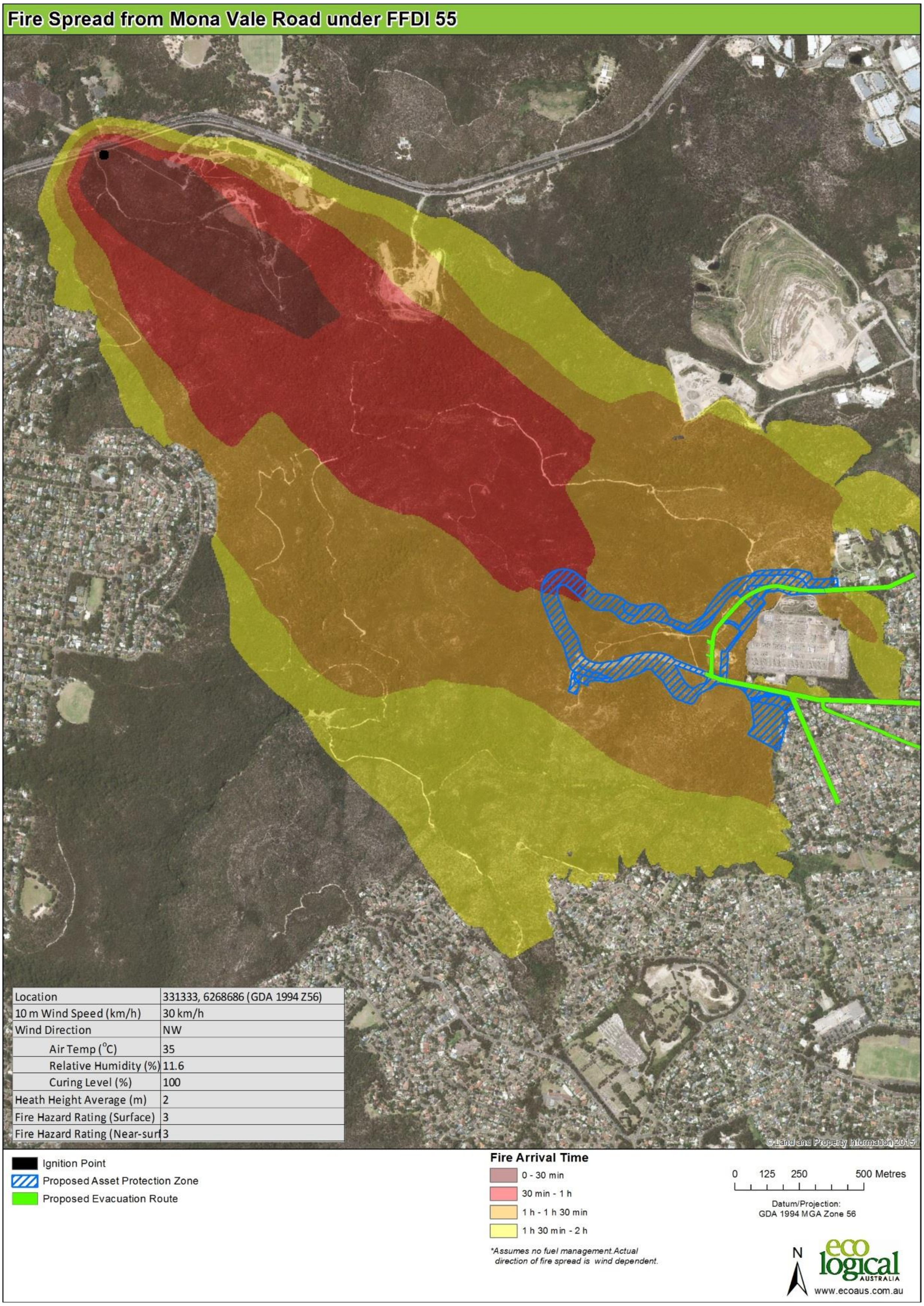


Figure 4: Fire Spread from Mona Vale Road under FFDI 55

6 Discussion

It is the author's view that the bushfire protection measures required for a subdivision under Planning for Bushfire Protection 2006 can be achieved on the proposal site due to the large available area. Any unresolved subdivision design matters on larger parcels of land are resolvable, but sometimes at the expense of lot yield.

This review therefore focusses on whether the proposal meets 'higher order' planning considerations such as the appropriateness of residential subdivision extending out from the current urban bushland interface into areas exposed to steeper, forested land. Model outputs enabled comparison of 'existing' versus 'proposed' interfaces, with interpretation of the comparative data provided.

If a net improvement in safety/resilience is achievable, is it of a level that justifies enlarging the bushland urban interface and extending into an area that includes steeper forested slopes? The review provides information that enables a largely objective comparison of the bushfire risks and an aid in determining the appropriateness of the planning proposal.

6.1 Directions under Section 117(2) under Environmental Planning and Assessment Act 1979

The RFS letter to Northern Beaches Council (of about 23.9.16) identified various concerns under S. 117 of the EPA Act; and these matters are discussed below.

Objectives

- *Protect life, property and the environment from bushfire hazards, by discouraging the establishment of incompatible land uses in bushfire prone areas;*
- *Encourage sound management of bush fire prone areas.*

Comment is provided below on each of the specific RFS concerns regarding the planning proposal (shown in italics) and the abovementioned objectives:

"*The proposal fails to achieve the above objectives and fails to demonstrate how the rezoning will:*

Comment: The investigation indicates the objectives can be achieved by the planning proposal.

- *Not increase the risk to life from bushfire*

Comment: Table 1 shows that the proposal increases the number of buildings exposed to all BAL levels except for BAL FZ where one existing house is likely to be removed from BAL FZ. However, this alone is an inadequate assessment of the risk to life.

If fuel management were to occur within the bushland within the TransGrid property (to lower risk to the sub-station and neighbours) the BAL exposure would drop significantly in both the existing and proposed interfaces. A detailed assessment by TransGrid of its substation bushfire risks and the potential impact of its fuel management on the existing urban interface would highlight these benefits.

Even without TransGrid fuel management the 'shielding' associated with the planning proposal would likely decrease the severity and frequency of bushfire attack on the existing urban interface.

The TransGrid substation is substantially better protected from fire attack by the planning proposal and if fuel management were also to occur within its boundary it is possible for the radiant heat exposure to decrease well below 10 kW/m^2. It is not possible for a <10 kW/m^2 exposure without the shielding provided by the planning proposal. Given the significance of this specific substation (servicing a large part of the Sydney population and potentially thousands of houses under bushfire attack) the planning proposal is considered NOT to increase the risk to life; rather it lowers that bushfire risk.

- *Not place inappropriate development in areas exposed to unacceptable bushfire hazard;*

Comment: The proposal does not include inappropriate development types "… not permitted on bushfire grounds …" under PBP (p. 9), it also does not include the higher risk Special Fire Protection Purpose developments. If the planning proposal was considered in isolation to the existing interface risks, it would be considered inappropriate; however, the proposal lowers an unacceptably high bushfire risk associated with the existing urban interface and older housing stock.

- *Ensure appropriate bush fire protection measures can be afforded to properties at risk*;

Comment: The development can meet or exceed the performance criteria within PBP 2006. The proposal also lowers the risk to the existing urban interface.

- *Minimise negative impacts on the surrounding environment;*

Comment: Other reports identify this as achievable.

- *Ensure the provision is made for adequate evacuation for the community, and*

Comment: The proposal provides two alternative egress routes, with a third possible part way along the Ralston Ave egress. It also potentially provides a solution to the much higher risk bushfire attack when evacuation time is insufficient (discussed later in the report).

- *Ensure that the development is capable of complying with PBP.*

Comment: The development can meet or exceed the subdivision performance criteria within PBP 2006.

6.2 Bushfire Attack Level (BAL) comparisons

Figure 1 and **2** show the existing and proposed BAL levels and **Table 1** compares the number of houses at different BAL exposures. There are two important differences in the comparative risk: firstly, the majority of existing interface dwellings are not constructed to meet their BAL (estimated at >90% of dwellings), whereas all proposed dwellings will meet or exceed their BAL exposure construction requirements. Secondly, the likelihood of the BAL occurring on the existing interface is substantially reduced by the planning proposal. Bushfire attack will less often penetrate to the existing interface (as fire pathways are reduced) and those that reach the existing interface will likely be less intense because of the interrupted, shortened or narrowed fire pathways.

The proposal exposes more dwellings to bushfire attack than exist at present, however, the new dwellings will be largely bushfire resilient, particularly if Strategic Fire Advantage Zones and/or enlarged APZ are provided in key locations. A significantly safer urban interface for the locality appears feasible, at least in terms of building survival. It is probable that much lower building loss will occur under the proposal (including its sheltering of the existing interface) than under the existing situation. Furthermore, this could be improved substantially with fuel management on the TransGrid land.

6.3 Enlarged APZ and SFAZ

Given the high risk of bushfire impacts occurring before off-site evacuation can occur at the proposed and existing interface, enlarged APZs in the most exposed portions of the proposal perimeter would increase occupant safety. A higher safety level on the urban perimeter reduces potential firefighter load and with appropriate landscaping can achieve a low risk even under extreme bushfire attack scenarios.

With the addition of the proposed Strategic Fire Advantage Zones (SFAZ) the proposal offers a resilient new urban interface and, indirectly, a lowering of the risk to the existing interface.

The APZ proposed under the powerline easement to the south significantly lowers the BAL for nearby dwellings and potentially to a level where they are resilient to bushfire attack.

6.4 Substation and communication tower risks

The Sydney east TransGrid substation is a critical power supply to a large part of Sydney. Under the adverse heat and smoke conditions during major bushfires many lives are at risk if power fails e.g. elderly and infirmed. Also in power failure, many communication systems (personal and community) fail or perform inadequately.

The loss of power at the same time as a bushfire impacts the existing interface will likely increase building loss and the loss of life. The proposal lowers the risk to the power supply to the extent that with minimal fuel management the substation should survive any bushfire attack.

The effect of the proposal on conductors has not been evaluated, however, with reduced fire pathways, SFAZ and powerline easement management the risk should reduce. If the proposal includes assistance in the maintenance of the TransGrid APZ, it will likely add reliability through use of contractors, and thereby reduce the burden on RFS and others.

The Telstra communications tower to the west of the substation is currently within the flame zone and it is likely that its plastic and rubber components will fail at <10kW/m^2 and at the predicted higher BALs various metals will melt. Mobile phone and other communications from the tower are critical to minimising loses in an extreme bushfire attack. The proposal lowers the risk considerably to the communications tower to the extent where simple measures can all but eliminate the risk of communications failure.

6.5 Landscaping within lots

Research clearly shows that burning debris igniting gardens contributes to the destruction of dwellings e.g. 2003 Canberra fires. The existing urban interface does not have specific APZ appropriate landscaping controls and most dwellings have higher risk of destruction because of this.

The proposal will reduce the burning debris load on the existing interface and increase its resilience to burning debris attack. Within the proposal, APZ garden design principles can be imposed, these need to be more specific than the APZ guidelines typically provided as part of current development consent e.g. as in Ginninderry in the ACT.

6.6 Evacuation

Figures 3 and **4** show an indicative fire progression under FFDI 100 and FFDI 55 where the fire attack will be so rapid that safe and effective evacuation from both the existing and proposed interface is not possible from a fire starting on or near Mona Vale Road.

This type of bushfire attack, where on-site refuge is necessary, is potentially the most threatening to life. The number and quality of evacuation routes have little effect on this risk as evacuation is not possible. However, on-site refuge safety can be enhanced by firefighter intervention and an alternate egress is considered important for this option remaining viable at least under some circumstances.

Refuge in dwellings at the existing urban interface under an FFDI 100 or even FFDI 50 would be life threatening as most dwellings are not constructed to withstand the bushfire attack levels likely. Over 104 dwellings (approximately 270 people) at the existing interface would be unsafe for refuge, however, with the potential shielding by the proposed development this could drop to about 84 dwellings and with fuel management on the substation land may reduce to near zero.

The key to reducing the risk to existing interface dwellings does not rely solely on fuel management of the substation land, but the reduction of fire pathways through the shielding effects of the proposed development. This shielding and substation fuel management together substantially reduces the risk.

With regard to early evacuation the proposal has two PBP compliant alternative egress routes, and a third possibility off Ralston Avenue onto Elm Avenue. If early evacuation is undertaken there is no fire impact on the roads in question, however, wind and potentially smoke may affect the egress. There are no dead-end roads forming the proposal interface.

The existing interface, however, has two cul-de-sacs within 100 m of the bushland (Skeane Pl and Seeana Pl). Coordination of early evacuation of the existing interface without a perimeter road would likely be more difficult than the proposed interface as the road egress routes are less well defined (this assumes evacuation of the existing interface is no longer necessary).

The suitability of evacuating the proposed development can be quantified if required with new tools such as the RMIT Evacuation Simulation, or similar. This may be important as the descriptions of evacuation risk associated with the proposal in other reviews of the development proposal are sensationalised, poorly researched and lack objectivity. This review demonstrates with fire simulations that on-site refuging is the key ‘evacuation’ risk and off-site evacuation a lesser but nevertheless important risk. It is anticipated that if off-site evacuation risk is evaluated with the RMIT tool or similar, the findings are likely to demonstrate an appropriately safe and efficient early evacuation process.

A neighbourhood safer place (NSP) may be feasible within the planning proposal. If this was provided the risk associated with egress routes would be further diminished.

7 Conclusion

The planning proposal has the potential to meet the requirements of Section 117(2) objectives under the EPA Act 1979, Planning for Bushfire Protection (2006) subdivision requirements and AS3959. However, to be confident that the proposal results in a safer community (a fundamental requirement under S. 117(2)) the bushfire shielding benefits for the existing interface need to be enhanced by in-perpetuity and reliable fuel management within the TransGrid Sydney east substation lands.

The highest risk to life and property in the locality is not associated with new development, but with older housing stock and the existing urban interface. It is rare that that the bushfire risk to a problem older interface can be improved to the extent that this proposal offers. This review shows that under an FFDI 100 and in unmanaged vegetation, a bushfire attack from as far away as Mona Vale Road would place at extreme risk about 270 lives who would need to refuge in 104 ‘non-compliant’ dwellings at the current urban interface. Also the failure of the TransGrid substation and the Telstra communication tower in a bushfire attack would significantly extend the loss of life. A reduction of these risks is unlikely achievable by any other means than a planning proposal similar to that reviewed.

Planning for Bushfire Protection 2006 and the Section 117(2) offer useful guidelines for assessing a planning proposal, however, a comprehensive locality-specific and strategic risk analysis may reveal (as in this instance) major risk reduction opportunities not otherwise considered. The unique risks reviewed in this proposal involving the power supply for a large part of Sydney, a major Telstra communication tower, and an older urban interface; and the magnitude of the risk from bushfire attack present unusual circumstances. One where the expansion of the urban interface into a steeper, forested area provides a significantly safer urban interface, and wider community, than exists or could be achieved by other reasonably foreseeable options.

Despite these significant community benefits, it would not be appropriate to place additional dwellings and people into a bushfire prone area unless they too had a high resilience and an appropriate level of risk to life and property. PBP and AS3959 provide some of the highest standards for bushfire protection in the world and a development built and maintained to these standards are potentially resilient to even extreme bushfire attack.

A higher level of surety in the ongoing maintenance and performance in a bushfire attack of the proposal may be as important as the initial development design. Mechanisms to achieve this under community title appear feasible e.g. landscape covenants, auditing of garden and building risk etc.

Based upon this strategic level bushfire risk review the planning proposal, with some refinements, is considered suitable for approval.

8 Recommendation

It is recommended that:

i. Improvements to the community-wide bushfire risk associated with the subject planning proposal be considered as an appropriate way to fulfil the EPA Act Section 117(2) directions;
ii. The following strategic level improvements to the planning proposal be considered:
    a. The understorey and ground level fuels within the TransGrid property be maintained at an APZ standard e.g. in a management agreement between community title and TransGrid
    b. Application of a garden landscape covenant based upon national best practice design
    c. Provision of a Neighbourhood Safer Place and/or larger APZs for lots most at risk of a head fire under an FFDI >50.

Rod Rose
Principal Bushfire Consultant
FPAA BPAD-L3 Certified Practitioner No. BPAD1940-L3

BPAD
Bushfire
Planning & Design
Accredited Practitioner
Level 3

Appendix A – Curriculum Vitae

CURRICULUM VITAE

Rodney Leith Rose

BUSHFIRE PRINCIPAL

QUALIFICATIONS

- Graduate Diploma in Design for Bushfire Prone Areas
- Associate Diploma with Distinction in Environmental Control
- Master of Business (partial completion)
- Numerous bushfire, ecological and natural area management certificates from NPWS and RFS
- Member of Environmental Institute of Australia and New Zealand (MEIANZ)
- FPAA BPAD-L3 Certified Practitioner No. BPAD-PA-1940

Rod's responsibilities include oversight of ELA's national bushfire team. He has been a leader in bushfire planning in Australia for decades and has completed thousands of bushfire protection strategies and high-end property protection projects; he has pioneered many fire ecology/GIS strategies. Rod is innovative and pragmatic; and is a very experienced and effective negotiator and facilitator. He has provided expert witness advice to NSW, Queensland and Federal Courts.

Rod's expertise has developed from more than 40 years in the bushfire and environmental industry; it includes 'hands-on' roles in the NSW NPWS, NSW RFS; through to leadership, management, and pioneering roles in both public and private sector. He is a highly competent/experienced team leader and trouble shooter. He is technically very strong; and is an astute planner and strategist.

Between 1994 to Nov 2008, Rod was the Managing Director of BES (Bushfire and Environmental Services) which subsequently merged with ELA. As Managing Director he had oversight of the Environmental, Land-care and Bushfire Divisions of BES. His expertise was used to prepare property management plans, threatened species protection planning, fire ecology, ecological plans, weed management planning, REFs, and numerous bushfire planning projects (see below).

Rod has also held senior positions in land management, emergency management or bushfire management with Shoalhaven City Council, NSW NPWS and the NSW RFS.

BUSHFIRE RELEVANT PROJECT EXPERIENCE

- Bushfire projects:
  - over 3000 bushfire protection assessments/plans for LES/LEP re-zoning, structure plans, masterplans, special fire protection purpose developments (incl. schools, aged care, child care, retirement villages, tourism, eco-tourism), commercial, industrial, subdivisions, dwellings, 100B and 79BA projects *etc*,
  - over 150 landscape wide bushfire management plans (>1.7 million hectares in Australia);
  - bushfire protection plans > 70 towns and villages, comprising > 2,200 kms of urban bushland interface;
  - over 60 evacuation plans and fire response plans;
  - bushfire training; bushfire legislation advice; fire control centre design;
  - bushfire behaviour and cause analysis; fire mapping and modelling;
  - Fire Management Plans for Defence, local councils and private lands.
  - bushfire audits of retirement villages;
  - bushfire risk assessment and plans;

- Plans of Management prepared for 10 NSW NPWS National Parks.
- Annual hazard reduction planning in most regions of NSW & SE Qld.
- Displan (Disaster Plan) and Disaster Hazard Analysis - Shoalhaven City.
- NSW Land and Environment Court appearances as a bushfire expert and court appointed expert;
- Bushfire expert witness to Coroners Court; Supreme Court, District Court (>30 hearings)
- Defence Department Estate fire management plans and building protection assessments throughout Australia
- Bushfire Strategy and Evacuation Plan, Three Capes Track, Tasmania
- Various Bushfire Management Plans, Western Australia for Department of Defence.
- IPART bushfire audit of all NSW Electricity Providers

Appendix B – Fire Runs

1 Results summary

The buffer distances used for the BAL mapping shown in **Figures 1** and **2** are provided in **Table 1** and **Table 2** below which represent the existing and proposed interfaces respectively. Each buffer distance was calculated using the NBC Bushfire Attack Assessor in accordance with Appendix B: Detailed Methodology for Determining the Bushfire Attack Level (BAL) – Method 2 of Australian Standard 3959: Construction of buildings in bushfire-prone areas' 2009. Fuel loads were taken from University of Wollongong fuel loads as used in the new Draft PBP.

Table 1: Bushfire Attack Level distances (m) for the existing interfaces.

Interface*	BAL FZ	BAL 40	BAL 29	BAL 19	BAL 12.5	10KW/m^2
a	10	11	16	24	100	NA
b	16	17	25	35	100	NA
c	29	31	42	55	100	NA
d	27	29	39	53	100	NA
e	19.5	20	27	34	100	NA
f	18	20	27	36	100	NA
g	19	22	30	41	100	NA
h	13	15	21	30	100	NA
i	21	21	23	28	100	NA
j	12	14	20	28	100	NA
k	20	22	31	42	100	NA
l	9	10	13	17	100	20
m	32	33	45	59	100	67
n	29	31	42	55	100	64
o	30	30	43	57	100	65
p	38	38	50	66	100	76
q	20	23	32	44	100	51
r	10	11	16	23	100	28
s	20	23	32	44	100	51
t	16	17	25	34	100	41
u	10	11	15	21	100	24
v	11	12	17	24	100	28

*Interfaces as indicated in Figure 1

Table 2: Bushfire Attack Level distances (m) for the proposed interfaces.

Interface*	BAL FZ	BAL 40	BAL 29	BAL 19	BAL 12.5	10KW/m2
b	16	17	25	35	100	NA
c	29	31	42	55	100	NA
d	18	19	27	36	100	NA
e	19.5	20	27	34	100	NA
f	18	20	27	36	100	NA
g	19	22	30	41	100	NA
h	13	15	21	30	100	NA
i	21	21	23	28	100	NA
l	9	10	13	17	100	20
m	20	20	21	24	100	27
n	19	19	22	28	100	31
o	10	10	13	16	100	18
q	13	13	17	22	100	25
r	10	10	14	18	100	20
s	14	14	19	24	100	27
t	16	17	25	34	100	41
u	10	11	15	21	100	24
v	11	12	17	24	100	28
w	19	19	20	24	100	NA
x	10	11	15	19	100	NA
y^	10	13	19	27	100	NA
z^	50	61	78	98	100	NA
za^	14	19	28	39	100	NA

*Interfaces as indicated in Figure 1

^Distances for these interfaces were calculated using AS 3959-2009 Method 1 to remain consistent with the assessment previous APZ mapping by Travers.

2 Example Bushfire Attack Assessor and Short Fire Run Outputs

The following two examples (interface H and interface E) represent the type of assessment that was performed for each interface.

As the review has found that management of the TransGrid land to APZ standard is required, these reports are less important, as they only give a perspective on the BAL exposures of existing dwellings and the conclusions would be the same if it was 50 houses instead of 104 that are non-compliant. The BFAA reports for each one of the numbers in Tables 1 and 2 above can be provided if required.

2.1 Interface H

FPA AUSTRALIA Certified Business Bushfire Planning & Design

NBC Bushfire Attack Assessment Report V2.1

AS3959 (2009) Appendix B - Detailed Method 2

Print Date: 15/08/2017 **Assessment Date:** 3/08/2017

Site Street Address: Ralston Avenue, Belrose, Belrose

Assessor: Mr Admin; admin

Local Government Area: Ku-ring-gai **Alpine Area:** No

Equations Used

Transmissivity: Fuss and Hammins, 2002
Flame Length: RFS PBP, 2001
Rate of Fire Spread: Noble et al., 1980
Radiant Heat: Drysdale, 1985; Sullivan et al., 2003; Tan et al., 2005
Peak Elevation of Receiver: Tan et al., 2005
Peak Flame Angle: Tan et al., 2005

Run Description: Interface H

Vegetation Information

Vegetation Type:	Forest	**Vegetation Group:**	Forest and Woodland
Vegetation Slope:	9 Degrees	**Vegetation Slope Type:**	Upslope
Surface Fuel Load(t/ha):	20.5	**Overall Fuel Load(t/ha):**	31.1

Site Information

Site Slope	3 Degrees	**Site Slope Type:**	Upslope
Elevation of Receiver(m)	Default	**APZ/Separation(m):**	14

Fire Inputs

Veg./Flame Width(m):	100	**Flame Temp(K)**	1090

Calculation Parameters

Flame Emissivity:	95	**Relative Humidity(%):**	25
Heat of Combustion(kJ/kg	18600	**Ambient Temp(K):**	308
Moisture Factor:	5	**FDI:**	100

Program Outputs

Category of Attack:	VERY HIGH	**Peak Elevation of Receiver(m)**	6.12
Level of Construction	BAL 40	**Fire Intensity(kW/m):**	21243
Radiant Heat(kW/m2):	29.28	**Flame Angle (degrees):**	61
Flame Length(m):	12.33	**Maximum View Factor:**	0.448
Rate Of Spread (km/h):	1.32	**Inner Protection Area(m):**	14
Transmissivity:	0.86	**Outer Protection Area(m):**	0

2.2 Interface E

The following Short Fire Run Inputs and outputs were used for interface E. The outputs were then fed into the Bushfire Attack Assessor.

Step #	Desc	Symbol	Desciption	Value	Unit	Notes
1	Site specific inputs	E_{slope}	Effective slope	11	degrees	+ = downslope, -=upslope
		S_{slope}	Site slope	6	degrees	
		h	Elevation of reciever	Default	metres	
		Veg	Vegetation formation	Sydney Coastal DSF	Type	Create lookup Appendix A
		w	Surface fuel load	20.5	t/ha	Create lookup Appendix A
		W	Overall fuel load	31.1	t/ha	Create lookup Appendix A
		d	Seperation distance	20	metres	
		E_{fh}	Average elevtaed fuel height	1.4	metres	From Vesta table
2	FDI	FDI	FDI from PBP (Table A2.3)	100		Create lookup
3	Forward Rate of Spread	R	FROS	2.46	km/hr	
		$FFDI$	FFDi from PBP (Table A2.3)	100		
		w	Surface fuel load	20.5	t/ha	
		R_{slope}	FROS corrected for slope	5.25	km/hr	
		E_{slope}	Effective slope	11	degrees	
4	Fully developed fire intensity	I	Intensity	84438	kW/m	
		H	heat of combustion	18600	kJ/kg	
		W	Overall fuel load	31.1	t/ha	
		R_{slope}	FROS corrected for slope	5.25	km/hr	
5	Fully developed Fire Flame Length	L_f	Flame length	37.89	metres	
		R_{slope}	FROS corrected for slope	5.25	km/hr	
		W	Overall fuel load	31.1	t/ha	
6	Fully developed fire transmissivity	Determined using NBC Bush Fire Attack Assessor (BFAA)				
7	Fully developed fire radiation					
8	SFR Length	L_{SFR}	SFR length	160	metres	
9	SFR Intensity	I_{SFR}	SFR Intensity	55658	kW/m	Modified Byram 1959
		H	heat of combustion	18600	kJ/kg	
		w	Surface fuel load	20.5	t/ha	
		R_{slope}	FROS corrected for slope	5.25	km/hr	
10	SFR Head Width	L/B	Length / Breadth ratio	2.82		SFR research
		V	Wind speed	30	km/hr	
		W_{SFR}	SFR Head width	56.7	metres	
11	SFR Flame Height	F_h	Flame height	23.16	metres	Project Vesta Fh formula
		R_{slope}	FROS corrected for slope	5254.90	m/hr	
		E_{fh}	Elevated fuel height	1.4	metres	
12	SFR radiation	Determined using NBC Bush Fire Attack Assessor (BFAA)				
		a	Create new record/run in BFAA			
		b	Enter site specific inputs from step 1			
		c	Modify flame width in BFAA with output from Step 10			
		d	Modify fuel loads (as per RHS process) until Flame Length (BFAA) = SFR Flame Height (Step 11)			
		e	Record RHF output			

NBC Bushfire Attack Assessment Report V2.1

AS3959 (2009) Appendix B - Detailed Method 2

Print Date: 15/08/2017 **Assessment Date:** 3/08/2017

Site Street Address:	Ralston Avenue, Belrose, Belrose		
Assessor:	Mr Admin; admin		
Local Government Area:	Ku-ring-gai	**Alpine Area:**	No

Equations Used

Transmissivity: Fuss and Hammins, 2002
Flame Length: RFS PBP, 2001
Rate of Fire Spread: Noble et al., 1980
Radiant Heat: Drysdale, 1985; Sullivan et al., 2003; Tan et al., 2005
Peak Elevation of Receiver: Tan et al., 2005
Peak Flame Angle: Tan et al., 2005

Run Description: Interface E

Vegetation Information

Vegetation Type:	Forest	**Vegetation Group:**	Forest and Woodland
Vegetation Slope:	7.4 Degrees	**Vegetation Slope Type:**	Downslope
Surface Fuel Load(t/ha):	13	**Overall Fuel Load(t/ha):**	20.45

Site Information

Site Slope	0 Degrees	**Site Slope Type:**	Downslope
Elevation of Receiver(m)	Default	**APZ/Separation(m):**	19.5

Fire Inputs

Veg./Flame Width(m):	45.3	**Flame Temp(K)**	1090

Calculation Parameters

Flame Emissivity:	95	**Relative Humidity(%):**	25
Heat of Combustion(kJ/kg	18600	**Ambient Temp(K):**	308
Moisture Factor:	5	**FDI:**	100

Program Outputs

Category of Attack:	VERY HIGH	**Peak Elevation of Receiver(m)**	7.93
Level of Construction	BAL 40	**Fire Intensity(kW/m):**	27465
Radiant Heat(kW/m2):	29.54	**Flame Angle (degrees):**	55
Flame Length(m):	19.35	**Maximum View Factor:**	0.457
Rate Of Spread (km/h):	2.6	**Inner Protection Area(m):**	20
Transmissivity:	0.85	**Outer Protection Area(m):**	0

Appendix C – SPARK

The fire spread maps (**Figures 3** and **4**) were created using the CSIRO developed Spark bushfire modelling application. The Spark software is designed to incorporate a multitude of user inputs, current fire behaviour propagation models and state-of-the-art simulation science. This allows modelling of fire spread across the landscape using a specific location and environmental conditions. Further information can be found on the CSIRO website (https://research.csiro.au/spark/).

Vegetation was determined using Sydney Metro CMA vegetation mapping (2016). Two vegetation fire spread models where used to represent fire spread through the different types of vegetation present.

Forest vegetation types were modelled using the Cheney *et a*l 2012 rate of spread model:

Cheney, N.P., Gould, J.S., McCaw, W.L. and Anderson, W.R. (2012) Predicting fire behaviour in dry eucalypt forest in southern Australia. *Forest Ecology and Management* **280**, 120-131.

Heath/shrubland vegetation was mapped using Anderson *et al* 2015:

Anderson, W.R., Cruz, M.G., Fernandes, P.M., McCaw, W.L., Vega, J.A., Bradstock, R.A., Fogarty, L., Gould, J., McCarthy, G., Marsden-Smedley, J.B., Matthews, S., Mattingley, G., Pearce, G. and van Wilgen, B.W. (2015) A generic, empirical-based model for predicting rate of fire spread in shrublands. *International Journal of Wildland Fire* **24**, 443-460.

The effect of slope on rate of spread was incorporated by using the 'kataburn' formulas as proposed by Sullivan *et al* 2014:

Andrew L. Sullivan, J. J. Sharples, S. Matthews, Matt P. Plucinski: A downslope fire spread correction factor based on landscape-scale fire behaviour. Environmental Modelling and Software 62: 153-163 (2014)

- Input caveats and assumptions for the design fires:
- The mean absolute percentage error (MAPE) for the forest rate of spread model is 35% (prescribed burns) and 54% (wildfire), and for the heath/shrubland rate of spread model is 77% (prescribed burns) and 33% (wildfire) (Cruz *et al*. 2015).
- The rate of spread models used were developed with a focus on producing an accurate rate of spread for the head fire. The estimate of back and flank fire spread may not be as accurate.
- The wind direction standard variation factor is assumed to be 20 degrees.

Appendix D – Material melting points

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PHYSICAL CONSTANTS FOR INVESTIGATORS

by Tony Cafe

Reproduced from "Firepoint" magazine - Journal of Australian Fire Investigators.

At the fire scene the investigator essentially studies the effect of heat on the various materials which survived the fire. From this study, the investigator determines the nature of the fire, its progress from the area of origin and hopefully the cause of ignition. To successfully achieve this goal the investigator needs to refer to the scientific literature for the physical constants of the various materials found at the fire scene because the investigator's conclusions must be reached using a logical and scientific methodology.

The following tables should be of help to the fire investigator in understanding the cause and progress of the fire. The information has been extracted from various sources such as Kirk's Fire Investigation, Cooke & Ide's Principles of Fire Investigation, John N. Cardoulis' The Art and Science of Fire Investigation (1990) and the Fire Protection Handbook. All temperatures are in degrees Celsius and it is noted there exists some discrepancies in the literature of the various physical constants of materials and so the temperatures and constants should be treated as approximates.

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2. PHYSICAL CONSTANTS OF MATERIALS

2.1 SOLIDS

2.1.1 VARIOUS MATERIALS

Reactions to temperature exposure	
Reaction	**Temperature (Celsius)**
Wood slowly chars*	120°-150°

Decayed wood ignites	150°
Ignition temp of various woods	190°-260°
Paper yellows	150°
Paper ignites	218°-246°
Oil soaked lagging ignites	190°-220°
Leather ignites	212°
Hay ignites	172°
Coal ignites	400°-500°
* wood chars at a rate of approximately 30-50 mm/hour	

2.1.2 PLASTICS

Melting points and ignition temperatures		
Plastic	**Melting Point Range**	**Ignition Temperature**
ABS	88°-125°	416°
Acrylics	91°-125°	560°
Cellulosics	49°-121°	475°-540°
Nylons	160°-275°	424°-532°
Polycarbonate	140°-150°	580°
Polyesters	220°-268°	432°-488°
Polyethylene ld	107°-124°	349°
Polyethylene hd	122°-137°	349°
Polypropylene	158°-168°	570°
Polystyrene	100°-120°	488°-496°
Polyurethanes	85°-121°	416°
PTFE	327°	530°
P.vinylideneclor	212°	454°
PVC	75°-110°	435°-557°
Wool		228°-230°
Cotton		250°
Rubber		260°-316°

2.1.3 METALS

Melting points and flame colours		
(o) & (r) denote oxidizing and reducing conditions respectively		
Metal	**Melting Point**	**Flame Colour**
Aluminium	660°	Colorless
Copper	1080°	Green (o) Red (r)
Lead	327°	Colorless
Tin	232°	Colorless
Bismuth	271°	Colorless
Zinc	419°	Colorless
Aluminium alloy	600°	Colorless
Antimony	630°	Colorless
Magnesium	651°	Colorless
Brass	900°-1000°	Green (o) Red (r)
Silver	961°	Colorless
Bronze	1000°	Green (o) Red (r)
Gold	1063°	
Cast iron	1200°-1350°	Yellow-brown
Manganese	1260°	Violet (o)
Nickel	1450°	Brown-Red
Cobalt	1490°	Blue
Steel	1100°-1600°	Brown-Red
Platinum	1770°	
Titanium	1670°	
Chromium	1900°	Green
Tungsten	3410°	
Solder 60/40	183°	
Electric fuses	371°	
Carbon	3730°	
Pure iron	1535°	

3. TEMPERATURE INDICATORS

3.1 STEEL

Appearance	Temperature
Yellow	320°
Brown	350°
Purple	400°
Blue	450°
* loses 50% of its structural strength and sags at 550°	
* melt point of steel 1100°-1650°	

3.2 CONCRETE AND CEMENT

Appearance	Temperature
Reddish pink - reddish brown	300°
Gray	300°-1000°
Buff	>1000°
Sinters and yellowish	>1200°
* sand and sandstone becomes friable at 573°	
* wall masonry collapses at 760°	

3.3 GLASS

Effect	Soda	Borosilicate
Very slight distortion	700°	750°
Slight distortion	750°	800°
Considerable distortion	800°	850°
Medium fluid flow	850°	900°
Liquid flow	900°	950°
* glass thermally cracks at 90°-120°		

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