Travers

bushfire & ecology

Fuel Management Plan

Lot 1 DP 1139826
Ralston Avenue,
Belrose

April 2017
(REF: A17029FMP)

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Ralston Avenue, Belrose

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Disclaimer:

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The mapping is indicative of available space and location of features which may prove critical in assessing the viability of the proposed works. Mapping has been produced on a map base with an inherent level of inaccuracy, the location of all mapped features are to be confirmed by a registered surveyor.

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Executive Summary

A planning proposal has been prepared to develop land for a residential subdivision at Lot 1 DP 1139826, Ralston Avenue, Belrose. The planning proposal will rezone 17.27ha of the land to R2 Low Density Residential, 119.05ha to E3 Environmental Management and 0.3ha to RE1 Recreational Zone– see Figure X1 below.

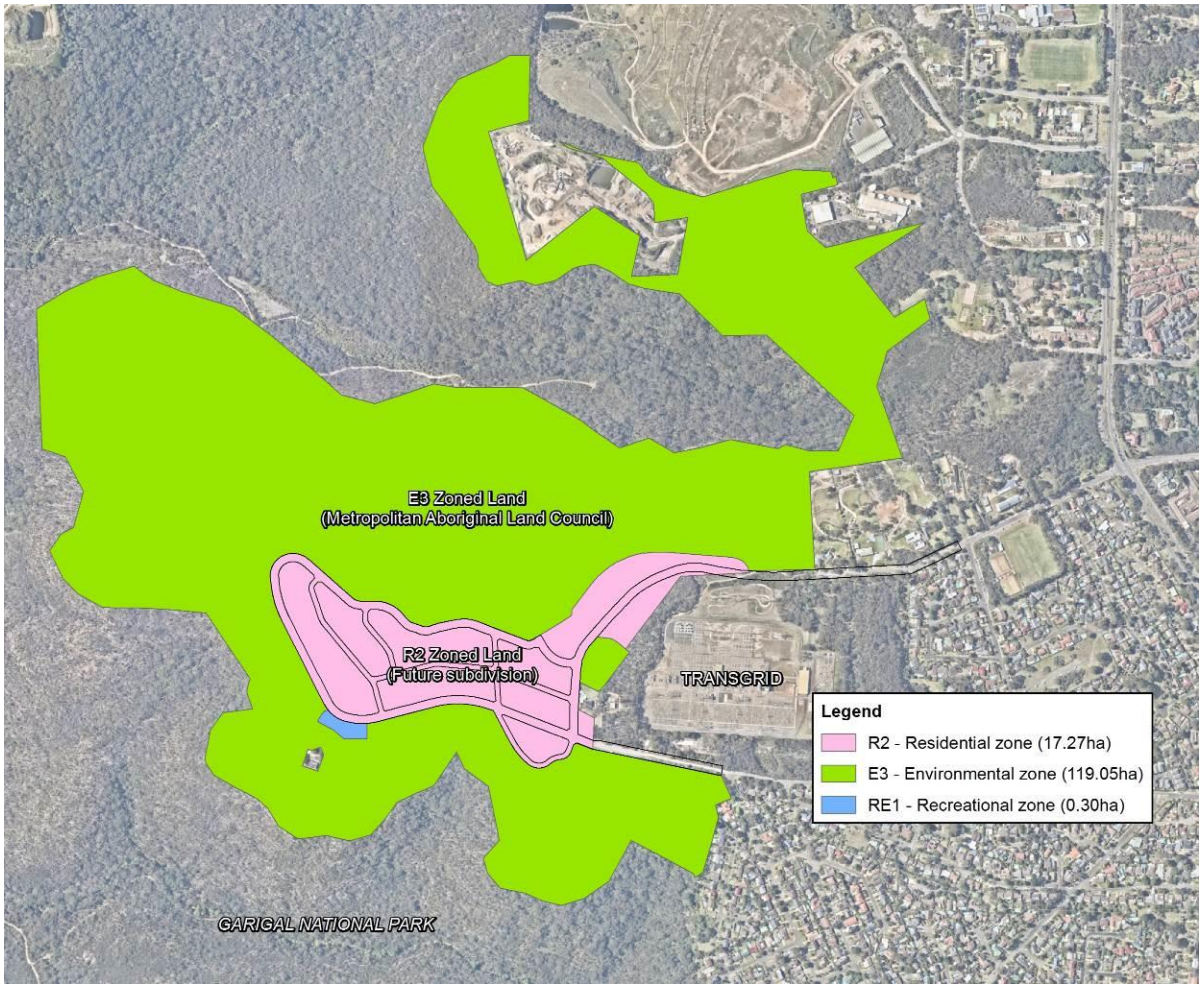

Figure X1 – Zoning plan

This plan brings together various policies, guidelines and instructions relevant to the fire management; and is a living document that should evolve as new knowledge or technologies come to hand. The fuel management programs advised must be reviewed annually within the five (5) year program of works to account for any changes which may be triggered by the following:

- following a major fire event to ascertain if the bushfire management zones were successful in reducing consequences or, if there are lessons learnt from the event
- changes to the bushfire risk in the area due to the effectiveness or otherwise of the bushfire management zones
- changes to economic circumstances, organisational responsibilities or legislation.

Fuel management authority

This fuel management plan has been undertaken to facilitate the ongoing management of bushfire hazards within the proposed E3 zoned land especially focusing on the asset protection zone (APZ) landscape adjoining the R2 lands – see Figure X2.

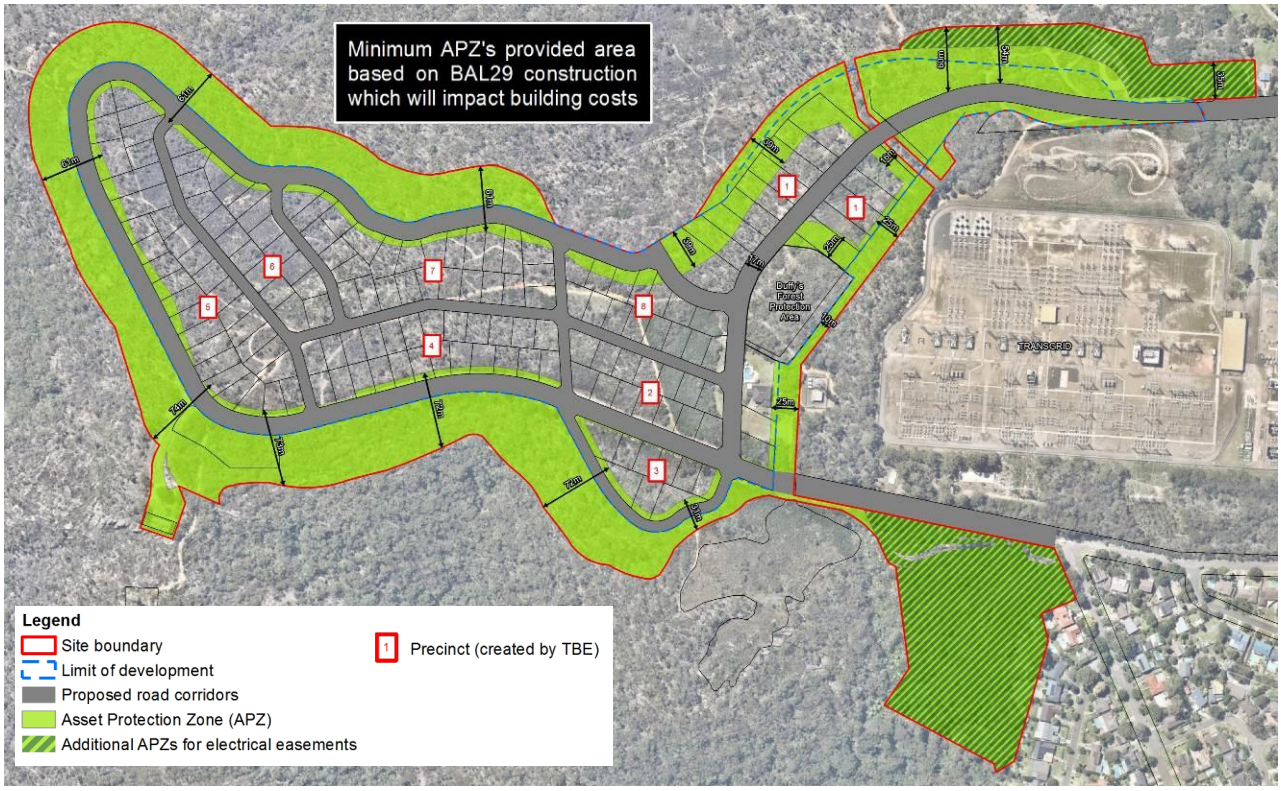

Figure X2 – Asset protection zones on R2 and E3 lands

Responsibility for fuel management works

This fuel management plan (FMP) has been prepared for the E3 zoned portion of land only (10.15ha) with its implementation and ongoing management being the responsibility of the community association set up under the community title development framework. It is estimated that the initial works to create the APZ will be in the vicinity of $200,000-$250,000.

The community association will arrange for fuel management works to be undertaken by a competent professional organisation.

Amendments to this FMP will be the responsibility of the community association and approved by Northern Beaches Council under the relevant development application process and or amendments.

Land to be managed

The proposed R2 land will be managed by the owners of the individual allotments and these lands will not be subject to an integrated management regime as for the E3 lands. Rather they will be managed by the individual land owners and are therefore not discussed further within this report.

The implementation of the APZs will require modification of 10.15ha of the E3 land (including *TransGrid* Easements). Attention has been given to the varying landscape character and the

need to provide habitat function through the retention of various landscape elements such as trees, shrubs, sandstone outcrops, etc.

In addition, a prescribed burning program is proposed in land entitled the Strategic Fire Advantage Zones (SFAZ) and Land Management Zones (LMZ). Hazard reduction burning is to be undertaken in consultation with surrounding landholders (MLALC & National Parks).

Ongoing management of the APZ is likely to be in the vicinity of $120,000 after purchase of required machinery. It is envisaged that some APZ works will occur by the development contractors at project start up whilst more sensitive works would be undertaken. For example, roadway and in-lot setback (5.18ha) would be undertaken by contractors, whilst E3 lands APZ (10.15ha) would be undertaken by *Community Association.* APZ management is detailed in Figure X3.

- The APZ located on E3 lands (10.15ha) and an additional 2.34ha internal to E3 lands will be managed by *Community Association* (69.5%)
- the public roadway comprises 19.3% (3.46ha) of the APZ
- the private allotments comprise 9.6% (1.72ha) of the APZ and are managed by the private allotment owners.
- the portion of RE1 lands comprise 1.7% (0.3ha) of the APZ and is managed by council as on open space park.

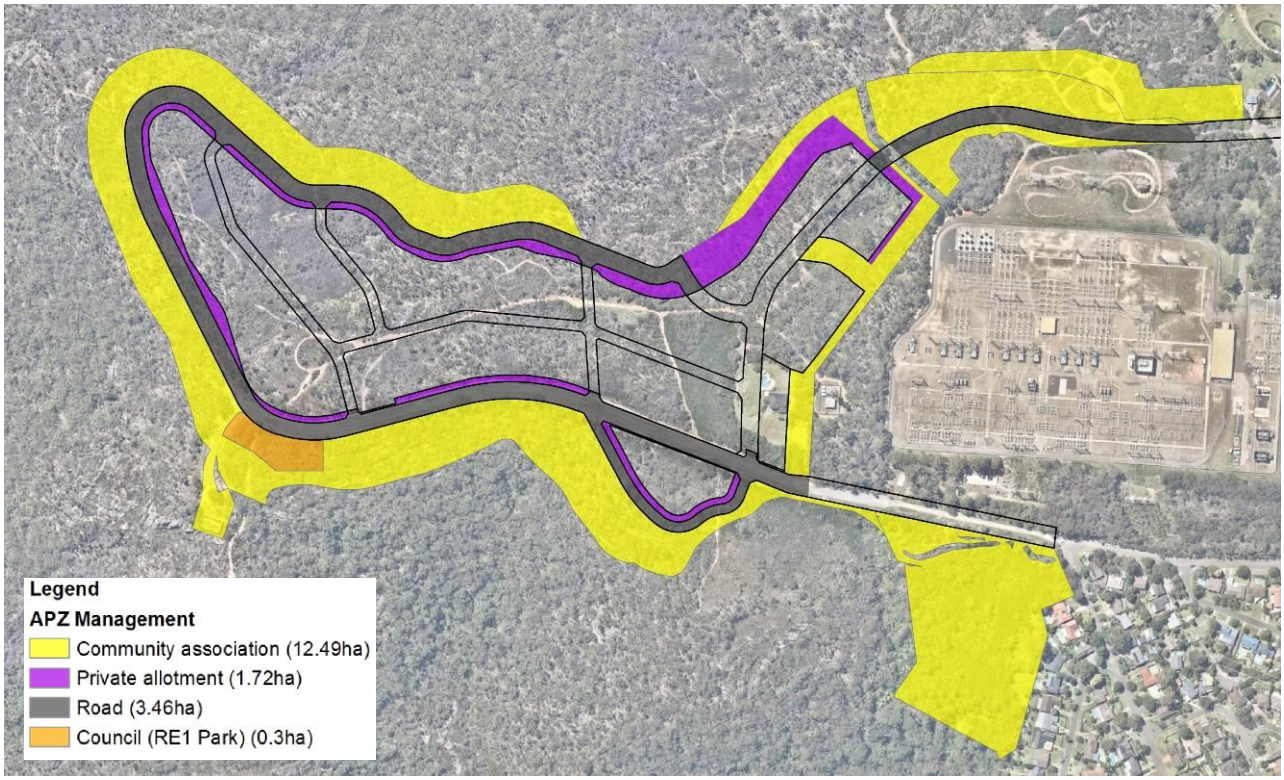

Figure X3 – General APZ management

Excluding roads, the community association contributes approximately 70% of all maintenance works.

Upon initiation of the APZ within the E3 lands a detailed mapping exercise should be undertaken to define the management treatments across the five (5) APZs zones. This will be the basis of the future works sheets for the APZ zones and the auditing protocols. Table 3 and Figure 6 are useful for this exercise.

Works program

Fuel reduction within the APZ will be undertaken by the community association in accordance with recommendations outlined in the operational works schedule - see Annexure 1.

Trail maintenance will be undertaken by the community association in accordance with recommendations outlined in the operational works schedule - see Annexure 1.

Training

Training should be undertaken to initiate work concepts and standards of care and / or construction of the APZ to assure adequacy with NSW Rural Fire Service (RFS) APZ standards; and to maintain habitat opportunities for insitu wildlife.

Ongoing auditing of works required

To ensure that regular reviews are undertaken, this fire plan has an operational life span of 5 years. At the completion of this time period, the plan will be formally reviewed via a similar process as outlined above.

Given the expected residential development program for the project will be over 2-3 years, this plan should be reviewed six monthly during the development stages of the project and annually after project stabilisation.

Of particular note will be the need to monitor lands that have been sold by the developer and are not built upon and therefore may cause an interim hazard for neighbouring allotments that have built houses. This can be a major impediment to hazard management and the management of those hazards must be dealt with quickly.

Plan monitoring

Monitoring will be undertaken on an annual basis with an audit review prepared by an independent bushfire adviser. The suggested schedule for maintenance of these tracks is attached in Annexure 1.

This fuel management plan will enable the land managers to understand the vegetated landscape and apply practical prescriptions to ensure that the future residents and neighbours are able to live safely.

There are a number of ways to evaluate the effectiveness of this plan. The monitoring of the issues outlined below will determine the level of success from the implementation of this plan. It will also prove how effectively the actions recommended by this plan have reduced the impact of adverse fire events and management.

Plan success

The issues which will govern this plans success are:

- protection of life and property from the adverse effects of fire

- maintenance of reduced hazardous fuel levels in strategic locations associated with the residential settlements
- the demonstrated ongoing and effective management of the E3 APZ
- the retention of insitu habitat elements and wildlife utilisation within the E3 APZ
- maintenance of biodiversity through the appropriate management of fire regimes
- management of existing fire trails
- communication of management decisions in respect of the FMP 2017-23 and its implementation program.

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DEFINITIONS

Aerial Detection	The discovering, locating and reporting of fires from aircraft.
Aerial Fuels	The standing and supporting combustibles not in direct contact with the ground and consisting mainly of foliage, twigs, branches, stems, bark and creepers.
Aspect	The direction towards which a slope faces, e.g. northeast. Slopes on a west to north-westerly aspect are the most hazardous during fire fighting operations.
Assets at Risk	The natural resources or improvements that may be jeopardised if a fire occurs. Examples include: threatened species habitat, rainforests, forestry coups, human built structures or infrastructures, information signs, transmission poles etc. and may also include scenic values. For the fire manager it may also include natural values that may be threatened by a fire (e.g. water catchment quality).
Back-burning	A fire started intentionally along the inner edge of a fire line to consume the fuel in the path of a wildfire.
Buffer	A strip or block of land on which the fuels are reduced to provide protection to surrounding lands.
Burning Programme	All the prescribed burns scheduled for a designated area over a nominated period of time.
Bushfire Management Zone (BFMZ)	Management areas where a specified fire management operational objective, strategy and performance indicator has been developed to militate against the threat of a wildfire.
Coarse Fuels	Dead woody material, greater than 25mm in diameter, in contact with the soil surface (fallen trees and branches).
Crown Fire	A fire burning in the crowns of trees and usually supported by fire in ground fuels. It is a fast travelling fire that usually consumes all available fuels in its path.
Ecosystem	The interacting system of a biological community, both plant and animal, and its non-living surroundings
Edge Burning	A term used to describe perimeter burning of an area in mild conditions prior to large scale prescribed burning. This practice is used to strengthen buffers and to reduce mop-up operations.
Fine Fuels	Generally all fuels less than 6mm in diameter, comprised of surface litter and aerial shrub layer.
Fire	The chemical reaction between fuel, oxygen and heat. Heat is necessary to start the reaction and once ignited, fire produces its own heat and becomes self-supporting. Removal of any one of the three elements of fuel, oxygen and heat will extinguish a fire.
Fire Behaviour	The manner in which a fire reacts to the variables of fuel, weather and topography. Changes in any of these variables with result in a change in the fires behaviour.
Firebreak	Any natural or constructed discontinuity in a fuel bed used to segregate, stop and control the spread of a wildfire, or to provide a fire line from which to suppress a fire.
Fire Extent	The area burnt by a wildfire, measured in hectares. Within that area there will be “islands” of unburnt vegetation (these islands are generally included in the total fire extent). *NB: it is preferable that fire affect only part of a vegetation community at any one time so that nearby areas of more mature plants may provide a seed source for recolonisation and animals will have suitable unburnt habitat in order to seek shelter and forage.*
Fire Front	The part of a fire where the rate of spread, flame height and intensity are greatest, usually when burning downwind or upslope.
Fire Intensity	The rate of energy released per unit length of fire front. This is usually expressed as kilowatts per metre (kW/m).
Fire Management	All activities associated with the management of fire-prone land, including the use of fire to meet land management goals and objectives.
Fire Perimeter	The entire outer boundary of a fire area.
Fire Regime	The history of fire in a particular vegetation type or area including the frequency, intensity and season of burning (season in this context refers to the time of the year in which the fire occurred). It may also include proposals for the use of fire in a given area.
Fire Season	The period(s) of the year during which fires are likely to occur, spread and do sufficient damage to warrant organised fire control. In New South Wales the core fire season is from 1st October to the 31st March of the following year.

	NB: At the regional scale, the season may be introduced or extended by one month dependent upon the prevailing weather conditions, drought indexes and number of wildfire's that may already be burning within that area.
Fire Storm	Violent convection caused by a large continuous area of intense fire; often characterised by destructively violent surface in-drafts, a towering convection column, long distance spotting, and sometimes by tornado-like whirlwinds.
Flame Height	The vertical distance between the tip of the flame and ground level, excluding higher flame flashes. Expressed in vertical metres.
Fuel	Any material such as grass, bark, leaf litter and living vegetation which can be ignited and sustains a fire. Fuel is usually measured in tonnes per hectare of dry weight.
Fuel Arrangement	A general term referring to the spacing and arrangement of fuel in a given area.
Fuel Load	The oven dry weight of fuel per unit area. Commonly expressed as tonnes per hectare.
Fuel Bed	The arrangement and vertical profile of all readily combustible materials lying on the ground.
Fuel Management	Modification of fuels by prescribed burning, manual removal, slashing, grazing, or other means. The objective is to reduce the fuel thereby reducing the risk posed by unplanned fires.
Fuel Type	An identifiable association of fuel elements of distinctive species, form, size, arrangement, or other characteristics that will cause predictable rate of spread or difficulty of control under specified weather conditions.
Habitat	A physical portion of the environment that is inhabited by an organism or population of organisms. A habitat is characterised by a relative uniformity of the physical environment and fairly close interaction of all the biological species involved. *NB Organisms within a given habitat will express a level of co-dependency upon one-another. The loss of the physical characteristics of a given habitat can have severe and long term detrimental effects upon the organisms living in that habitat.*
Hazard Reduction	*see Fuel Management*
Island	An unburnt area within a fire perimeter. Islands are critical for species survival and recruitment after a wildfire event.
Keetch Byram Drought Index	A numerical value reflecting the dryness of soils, deep forest litter, logs and living vegetation, and expressed as a scale from 0 – 200 points. When 100 points has been reached in an area, that area is said to be in drought
NPWS	The National Parks and Wildlife Service of New South Wales (OEH).
NSWFB	The New South Wales Fire Brigades
OEH	Office of Environment & Heritage
Prescribed Burning	The controlled application of fire under specified environmental and weather conditions to a predetermined area and at the time, intensity, and rate of spread required to attain planned resource management objectives.
RFS	The New South Wales Rural Fire Service.
Rate of Spread	The forward progress per unit time of the head of the fire or another specified part of the fire perimeter.
SF	State Forests of New South Wales
Scorch Height	The height above ground level up to where foliage has been browned by a fire.
Slip-on Unit	A fire-fighting unit that can be placed on to the back of a four wheel drive vehicle to convert it to a fire tanker. *Depending upon the unit's water carrying capacity, a four wheel drive tray top vehicle could be converted to Category 2, 7 or 9 fire tankers in a very short space of time.*
Spot Fire	Isolated fires started ahead of the main fire by sparks, embers or other ignited material, sometimes to a distance of several kilometres.
Striker	A small four wheel drive fire tanker capable of carrying from 400 to 600 litres of water for fire fighting purposes. Also known as a Category 9 Fire Tanker.
Structure Fire	A fire burning part, or all of any building, shelter, or other human made construction.
Tanker	A mobile fire fighting vehicle equipped with a water tank, pump, and the necessary equipment for spraying water and/or foam on unplanned fires. *NB bushfire fighting tankers have been designated into nine 'Categories' delineating water carrying capacity and whether the unit is two or four wheel drive capable.*

Definitions are sourced from the *Australian Fire Authorities Council (AFAC) Glossary of Rural Fire Terminology.*

Foreword

This updated fuel management plan (second revision) includes a consolidated update outlining all of the correspondence between the proponent and the authorities (i.e. NSW Rural Fire Service) to provide a clear sequence of events and appropriate responses/outcomes to each of the matters raised.

The following Table F1 provides a summary (starting from most recent) of the preliminary reporting / assessment phases of the planning proposal and subsequent consultation which has been undertaken in accordance Condition 3 of the Gateway Determination Issued by the Department of Planning and Environment (DPE) and Section 117 Direction 4.4 – Planning for Bushfire Protection.

Following submission of the planning proposal consultation with the NSW Rural Fire Service (RFS) and NSW Office of Environment and Heritage (OEH) occurred as detailed below. Additional research and investigation was undertaken and amendments to the planning proposal were made to seek the rezoning of the site to R2 – Low Density Residential, RE 1 Public Recreation and E3 Environmental Management. Changes to the internal lot design include the creation and conservation of a pocket of Duffys Forest within the eastern portion of the site, reducing the total number of residential lots and increasing the amount of E3 zoned land.

Table F.1 – Consultation outcomes

Comments from Authority	Response from proponent
Onsite meeting with NSW RFS representatives – 1st October 2015. RFS issues discussed on site include:	A site inspection occurred with three (3) officers of the RFS in attendance (Jason Maslen, Garth Bladwell and George Sheppard). They noted the slopes were as per the advice of TBE and that the APZ's were on lands that are either rocky or stable. The RFS referred to one area to the south west that required further detail to be provided in regard to APZ management and road construction. TBE advised this was within PBP acceptable limits but agreed to provide engineering advice regarding road design at DA stage. A revised bushfire protection assessment and fuel management plan have been prepared (December 2015) to detail the matters raised at the site inspection.
• Request for clarification on how and who will manage the APZ. How it will be funded in perpetuity. Who will hold the fund and what mechanism can be put in place to ensure that the required ongoing management tasks are completed.	• The Fuel Management Plan (FMP) has been updated to provide further clarification outlining funding and ongoing management of the APZ by MLALC.
• Width of the APZ in the southern side of the development lots.	• APZ width have been clarified within the Bushfire Protection Assessment (BPA)
• Classification of the short and tall heath vegetation on the mid northern side of the development area.	• A forest vegetation formation has been used to determine the APZ distances in this area as identified within the BPA (revision 1 & 2)
• NSW RFS will not support isolated lots in the north-eastern side of the site (Lots 1, 2 & 3).	• This was resolved by lot redesign to facilitate the retention and protection of the Duffys Forest vegetation within the E3 zone. The two/three lots are as per PBP 2006 and surrounded by two roads and are therefore not isolated and should be reviewed by the RFS as being permissible.
• Amend the Fuel Management Plan with the latest vegetation mapping.	• The FMP has been updated to reflect the latest vegetation mapping.

NSW RFS letter – 9th July 2015 In response to advice that that the DPE has issued the developer with an E3 Environmental Management zoning. • RFS raise the same previous concerns about APZs on steep lands • Further site analysis required on behalf of the applicant to identify suitable areas for possible development • RFS advise that there is opportunity for limited development adjoining established residential areas along Ralston Avenue.	TBE response – see below

NSW RFS letter – 26th June 2015. Provision of additional comments:	TBE letter of response to the NSW RFS – 11th August 2015
• Location of APZ on slopes greater than 18 degrees in not supported in general. Proposal to develop a Fuel Management Plan (FMP) to address the issue of APZs on steep slope in unsupported. The submission of a FMP at development application stage to address these issues in considered too late in the process and is unacceptable.	• TBE recommend RFS visit the site to appreciate the bushfire risk and that an FMP has been prepared to address feasibility and ongoing management of the APZs. Further slope analysis plans were prepared to highlight areas where slopes exceed 18 degrees. TBE advised that where slopes did exceed 18 degrees (in limited cases) it consisted of rock ledges, devoid of fuel which aid in reducing the overall bushfire risk.
• Majority of APZ's will not be located within individual allotments which will remain privately own. The question is who would enforce a positive covenant and who would undertake the APZ works.	• The land owner responsible for ongoing management of the E3 zoned land is MLALC. This is to be enforced under a positive covenant in accordance with the FMP. The APZ is to be self-managed with audits undertaken by specialist firms. On-going funds for management will be from the development consortium.
• APZ's are proposed in E2 zoned land which may conflict with the objectives of the zone.	• Proposed zoning was amended from E2 to E3 and an FMP was prepared to address ecological constraints and any zoning conflicts.

• An additional 1m APZ where slopes exceed 18 degrees is considered inconsequential to compensate for the additional increase in slope.	• The APZ was determined based on AS3959 which identifies an APZ of 61m adjacent to forest vegetation on slopes of >15 to 20 degrees. Further slope analysis was provided and RFS concern should now be resolved.
• A 100m Strategic Fire Advantage Zone (SFAZ) is expected to fall to the NSW RFS creating an additional burden on existing resources.	• FMP was prepared to refine location of the SFAZ within land owned and managed by MLALC. Ecological burning is recommended in accordance with the FMP. SFAZ is not a burden and falls in line with contemporary bushfire planning initiatives with the funding model an agreed protocol with contributions from insurance companies, state & local government.
• Recommendation to edge the SFAZ with a fire trail is considered unachievable given the terrain. Addition of fire trails will create an additional financial burden of the RFS	• An FMP has been prepared and existing fire trails will be enhanced and managed in accordance with FMP. The land is not owned by the RFS so it is not burden.

Office of Environment and Heritage (OEH) Letter – 27th February 2015	TBE letter of response to NSW RFS & Office of Environment & Heritage (OEH) – 4th May 2015
• NSW RFS has confirmed that the proposal does not comply with PBP 2006. Resolution of the bushfire protection measures is required before further consideration can be given to the biodiversity impact.	• RFS noted that they were not opposed to development of the site. FMP to be prepared to further outline proposals compliance with PBP.
• It is likely that the APZs will need to be revised in order to ensure the proposal complies with bushfire planning guidelines	• Modification of APZs may occur as a result of final development design, fuel management or other relevant studies. • Further details were provided on the scope of the FMP and a timeline for its development.

NSW Rural Fire Service (RFS) letter – 20th February 2015. RFS advise that they are not opposed to the development in principle and reiterate their concerns expressed in previous correspondence (6th June). These concerns include:	Travers bushfire & ecology (TBE*)* letter of response to the NSW RFS & Office of Environment & Heritage (OEH) – 4th May 2015
• Do not support location of APZs on land exceeding 18 degrees and recommend a modified lot layout	• RFS regularly permit APZ's on land >18 degrees and PBP permits the development of an alternate solution. The APZ's within the site, for the most part, are well below 18 degrees. The APZ's on steeper land consist of sandstone outcrops.
• BAL ratings under AS3959 are valid were the effective slope does not exceed 20 degrees. The slopes on site often exceed this.	• TBE advised a fuel management plan would be prepared illustrating slope gradients to comply with PBP.
• Requirement for public road widths are to comply with PBP regardless of final ownership. Perimeter roads are to have 8m width. All other roads 6.5m	• TBE concur that public roads are to comply with PBP requirements.

Introduction 1

A planning proposal has been prepared and submitted to develop land for a residential subdivision at Lot 1 DP 1139826, Ralston Avenue, Belrose.

1.1 Planning proposal

A planning proposal has been prepared to develop land for a residential subdivision at Lot 1 DP 1139826, Ralston Avenue, Belrose. The planning proposal will rezone 17.27ha of the land to R2 Low Density Residential, 119.05ha to E3 Environmental Management and 0.3ha to RE1 Recreational Zone– – see Figure 1 below.

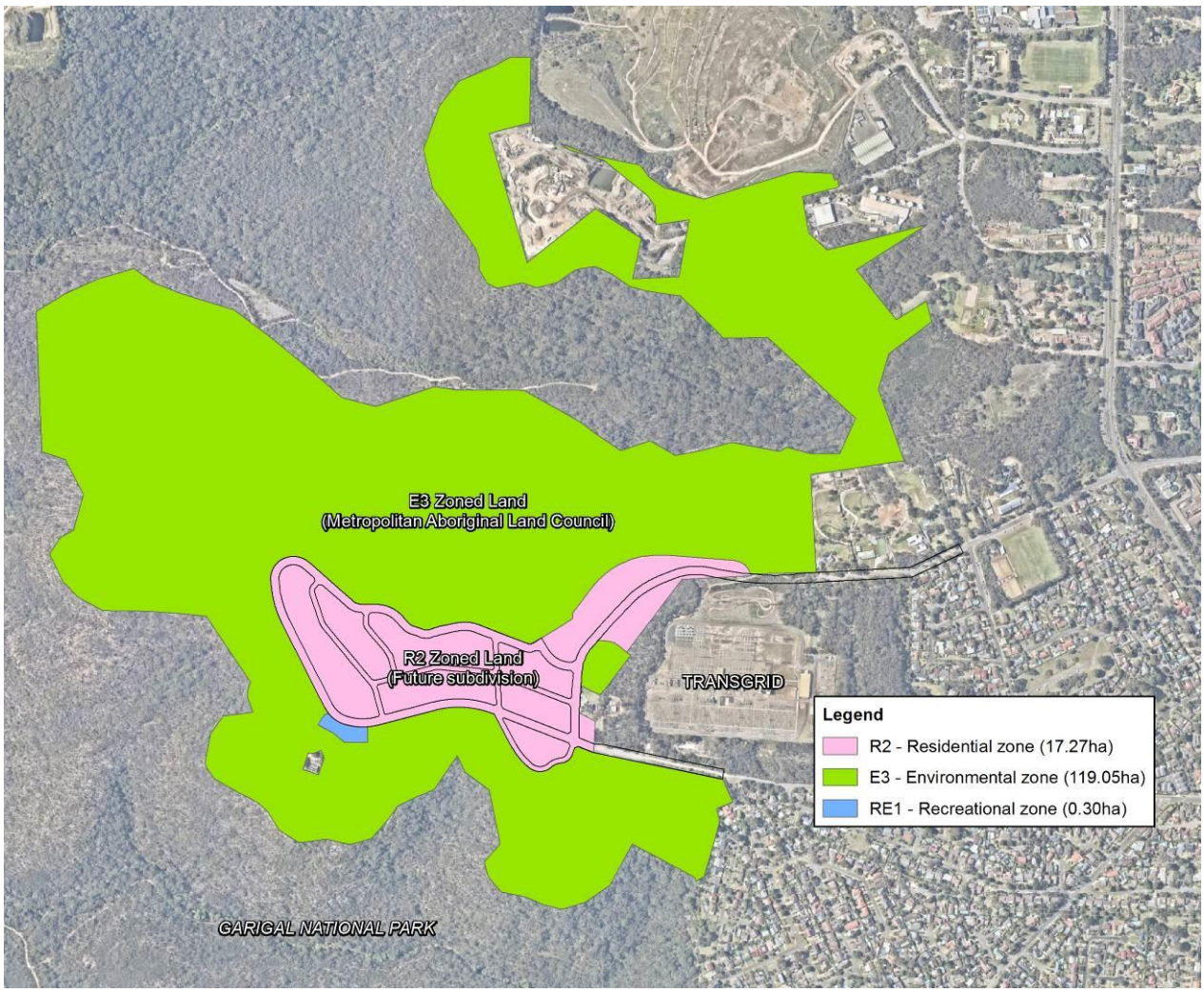

Figure 1 – Proposed zoning plan *(LTS Lockley – 22/03/2017)*

The planning proposal aims to create three (3) distinct land uses;

- **Development precinct** – 17.27ha portion of Lot 1 DP 1139826 for future residential development (Zoned R2). A small pocket park of 0.3ha in size will be zoned as RE1.

- **Asset protection zones (APZs)** - Create 10.15ha of the E3 land (including *TransGrid* Easements) of asset protection zones – proposed to be zoned as part of the E3 Environmental Management. These lands will be managed as APZs in full compliance with NSW Rural Fire Service limitations in regard to APZ management. Habitat retention will be a key priority for the fuel management works given the dual role that the APZs play in buffering the impacts of development on the urban/ bushland interface. Retention of trees, shrubs and surface fuels will be targeted for their intrinsic ecological value with ongoing management specified through a legally applied 'fuel management plan'.

- **Conservation Lands** - This environmental protection zone will be used as a biodiversity offset. The conservation lands will also be zoned as E3 Environmental Management to allow integrated management of the APZs and conservation lands by *Community Association*. The proposed offset area is an ecologically significant landscape which is known to contain threatened flora, fauna, ROTAP species and the endangered ecological community (EEC), Coastal Upland Swamp. It will create a conservation parcel of 119.05ha (including the additional Duffys Forest Protection Area) which will be retained.

This fuel management plan has been undertaken to facilitate the ongoing management of bushfire hazards within the proposed E3 zoned land especially focusing on the APZ landscape adjoining the R2 lands – see Figure 2.

Figure 2 – Asset protection zones on R2 and E3 lands

This plan brings together various policies, guidelines and instructions relevant to the fire management; and is a living document that should evolve as new knowledge or technologies come to hand. The fuel management programs advised must be reviewed annually within the five (5) year program of works to account for any changes which may be triggered by the following:

- following a major fire event to ascertain if the bushfire management zones were successful in reducing consequences or, if there are lessons learnt from the event
- changes to the bushfire risk in the area due to the effectiveness or otherwise of the bushfire management zones
- changes to economic circumstances, organisational responsibilities or legislation.

1.2 Land owner

The land owner for the purpose of this plan is the community association who will undertake the actions required of this plan in accordance with the schedules, programs, guidelines and instructions herein.

This fuel management plan has been prepared for the E3 zoned portion of land only, with its implementation and ongoing management being the responsibility of the *Community Association*.

1.3 Land to be managed

The proposed R2 land will be managed by the owners of the individual allotments and these lands will not be subject to an integrated management regime as for the E3 lands. Rather, they will be managed by the individual land owners and are therefore not discussed further within this report.

The implementation of the APZs will require modification, in the form of partial clearing, of 10.15ha of the E3 land (including *TransGrid* Easements). Attention has been given to the varying landscape character and the need to provide contiguous habitat function for several important species of fauna.

In addition, a prescribed burning program is proposed in land entitled the Strategic Fire Advantage Zones (SFAZ) and Land Management Zones (LMZ). Hazard reduction burning is to be undertaken in consultation with surrounding landholders (National Parks) and the NSW Rural Fire Service.

This fuel management plan is a document that identifies what is required in order to manage the hazardous fuels within the bushland landscape surrounding the residential portion of the Ralston Avenue, Belrose planning proposal.

It is expected the FMP will be formally approved by the NSW Rural Fire Service and the determining authority e.g. Sydney Planning Panel or Northern Beaches Council under delegation.

Fuel management works include;

- mechanical APZ works
- hazard reduction burning to lessen fuel accretion and reduce burn intensity for a wildfire, and prescription burning for ecological stewardship.

Information relating to this process has been compiled in this document to serve as a practical guide to managing the environmental and ecological values of this landscape.

1.4 Landscape context

The proposed development area is located on a plateau area of approximately 17ha. The perimeter to the north, west and south is gentle to steep sloping sandstone escarpments that consist of a variety of vegetation formations ranging from forest to heathland communities (refer Figure 1.1).

1.5 Objectives

The scope of this plan has taken into account the main priorities of fuel management planning i.e.:

- the protection of lives and property
- the protection of the ecological (plants and animals) and environmental elements (soil, water and air) of the landscape.

In determining priorities for fuel management, the land managers have a clear community obligation to protect life and property, as well as valuable natural assets.

In general terms, fuel management aims to:

- carry out hazard reduction (burning and physical removal) to protect life and property
- carry out hazard reduction (burning and physical removal) to protect the broad range of forest resources and assets from the effects of uncontrolled wildfire
- implement infrastructure works that allow fuel management to occur (e.g. construction and maintenance of fire trails).

1.6 Fuel management strategies

In areas adjacent to high value assets and where life and property are at risk, the objective of strategic fuel management is to maximise fire suppression options by fire fighters in the event of a wildfire.

Hazard reduction burning is the most efficient and cost effective method of fuel management, allowing protection of a broad range of assets. In determining the frequency and intensity of proposed burning, the primary consideration is the value of the asset to be protected and the range of wildfire suppression options required to protect that asset. The implementation of APZs will require physical works to manage fuel levels.

Across the landscape, objectives will be met by establishing a mosaic of fire regimes in priority zones to reduce fuel levels. These priority zones include limited strategic burning around population areas and valuable assets, variable frequency broad area burning, and burning for species management or other more specialised ecological purposes.

In some areas, hazard reduction burning will be excluded. These will be identified as no burning zones and include most riparian zones.

In the broader forest area, where life and property are not directly at risk, fuel management aims to provide a mosaic of burnt and unburnt areas. This allows an indirect fire suppression effort in the event of a wildfire due to lower fuel levels and lower fire intensities occurring; in addition this process also seeks to maintain biodiversity in the long-term, due to:

- preservation of foraging resources
- maintenance of seed stocks across the localised area within unburnt areas
- preservation of habitat and refuge for ground dwelling fauna

Uncontrolled wildfires, particularly crown fires in unmanaged fuels, are unacceptable not only for safety matters but also from the devastating damage to ecological systems that result. With development occurring on the eastern seaboard and natural landscapes diminishing it is imperative to maintain biodiversity in a manner that allows natural foraging capability for wildlife whilst also recognising the complexity of those systems through the appropriate use of prescribed fire regimes. Thus, fuel management aims to protect all natural resource values, so that in the event of a wildfire, a range of fire suppression options is available.

1.7 Policy and planning context

1.7.1 Rural Fires Act 1997

A bushfire hazard reduction certificate is required to be issued for hazard reduction works, including hazard reduction burning and mechanical APZ works. The *Bush Fire Environmental Assessment Code (BEAC)* has been developed under Sections 100J to 100N of the Act.

1.7.2 Bushfire Environmental Assessment Code 2006

The Code is designed to provide a streamlined system for assessing the potential environmental impacts of proposed hazard reduction works. The Code has been prepared with regard to the principles of ecological sustainable development and aims to protect threatened species, endangered communities and heritage values.

The Code only applies to works within APZs, SFAZs and LMZs and includes standards for the protection of biodiversity and lists management actions identified within the Threatened Species Hazard Reduction List. The Code also includes methods for modifying these conditions where the List would prevent the works proceeding.

The Code also stipulates conditions for hazard reduction and Aboriginal heritage where the Aboriginal Heritage Information Management System (AHIMS) identifies the location of an Aboriginal heritage item.

1.7.3 Warringah-Pittwater Bush Fire Risk Management Plan 2010

The Warringah-Pittwater Bush Fire Risk Management Plan (BFRMP) was created in accordance with Part 3 Division 4 of the *Rural Fires Act 1997 (RF Act)*. This plan is a strategic document that identifies various assets at risk across all land tenures and sets out a 5-year program of coordinated multi-agency treatments to mitigate the risk.

The objectives under the Warringah-Pittwater BFMRP are to:

- reduce the number of human-induced bush fire ignitions that cause damage to life, property and the environment
- manage fuel to reduce the rate of spread and intensity of bush fires, while minimising environmental/ecological impacts
- reduce the community's vulnerability to bush fires by improving its preparedness
- effectively contain fires with a potential to cause damage to life, property and the environment.

Fire management plans are recognised as a treatment that reduces the overall bushfire risk to a specified area.

1.7.4 National Parks and Wildlife Act 1974

Section 90 of the *National Parks and Wildlife Act 1974 (NPW Act)* states that it is an offence to knowingly disturb, damage or destroy relics or Aboriginal sites. The implementation of the Aboriginal heritage provisions of the Act is the responsibility of the NSW National Parks and Wildlife Service. Harm includes destroy, deface or damage of Aboriginal object or Aboriginal Place, and in relation to an object, move the object from the land on which it has been situated.

1.7.5 Commonwealth Environmental Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environmental Protection & Biodiversity Conservation Act 1999 (EPBC Act)* applies if it is considered that a significant impact on a *'matter of National Environmental Significance (NES)*' is likely.

In respect of matters required to be considered under the *EPBC Act;*

- Two (2) threatened fauna species occur, being Giant Burrowing Frog (*Helioporus australiacus*) and Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Two (2) threatened flora species occur, being *Tetratheca glandulosa* (listed as vulnerable) and *Grevillea caleyi* (listed as endangered)

1.7.6 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979 (EP&A Act)* is the principal planning legislation for the state and provides a framework for environmental planning instruments and assessments for development proposals.

In considering the potential impact to the environment, as a result of hazard reduction works, this plan must also consider whether there is likely to be a significant effect on species, populations or ecological communities, or their habitats.

Section 5A (s.5A) of the *EP&A Act* lists seven (7) factors that must be taken into account by a consent / determining authority in the administration of when considering an activity.

1.7.7 Threatened Species Conservation Act 1995

The specific requirements of the *Threatened Species Conservation Act 1995 (TSC Act)* must be addressed in the assessment of impacts on threatened flora and fauna, populations and ecological communities. All works of a fire hazard mitigation nature must address the environmental consequences of any activity.

The schedules of the *TSC Act* identify endangered or vulnerable species, populations, ecological communities, critically endangered species or ecological communities and the associated key threatening processes.

The *TSC Act* provides for the mapping of habitats that are critical to the survival of those identified threatened species, populations and ecological communities that are classified as endangered (critical habitats). The *TSC Act* also sets out the methods of assessment, management and regulation of actions that may damage critical or other habitat or otherwise significantly affect threatened species, populations and ecological communities.

Threatened flora within 5km and threatened fauna within 10km of the planning proposal has been identified within the flora and fauna report prepared by *Travers bushfire & ecology*.

1.7.8 Noxious Weeds Act 1993

The objectives of the *Noxious Weeds Act 1993 (NW Act)* include reducing the negative impact of weeds on the economy, community and environment by preventing the establishment, restricting the spread and reducing the area of significant noxious weeds.

The *NW Act* requires the community association to control noxious weeds on land under its control and prevent the weeds from spreading to adjoining land.

Proposals for hazard reduction need to be assessed in terms of their effect on the control and/or spread of weeds according the *BEAC*.

Fuel Management 2

Fuel management is the planned reduction of hazardous fuels. The basis of fuel management is to lessen the potential intensity of a fire by the removal of excessive fuel without significantly impacting ecological systems.

2.1 Fuel management context

There are many factors which influence the potential impact of a bushfire upon a landscape. Climatic influences create the potential intensity and speed of a fire whilst topographic conditions assist in easing or stopping the path of a fire. The fire behaviour potential therefore has a marked bearing on the actual bushfire threat upon a locality.

The protection and ongoing management of the natural resources of the Belrose landscape are also primary in the assessment of bushfire management options.

The land subject to this planning proposal is vegetated and surrounded on three sides by Garigal National Park, with urban development and the *Belrose Waste Management Centre* to the east. The proposed development area is generally flat and will be accessed from residential areas to the east via Ralston and Wyatt Avenues. The remaining perimeter to the north, west and south are gentle to steep sloping sandstone escarpments that consist of a variety of vegetation formations ranging from forest to heathland communities.

The broad aims of fire protection are to take all practical steps to minimise potential damage to the forest from fire, minimise the spread of fires once they commence and promote co-operative fuel management and fire suppression with other fire control authorities and nearby landholders. More specifically, the objectives are to:

- protect life and property from wildfires
- prevent the spread of wildfires
- exclude fire from environmentally sensitive areas, and
- maintain biodiversity.

2.2 Climatic influences

The typical / average climate in the Warringah Pittwater area is for uniform rainfall throughout the year, although higher rainfall can be experienced in the months of February to April. Prevailing weather conditions associated with the bush fire season (generally from October to March) are north-westerly winds accompanied by high daytime temperatures and low relative humidity.

> *Temperatures* - Average seasonal temperature extremes range from 28.1^{o}C in summer to 17.1^{o}C in winter. The maximum highest daily temperature of 43.1^{o}C and the lowest being -3.5^{o}C.

Wind Speed - Wind speeds at 3pm typically average 13.4kph. Winds are more variable in summer and dominated by north-east sea breezes with occasional hot dry westerly winds and occasional southerly breezes.

Rainfall - Average annual rainfall is 1,133mm, with the majority of this occurring in late summer / early autumn (153mm) and reducing to 54.2mm in July.

Bushfire risk is greatest during the months from October to March with the occurrence of north-west winds, high temperatures and low humidity. However, bushfires have historically occurred from July during dry winter periods.

2.3 Fire history

Fire history is a useful tool in the assessment of fire behaviour potential and fire pathways. In the assessment of fire history a number of sources were targeted.

Warringah Pittwater Bush Fire Risk Management Plan – The Warringah Pittwater BFMC area and surrounding environment have on average 48 bushfires per year. On average, major fire occurrence is between 5–7 years. The main "*sources of ignition in the Warringah Pittwater BFMC area are of a suspicious nature*".

Rural Fire Service – Advice provided from the NSW Rural Fire Service shows recent hazard reductions burns within and external to *MLALC* land in 2009/10 and 2012/13. Within the site, a significant wildfire affected the property in 1987. This fire started in Garigal National Park in the north-west and burnt approximately 421ha of land. A smaller wildfire affected the site in 1994. The following time since fire and fire frequency map depict the fire history within *MLALC* land.

(OEH) National Parks and Wildlife Service – A review of the Garigal National Park Fire Management Strategy (2006) indicates that the majority of the site is subject to an 'Adverse Fire Regime'.

Figure 3 – Garigal National Park fire management strategy

2.4 Fire behaviour

The factors contributing to fire behaviour are principally influenced by the availability of fuel, the affectation of weather and the topographic conditions.

The hazard landscape, below the APZ, and peripheral to the plateau where the residential development is proposed, is downslope with the slope gradients predominantly in the range of 10-20 degrees and is made up of steep slopes and or escarpments – see Figure 4 below and more extensive explanation in A7.1 of Appendix 7.

The fire behaviour in this hazard zone will see fast moving fires move up the slopes. The zone for 100m below the APZ will be the *strategic fire management zone* and this zone (see Figure 7) will be burnt to reduce fuel loads and lessen potential fire intensity.

The APZ is located on the immediate periphery of the proposed residential area, as can be seen in Figure 4 the slope gradient of the APZ is predominantly <10 degrees. A small area in the very north-east has a slope over 20 degrees and an escarpment in the south-west also has a similar gradient.

The APZ is made up of perimeter roads for the development and the native bushland on the outer perimeter of the roads. By managing the APZ the affectation of radiant heat and flame will be diminished in accord with the RFS publication *Planning for Bush Fire Protection*.

The manipulation of fuel loads by careful burning in periods of low fire danger, reduces the possibility of ignition, allows wildfire damage to be moderated and facilitates wildfire control activities.

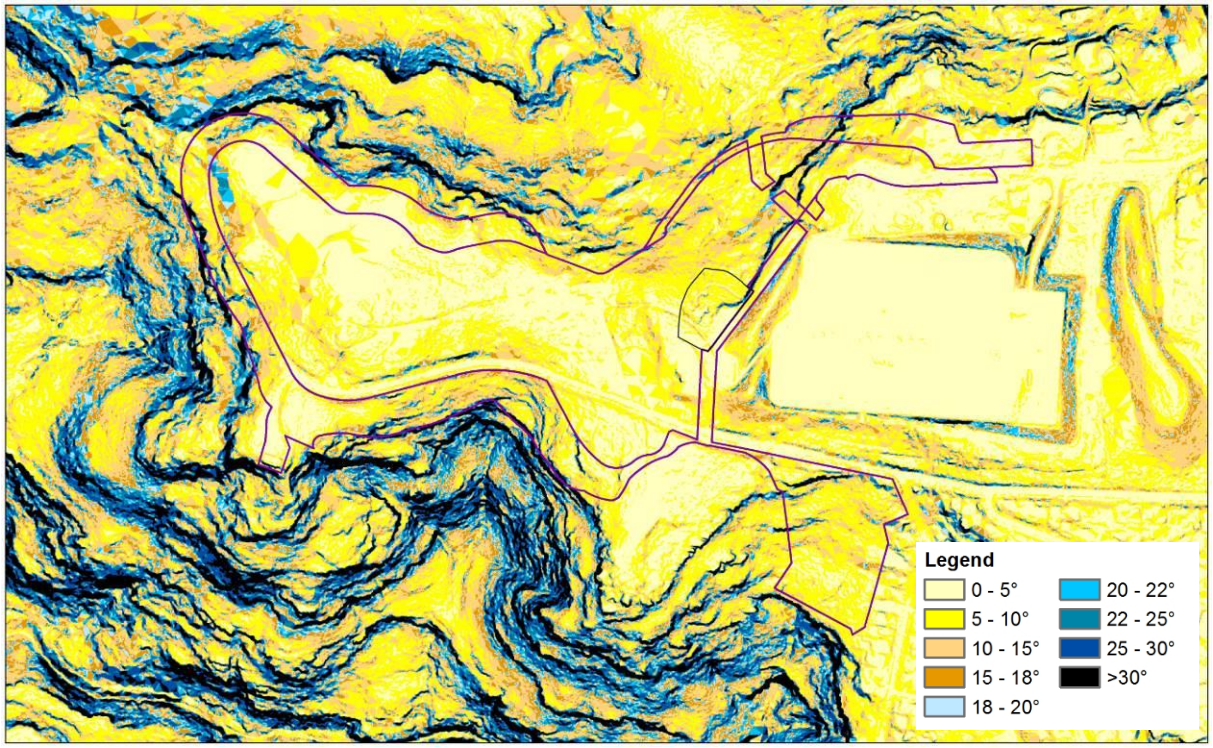

Figure 4 – Slope gradients

2.5 Fuel reduction

Fuel reduction reduces hazards in several ways in that it:

- reduces available fuel weight, reducing potential fire intensity and rate of spread,

resulting in reduced impacts on forest resource values, including soils, fauna, flora, watershed and aesthetics
- reduces fuel depth, thus reducing potential flame heights
- removes firebrand material, principally fibrous or flaky bark, reducing the potential for wildfires to generate spot fires ahead of the main front, overall wildfire rates of spread are thus reduced, increasing the potential safety and success of appropriate suppression measures.

Other benefits of active fuel management activities include:

- the opportunity to provide practical training in fire behaviour, fire safety and the use of fire control techniques and equipment
- the establishment of good liaison and working relationships with neighbours, RFS, Council and other authorities, in cooperative hazard reduction burns along common boundaries
- the possible reduction of resources required to suppress fires contained by effective hazard reduction.

2.6 Fuel characteristics

Fuel is generally defined as being organic matter up to 25mm in diameter that is deposited on, or attached to, the ground surface. Fuel includes litter, twigs, branches, shrubs, grasses, leaves and bark. Fuel can be further subdivided into surface fuel (fuel deposited on the ground surface) and near-surface fuel (aerial) that includes (shrub) branches and leaves.

In forests, most surface fuel is dead, while the near-surface fuel is a combination of dead and living material. Leaves, fragmented and partly decomposed organic material comprises the other main components. The ability to reduce fine fuels in a forest environment will generally reduce the intensity of a fire and assist greatly in the reduction of the spread of the fire.

Fine fuel is the material that is most readily and easily burnt due to its size and spatial arrangement. The weight and arrangement of fine fuel is important in determining the rate of spread and intensity of a fire. Fine fuels are generally less than 6mm in diameter and it is these fuels that burn first in any bushfire event however twigs up to 25mm in diameter are the dominant fuel component of a fire event. Fine fuels are firstly consumed providing heat transfer and heat source for the larger 6-25mm fuels.

Combustion is most favoured when fuel is scattered enough to let ample oxygen reach the flame zone but dense enough for efficient heat transfer (*Luke & McArthur*, 1978). These conditions are promoted by understorey vegetation, which provides a fuel source itself, as well as supporting and suspending accumulations of dead leaves, twigs and trailing plants.

Fuels can be described as having varying responses to fire intensity. This is primarily due to the combustibility of the fuel ‘type’ which in turn is a response to the ‘fine fuel presence’ and the dryness of that fuel. Each makes a contribution to the ability for fire to consume biomass quickly. Table 2.1 below describes the insitu vegetation communities and their classification.

Table 1 – Response to fire

Fuel category	Vegetation communities	Characteristics of fuel group
High	Short Heath (to 2.5m tall) Tall Heath (2.5 - 5m tall) Low Open Forest (to 10m tall) Open Forest (10+m tall) Sandstone Gully Forest Damp Tall Heath	Will generally ignite and burn quickly and intensely during an average fire season. Continuous fuel from ground to canopy in high quantities. Moderate to high surface fuel levels and open canopies allow sunlight and wind to quickly dry available fuels.
Moderate	Coastal Upland Swamp Riparian Woodland / Forest	Potential for high intensity bushfires when swamp is dry. Will generally burn with intensity when fanned by going fire. Harder to ignite due to shade and moist fine fuel layers.

Environmental protection 3

The impacts of the proposed fire management regime in relation to flora, fauna, hydrology and other resources are discussed in this section. The overall strategy is to maintain a fire regime which mitigates the potential for high intensity fire, reduces risk to ecological processes and promotes biodiversity.

Ecological studies occurred on 138.26ha of land and, following constraint assessments, a development precinct was determined which focused on approximately 23.32ha of plateau lands. The extent of the ecological studies required expert assistance and to that effect specialist advice was provided by;

- Dr Ross Goldingay *Southern Cross University* for the Eastern Pygmy Possum.
- Professor Michael Mahoney *Newcastle University* for the Giant Burrowing Frog and the Red-crowned Toadlet.
- Mr Gerry Swan for Rosenberg's Goanna.

3.1 Vegetation systems

A total of eight (8) vegetation communities occur within the APZ area - see Table 2 and Figure 5.

Table 2 – Extent of vegetation communities within the APZ

Vegetation community	APZ (ha)	APZ within Easement (ha)
Short Heath (to 2.5m tall)	0.49	0.14
Tall Heath (2.5 - 5m tall)	3.45	0.54
Low Open Forest (to 10m tall)	5.81	0.06
Open Forest (10+m tall)	2.04	1.32
Cleared, Managed, Landscaped or Weed Plume	1.80	0.65
Sandstone Gully Forest	0.35	0
Coastal Upland Swamp	0.22	0.3 (see note 1)
Damp Tall Heath	0.01	0.65
Total	**14.17**	**3.66**

Note 1: The CUS will not be harmed as a result of the Planning Proposal. The APZ ID is described in APZ 4 – see section 5 Pp 47.

The following do not occur within the APZ:

- Riparian Woodland / Forest

A total of nine (9) vegetation communities occur within the offset area - see Table 3 and Figure 5; and Figure 7 to review against the zone plan.

Table 3 – Extent of vegetation communities within the offset lands

Vegetation community	SFAZ	LMZ	Total
	Area (ha)	Area (ha)	Area (ha)
Short Heath (to 2.5m tall)	2.08	0.00	2.08
Tall Heath (2.5 - 5m tall)	5.97	3.07	9.04
Damp Tall Heath	0.41	0.00	0.41
Low Open Forest (to 10m tall)	18.02	18.00	36.02
Open Forest (10+m tall)	14.18	10.41	24.59
Cleared, Managed, Landscaped or Weed Plume	0.83	0.55	1.38
Coastal Upland Swamp	1.35	0.00	1.35
Sandstone Gully Forest	6.36	2.97	9.33
Riparian Woodland / Forest	0.00	0.00	0.00
TOTAL	**49.2**	**35**	**84.2**

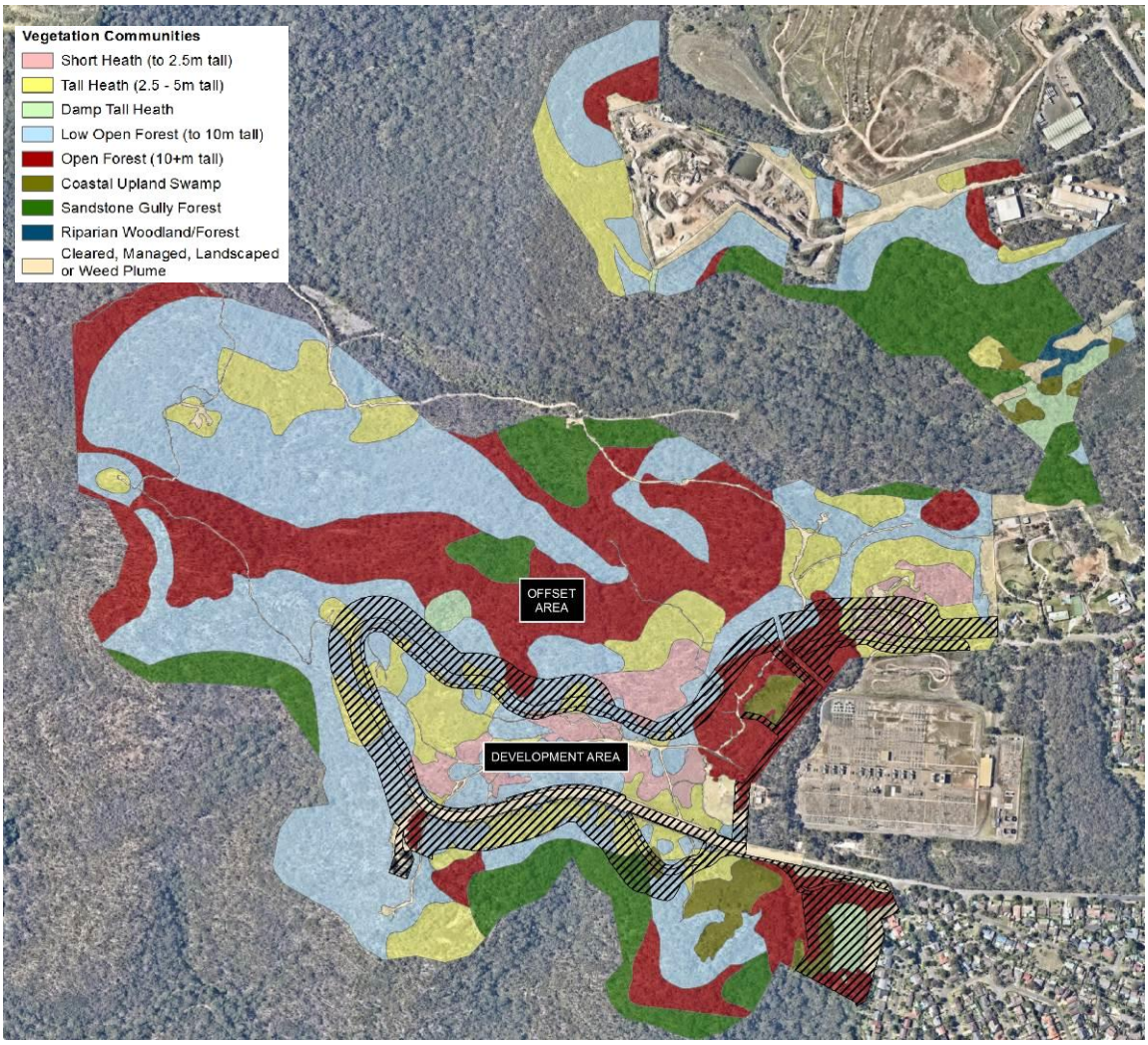

Figure 5 – Vegetation communities

3.2 Flora

A total of two hundred and ninety nine (299) flora species were observed within the study area during the survey. This number comprised two hundred and twenty six (226) native species and seventy three (73) exotic species.

The number of observed native species is high indicating species richness is good. The number of exotic species observed is very low with only a few quadrats recording more than 5% exotic species make up. Largely, the exotic species are confined to the edges of roads 7and around existing infrastructure.

Two (2) endangered species were observed, including *Tetratheca glandulosa* and *Grevillea caleyi.*

Two (2) ROTAP species were also observed, *Eucalyptus luehmanniana* and *Angophora crassifolia.* Both species were observed in both the development area and the offset area.

Eucalyptus luehmanniana is also a rare plant (ROTAP) species which was found in the Tall Heath and Low Open Forest on south east to south west facing slopes on or near sandstone benches near the top of the ridge. The exact population is unknown and the mapped distribution may not reflect the full extent of the species. However, observed habitat areas were mapped and the population size has been estimated on the basis of recorded densities. Approximately 80% of the estimated population will be retained within the proposed offset lands. Specimens located on the southern side of Ralston Avenue fall within a proposed APZ. Whilst there is no assurity of their retention, there are excellent opportunities to retain further trees and still comply with the standards for APZ. We recommend that the fuel management plan aims to protect as many of them as possible.

Angophora crassifolia, listed as a rare Australian plant (ROTAP species) has been observed broadly across the proposed development area and continues into the broader study area. This is a rare species due to its geographical range, occurring primarily in the northern suburbs of Sydney in near coastal locations, predominantly within the Warringah LGA. This species was located sporadically in clumps throughout the proposed development area, typically more so on the outskirts in the taller vegetation communities such as Low Open Forest and Open Forest and occasionally in the Tall Heath. Some large clumps were also located within the offset area and it is likely that the population is more extensive than mapped. Approximately 80% of the estimated population will be retained within the proposed offset lands. All specimens observed within and immediately adjoining the proposed development have been identified by GPS. All observed specimens are shown on Figure 1.

It should be noted that the majority of exotic species were only recorded adjacent to the Ralston Avenue entrance into the development area, around the existing residence or adjacent to prominent tracks. The remainder of the development area contained very few weeds.

3.3 Fauna species

To date, a total of ninety nine (99) fauna species were observed within the proposed development area during fauna surveys. This number comprised fifty five (55) species of bird, eighteen (18) species of mammal, eighteen (18) species of reptile and eight (8) species of amphibian. A total of ten (10) threatened fauna species have been recorded within, or in close proximity to, the development area. The recorded species include:

- Rosenberg's Goanna (*Varanus rosenbergi*),
- Red-crowned Toadlet (*Pseudophryne australis*),
- Giant Burrowing Frog (*Helieoporus australiacus*)
- Eastern Pygmy Possum (*Cercartetus nanus*)

- Eastern Bentwing-bat (*Miniopterus orianae oceanensis),*
- Little Bentwing-bat (*Miniopterus australis),*
- Grey-headed Flying-fox (*Pteropus poliocephalus*),
- Glossy Black-Cockatoo (*Calyptorhynchus lathami*),
- Little Lorikeet (*Glossopsitta pusilla*), and
- Powerful Owl (*Ninox strenua*)

Although not recorded within the proposed development area during surveys, it is considered that the proposed development area has varying potential for the following additional threatened fauna species to occur and offer constraints to development:

- Southern Brown Bandicoot (*Isoodon obesulus)*
- Spotted-tailed Quoll (*Dasyurus maculatus*), and
- New Holland Mouse (*Pseudomys novaehollandiae*).

Eastern Pygmy Possum was observed opportunistically by Council within a hollow during a site inspection. This observation suggests that parts of the subject site are utilised by Eastern Pygmy Possum for foraging in the banksia dominated communities and nesting within suitable hollows. Based on the known habitat preferences of this species, the proposed residential rezoning will result in the loss of 18.2% of the suitable nesting and foraging habitat within the entire study area (including the offset lands). However, the degree of habitat use and the importance of that habitat being lost for a local population of Eastern Pygmy Possum needs to be determined in consultation with specialists. A preliminary specialist report has been prepared by Professor Ross Goldingay *(University of Southern Queensland), 2013.*

Prof. Goldingay concluded that important areas of foraging habitat and breeding habitat will be affected by the proposed development and hollow surveys are required to determine the adequacy of the offset for breeding before a conclusion of significance can be made. Prof. Goldingay also suggests that opportunities for individuals to disperse east and west across the Forest Way should also be investigated.

Mr Gerry Swan was engaged to undertake a preliminary site study which resulted in the location of one (1) termite mound with a juvenile exit point and several more burrows (see Appendix 5 - Specialist Report on Rosenberg's Goanna - *Cygnet Surveys and Consultancy* November 2012 as amended March 2017). The termite mound and recorded burrows have however been located outside of the proposed development area. Further burrows have been identified in suitable habitat areas to the north and north-west of the proposed development area.

Mr Swan has concluded that the proposed development site is not critical to the survival of the population, that there is adequate habitat surrounding the proposed residential development site to maintain a viable population, and the proposed residential development is not likely to result in a significant restriction to the local population. Mr Swan also states that the proposed development is not likely to have a significant impact on the Rosenberg's Goanna population. Mr Swan has also verbally confirmed that the APZs, resembling a managed native vegetation landscape, are likely to be used for foraging purposes (Gerry Swan *pers.com*. 31 July 2013).

Prof. Michael Mahony, a recognised frog specialist was engaged to undertake target survey, habitat assessment and provide advice in respect to Red-crowned Toadlet and Giant Burrowing Frog (see Appendix 6 - Assessment of the distribution and habitat use by the Giant Burrowing Frog and Red Crowned Toadlet at Ralston Avenue Belrose, Prof. Michael Mahony, June 2013).

In respect to Giant Burrowing Frog, Prof. Mahony concluded that the considerable distance of the identified breeding habitat from the plateau, and the relatively large area of surrounding habitat, indicate that indirect impacts on hydrology are unlikely to impact on the Giant Burrowing Frog breeding habitat such that it is not likely that the proposal will impact on the local viable population of the Giant Burrowing Frog.

In respect to Red-crowned Toadlet, Prof. Mahony concluded that four (4) breeding locations have been identified within the subject site and twelve (12) breeding locations were identified within the study area outside the subject site. Movement of the Red-crowned Toadlet will mostly be in the escarpment and mid-slope areas.

Development of the plateau will not have a significant effect on the local population due to any removal of habitat or the breaking of corridors. The potential for impact on the population of the Red-crowned Toadlet is assessed to be related mostly to indirect impacts on the hydrology of the breeding habitat (rate, volume, and water quality of discharge). Specific mitigation measures are required to ensure that the hydrology of these sites is not altered by the proposal.

It may be concluded that significant areas of potential breeding habitat within the proposed offset lands are available for Rosenberg's Goanna, Giant Burrowing Frog and the Red-crowned Toadlet. This may also prove to be the case for Eastern Pygmy Possum, subject to further survey and advice. Despite this, indirect impacts such as stormwater on frog breeding areas and other edge effects such as cat predation need to be considered and mitigated to minimise impacts on threatened fauna species.

3.4 Habitat protection

One of the key aims of the fire management plan is to provide for the conservation of plant and animal species by maintaining biodiversity. The implementation of this aim will require the protection of habitat where possible. Given the significance of several species and their foraging capability a habitat assessment has been undertaken over the APZ section of the E3 landscape. The intention is to determine what special attributes this landscape has and for what species. A plan has been prepared and is attached as Figure 6. This figure identifies these attributes. The extent of the offset area surrounding the proposed development area is the only locally undeveloped area of the Lambert soil type within the connective natural landscape to the south of Mona Vale Road and west of Forest Way. The proposed development area covers the plateau area within this soil landscape. Habitat features of the Lambert soil type include:

- presence of greater than 50% rock outcrops
- open and closed heathland and scrubland
- broad ridges, wide benches with low broken scarps
- small hanging valleys and poor drainage areas.

Alternatively, the highly developed Somersby soil type is characterised by low open woodland and scrubland typically with less rock outcropping. The remaining surrounding, mostly uncleared, Hawkesbury sandstone to the north, west and south, whilst providing similar rocky features, provides slopes in excess of 25% and is characterised by open woodland and Tall Open Forest.

The fauna habitats present throughout the proposed development area include:

- vegetated areas of short heath, tall heath, wet heath, hanging swamp and low open forest with a heath to scrub understorey
- subsequent variations in density structure of vegetation

- other nectar producing resources, principally *Angophora*, *Eucalyptus*, *Melaleuca, Banksia* and *Acacia* species
- sandstone rocky areas providing shelter in the form of crevices, overhangs and basking opportunities for reptiles
- sparse to dense shrub layers, ground covers and leaf litter
- hollows mostly in the small size range
- A range of mostly sandy soil types providing burrowing and foraging opportunities
- ephemeral drainages and soaks.

Table 4 – Insitu habitat / refugia features identified within the APZ

Habitat feature / refugia	Location (Refer to Figure 6)	Benefiting species
Sandstone outcrops, crevices, overhangs and small caves at various aspects	3B-C, 3K, 3J, 4D, 5C, 7G, 8G-H	Reptiles
Sandstone slabs	4I, 3C, 6C, 7C, 7F-H,	Diamond Python & other reptiles
Loose sandy soil suitable for digging, burrowing and foraging	3J	Bandicoot
Occasional moist soils within hanging swamps	3J-K, 4J-K, 6F, 7F-G	Red-crowned Toadlet & other frog species
Ephemeral drainage lines off a heath-land plateau into sandstone rocky slopes	7F, 3J, 4J	Various species including Red-crowned Toadlet
Depressions providing temporary soaks after heavy rainfall	7F-H, 3K, 4K	Ground foraging mammals & frogs
Drainage line / creek line	3J, 4J, 6F, 7F,	Reptiles, amphibians
Fallen branches / small trees,	All zones	reptiles & amphibians
Artificial debris and refuse	6D, 7D	Reptiles & small mammals
Root ball shelter	5C	Small terrestrial mammals
Rock pool	5C	Birds
Termite mound	3K	Rosenberg's Goanna
Bandicoot diggings	3J	Bandicoots
Hollow bearing tree - Small to medium sized hollows in low density only within the Low Open Forest Community	3C, 4D-E, 5E, 6C-D, 7D-F, 8H,	Eastern Pygmy Possum and other small arboreal mammals
Nectar producing *Eucalyptus* trees providing foraging resources for all seasons excluding winter	All zones	Arboreal mammals, birds, bats
Dense tall heath containing *B. ericifolia*	3C, 4B-E, 4I, 5C, 5E-I, 6C-D	Eastern Pygmy Possum and nectarivore bird species
Large good quality Silvertop Ash	6D	Birds
Mature *Banksia ericifolia*	4I, 5C,	Eastern Pygmy Possum and nectarivore birds
Large seeding *Allocasuraina littoralis*	7D	Glossy black -Cockatoo
Patch of young *Banksia ericifolia*	5C, 7F & 7H	Eastern Pygmy Possum and nectarivore birds
Ecotonal edge of woodland, tall heath and low heath	5D	Various species
Mixed banksia, Scribbly Gum & Red Bloodwood	3C, 4D & 4I	Eastern Pygmy Possum and various species
Critical habitat	2C, 2D & 2H-M 3C-D, 3F, 3F-M, 4F-I, 5F-I	Rosenberg's Goanna critical habitat
Frog breeding habitat	4J, 7F,	Red Crowned Toadlet
Sap tree	5G,6G, 7D-F, 7G	Sugar Glider
Burrow	3J-K, 4K, 4F, 5F, 5C, 6C, 7H, 8H	Heath Monitor and terrestrial mammals

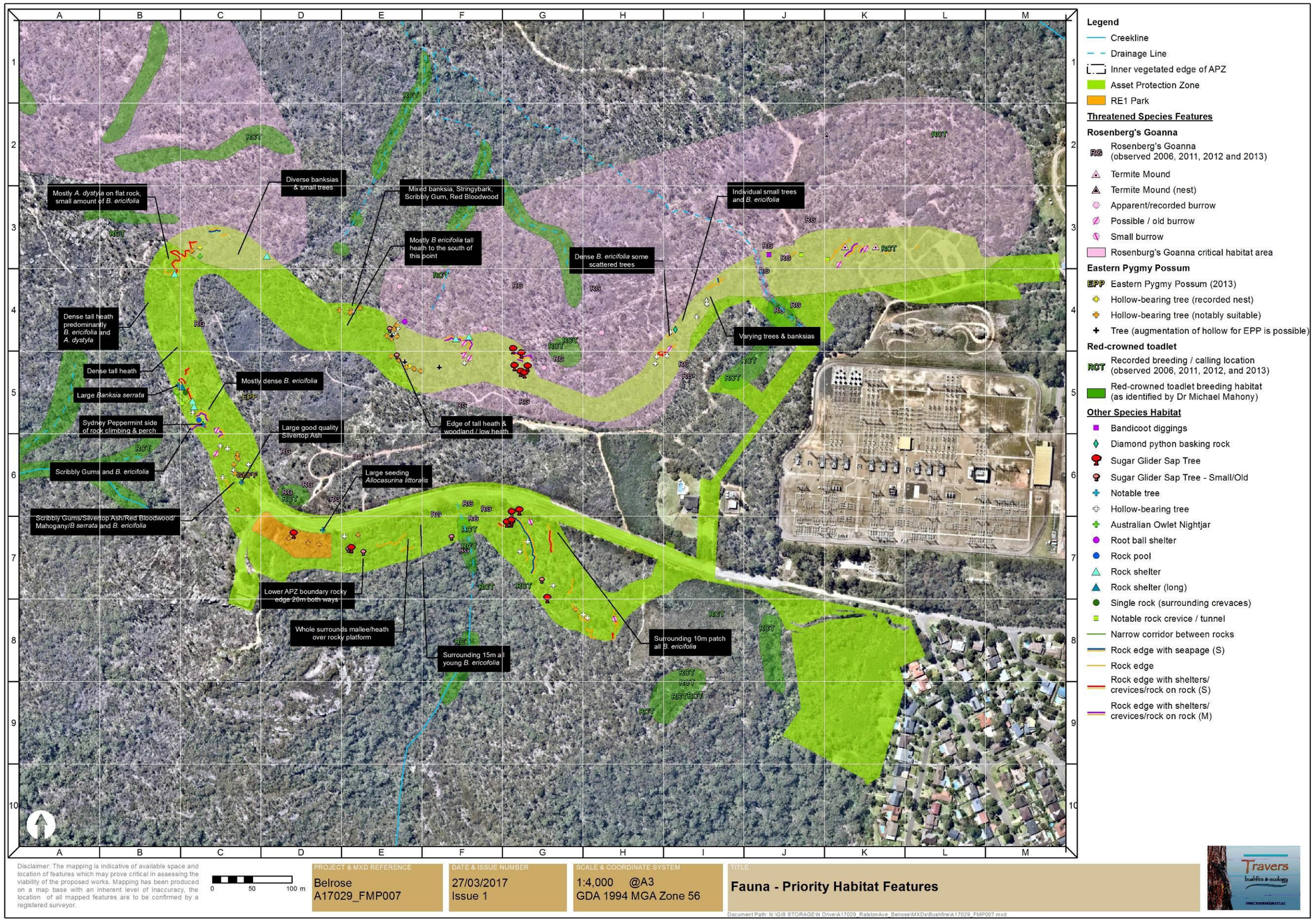

Figure 6 – Habitat resources

3.5 Prescription burning of the E3 lands

The over use of fire as a management tool and the high frequency of unplanned fire will lead (over time) to the simplification of the habitat. This will ultimately impact upon the carrying capacity of that habitat for the full mixture of wildlife (plants and animals).

Each plant community has a 'threshold of tolerance' to repetitive fire events. These thresholds are particularly useful to land managers to assist their fire management decisions. Thresholds for vegetation communities in the site are provided in the Tables below and are adapted from the original research of the NSW National Parks and Wildlife Service (Ross Bradstock, 1994).

Table 5 – Inter-fire interval thresholds

Vegetation formation	Vegetation type	Minimum SFMZ threshold (years)	Minimum LMZ threshold (years)	Maximum threshold	Notes
Dry sclerophyll forest (shrub/grass sub formation	Sydney North Exposed Sandstone Woodland Coastal Sandstone Gully Forest	5	8	50	Occasional intervals greater than 25 years may be desirable
Heathlands	Coastal Sandstone Rock Plate Heath Coastal Sandstone Heath - Mallee	7	10	30	Occasional intervals greater than 20 years may be desirable
Freshwater Wetland	Coastal Upland Damp Heath Swamp	7	10	35	Occasional intervals greater than 25 years may be desirable

The ideal fire regime is one that allows for the conservation of floristic diversity while also providing some management flexibility for annual fire management programs. This management flexibility is essential to accommodate the complex and dynamic decision making processes associated with prescription burning and unplanned fire suppression.

A diversity of fire regimes are required in order to maintain biodiversity. This means that over time there may be a need to implement fires of high, moderate and low intensity, frequency and size throughout the landscape.

Species reduction may be likely when fire regimes of relatively fixed intensity, frequency and extent prevail without interruption.

Accurate recording of all fires is essential. Assessment of fire regimes through mapping of the locality and characteristics of all fires will be ongoing so that strategies (manipulation of fire regimes) can be regularly reviewed, refined and adjusted.

Depending on the circumstances (a function of vegetation community type and prevailing fire regimes), there may be a role for both prescribed fire and / or fire-exclusion in parts of a given area in the future. e.g. riparian zones.

Autumn to early spring is the preferred period for prescribed burning because of the ease of extinguishment in these seasons. Burning in this time also allows the vegetation to regenerate in the milder temperatures of autumn, winter and spring. However, in terms of fire control, spring burning is acceptable in periods when the preceding rainfall has been sufficient to allow fires to extinguish overnight.

Spring burns are also important ecologically, as a variation in season for prescribed burn regimes is important for ecological conservation. Strip burning at appropriate times in strategic locations may be useful to slow or stop the movement of large fires spreading into or through the area and are a potential management consideration.

It is important not to rely solely on strategic burning alone. The need for well-designed and maintained fire trails to provide primary suppression capability coupled with effective fire fighting equipment provides the major tools to provide the required 'balance'.

Fire trail management requires the implementation of strip burning, where appropriate, adjacent to the trails in order to maintain an acceptable level of safety for fire fighters.

Maintenance of vegetative cover and diversity of structure within flora communities is essential for conserving viable fauna populations. It is undesirable for any individual fire or set of fires, closely-spaced in time, to burn the whole of a particular community type. Unburnt areas act as a refuge for fauna species that suffer habitat loss during and soon after fire. These refuge areas then become critical for the recolonization and protection of species.

3.6 Guiding principles of ecological fire management

Ecological research into fire-prone landscapes has established some general principles in relation to the fire regimes required to conserve biodiversity (NPWS 1996, 1999).

Groups of flora and fauna species respond similarly to fire according to identifiable characteristics of their life history. Therefore, it is not necessary to individually specify fire regimes for the conservation of every species. Requirements for most plant species can be summarised on the basis of a small number of groups. The knowledge of requirements for groups of animals is less advanced (NPWS 1996, 1999).

A diversity of fire regimes is required in order to maintain diversity of plant and animal species. This means that, over time, there may be a need to implement fires of high, moderate and low intensity, frequency and size throughout the landscape. A reduction in species numbers may be likely if fire regimes of relatively fixed intensity, frequency and extent prevail without interruption.

Given this knowledge, hazard management can still occur without compromising ecological systems or denuding scenic values. Planning strategies can accommodate effective fire management of the landscape to achieve the desired balance of species and habitats.

In NSW, the available knowledge on the way fire effects native animal species is currently insufficient to accurately formulate comprehensive fire regime thresholds for the management of fauna species, as can be done for many plant communities. However, size of habitat and diversity of resources within that habitat is a key element in the provision of appropriate fauna habitat for either an individual species or a population.

Indeed, the major long-term impact that fire has on fauna is the reduction of population size through changes in vegetation structure and floristics (habitat). The key characteristics of 'fire regimes' which impact on animals can be calibrated to include frequency of fire, season of fire and extent / patchiness of fire (NPWS 1999). The basic management regime for all fauna species is to maintain vegetative cover and structure (habitat).

The frequency of fires will determine the complexity and therefore the habitat value of the understorey, with frequent fires increasing exposure to predation and climatic influences and promoting the potential loss of food and shelter resources for either individuals or populations.

Fires occurring during the breeding season could potentially adversely affect some species by killing offspring or preventing breeding. Reduction of vegetation density may increase the exposure of the young of some species to predation.

Burns which are limited or patchy will provide a range of ages of vegetation which will provide a greater variety of food and shelter sources, enabling utilisation of an area by a greater number of species and / or individual / populations. Areas not burnt also act as important refuges by providing shelter and food sources, from which recolonisation of the burnt areas can occur (NPWS 2000).

Intense fires can initiate the creation of hollows in trees that, in turn, provide habitat for hollow-dependant fauna e.g. owls, gliders, micro-bats and some birds. Exclusion of such hollow-forming processes can cause significant impact upon such species, particularly threatened species, over time. It can also lead to a reduction in population size and thus impact an individual presence.

The guidelines within this plan intended for the management of animal species will be subject to the *TSC Act*. This Act provides the framework to protect and encourage the recovery of threatened species, populations and ecological communities.

The development of recovery plans by DECC (or equivalent) is a requirement under Part 4, Division 1 of the *TSC Act* to ensure the appropriate management and planning for the conservation of threatened species. As these recovery plans are developed there may be a need to adjust the fire management guidelines provided in this plan.

The prescription burning process requires environmental impact appraisal, fire history review, evaluation of biodiversity issues, weather prediction, fire behaviour prediction, ignition patterns, resource provision, neighbour notification, fire reporting, etc.

3.7 Wildlife response to fire

3.7.1 Flora

Tables below list some life history features of the threatened flora recorded in the Belrose development site by *Travers bushfire & ecology*. The fire response information can be used to formulate different fire regimes necessary to maintain the full suite of species on site. The locations and survey effort of recorded threatened species is depicted in Appendix 6.

Table 6 – Threatened flora species

Species	Habitat characteristics	Fire response
Acacia bynoeana	Erect or spreading shrub to 0.3m high growing in heath and dry sclerophyll Open Forest on sandy soils. Often associated with disturbed areas such as roadsides. Distribution limits N-Newcastle S-Berrima.	No fire more than once every 7 years

Species	Habitat characteristics	Fire response
Callistemon linearifolius	Shrub to 4m. Suitable habitat found in dry sclerophyll forest on the coast and adjacent ranges from Nelson Bay to the Georges River.	Fire response unknown. Adults are likely to be killed by fire. Therefore, the life cycle of this species will not be disrupted within this vegetation type provided that no more than 2 burns should occur within 5 years, with a burn being required at least every 30 years. The time frame of the proposed hazard reduction will fall within the acceptable fire regime guidelines for this species.
Epacris purpurascens var. *purpurascens*	Erect shrub to 1.5m high growing in sclerophyll forest and scrub and near creeks and swamps on Sandstone. Distribution limits N-Gosford S-Blue Mountains.	No fire more than once every 7 years
Eucalyptus camfieldii	Stringybark to 10m high. Grows on coastal shrub heath and woodlands on sandy soils derived from alluviums and Hawkesbury sandstone. Distribution limits N-Norah Head S-Royal NP.	No fire more than once every 7 years
Grevillea caleyi	Shrub mostly 1-3m high. Grows in laterite. Distribution limits Terrey Hills-Belrose area.	No fire more than once every 10 years
Haloragodendron lucasii	Straggling shrub to 1.5m high. Grows in open forest on sheltered slopes near creeks. Distribution limits Ku-ring-gai Plateau and Mt Wilson.	No fire more than once every 7 years
Lasiopetalum joyceae	Erect shrub to 2m high. Grows in heath and open forest on Hawkesbury sandstone. Distribution limits Hornsby Plateau.	No fire more than once every 7 years
Melaleuca deanei	Shrub to 3m high. Grows in heath on sandstone. Distribution limits N-Gosford S-Nowra.	No fire more than once every 8 years
Microtis angusii	Terrestrial orchid which is known from two populations, Mona Vale and Sunny Corner.	No fire

Species	Habitat characteristics	Fire response
Persoonia hirsuta	Erect to decumbent shrub. Grows in dry sclerophyll forest and woodland on Hawkesbury sandstone with infrequent fire histories. Distribution limits N-Glen Davis S-Hill Top.	*Persoonia hirsuta* can tolerate fires but is threatened by fires that are too frequent. The plant needs to reach reproductive maturity and have a chance to set seed for a few years to assist in maintaining a population in a fire prone or managed environment. A suggested fire interval for the species should be at least 10 years apart.
Pimelea curviflora var. *curviflora*	Woody herb or sub-shrub to 0.2-1.2m high. Grows on Hawkesbury sandstone near shale outcrops. Distribution Sydney.	*Pimelea curviflora var. curviflora* is likely to be fire tolerant, capable of re-sprouting following fire due to the presence of a tap root. Seedlings have been observed following fire. The species can survive for some time without any foliage after fire or grazing, relying on energy reserves in its tuberous roots to support regrowth. There is very limited information on fire treatments upon this species and it's mentioned in the priority actions for the species that further studies are required. Based upon the type of environment it typically occurs, sandstone or shale-sandstone transition forest, the fire regime should be within the limits of the ecological community, that being minimum of 7 years and maximum of 30 years.
Tetratheca glandulosa	Spreading shrub to 0.2m high. Sandy or rocky heath or scrub. Distribution limits N-Mangrove Mountain S-Port Jackson.	No fire more than once every 7 years

3.7.2 Fauna

Table 3.6 below lists natural history features of the threatened and locally significant fauna recorded at Ralston Avenue, Belrose by *Travers bushfire & ecology* (2015) and others.

The fire response information can be used to formulate different fire regimes necessary to maintain the full suite of species on site. The locations and survey effort for each of the threatened species identified below are depicted on Figure 6.

Table 7 – Threatened fauna species

Species	Habitat characteristics	Fire response
Giant Burrowing Frog *Heleioporus australiacus*	This species is most common on the Hawkesbury Sandstone. Males call from beside smaller semi-permanent to permanent streams or dams or from burrows within the bank of streams or dams however resting burrows have been found more than 200m from breeding areas.	Habitat lost to fire and species territory declines with lost breeding habitat. Streams with recorded use are to have a buffer protection area.
Red-crowned Toadlet	Red-crowned Toadlets are quite a localised species that appear to be largely restricted to the immediate vicinity of suitable breeding habitat. Occurs in open forests, mostly on Hawkesbury and Narrabeen Sandstones. Small colonies inhabit periodically wet drainage lines below sandstone ridges that often have shale lenses or cappings. Shelters under rocks and amongst masses of dense vegetation or thick piles of leaf litter. Breeding congregations occur in dense vegetation and debris beside ephemeral creeks and gutters.	This species is of particular fire management concern as it congregates in small areas and has limited dispersal capability. Thus certain populations can be relatively isolated and be impacted by fire events, with limited recolonisation potential. The most appropriate fire management procedure for this species is to undertake survey along drainages prior to prescribed burns. Burns near to ephemeral drainages should be undertaken following recent rainfall such that fuel loads have dried out but drainages remain moist. Colonies would be more likely congregated for breeding rather than dispersed at this time also.
Rosenberg's Goanna	Rosenberg's Goanna is a species that is likely to centre its activity on heath areas particularly where rock outcrops occur and also hanging swamps / wet heath, it is a Hawkesbury / Narrabeen sandstone outcrop specialist *(State Forests of NSW, 1995).* The species shelters in logs and rock crevices as well as excavated burrows (usually below rock). It is likely to also show preference for aspects to the north that is likely to get winter sun in the morning and afternoon.	Habitat lost to fire causes species to move away but regrowth provides opportunities. Active terrestrial termite mounds are a critical feature for nesting that will not likely be damaged by low intensity fires but should not be damaged during any mitigation works. This species is fast moving and may escape slow moving fires. When denning in burrows this species would be often safe from low intensity burns. When denning in ground hollows this species would need time to escape or take refuge. It would be expected that low intensity mitigation burns during the winter months are more likely to have less effect on the species when it is typically located deeper in more established winter burrows. Burns would not be expected to impact on nests incubated within termite mounds.

Species	Habitat characteristics	Fire response
Little Eagle *Hieraaetus morphnoides*	The Little Eagle occupies habitats rich in prey within open eucalypt forest, woodland or open woodland.	Habitat lost to fire reduces territory. No burning around known nesting sites at any time The fundamental management concern for the Little Eagle is ensuring that prescribed burns do not impact on nest locations particularly during the breeding period between July and October. Nests are large and detectable during diurnal surveys.
Glossy Black-Cockatoo *Calyptorhynchus lathami*	Suitable habitat in She-oak forests, woodlands and timbered watercourses. Also found in eucalypts and native cypresses. Feeds almost exclusively on Allocasuarina fruit.	Adults likely to escape fire. Potential for inappropriate fire regime to cause a decline in roosting tree hollow regeneration and habitat diversity. Moderate to Intense fires may cause tree damage and thus interrupting availability of feed species in a locality for several years. In accordance with the *Bushfire Environmental Assessment Code* (2006) no burning of Allocasuarina thickets is allowed.
Gang-gang Cockatoo	In summer, generally found in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter, may occur at lower altitudes in drier more open eucalypt forests and woodlands, and often found in urban areas. Move to lower altitudes in winter, preferring more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. Favours old growth attributes for nesting and roosting.	Protect large and hollow-bearing trees where species occurs. Manage remnant woodlands and forest for recovery of old-growth characteristics.

Species	Habitat characteristics	Fire response
Little Lorikeet	Forages primarily in the canopy of open *Eucalyptus* forest and woodland, yet also finds food in *Angophora, Melaleuca* and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity. Gregarious, travelling and feeding in small flocks (<10), though often with other lorikeets. Nests in proximity to feeding areas if possible, most typically selecting hollows in the limb or trunk of smooth-barked Eucalypts. Entrance is small (3 cm) and usually high above the ground (2–15 m). These nest sites are often used repeatedly for decades, suggesting that preferred sites are limited. Riparian trees often chosen, including species like *Allocasuarina*. Nesting season extends from May to September.	Protect large any hollow-bearing trees where species occurs. Protect large flowering *Eucalyptus* trees throughout the habitats frequented by this species. Manage remnant woodlands and forest for recovery of old-growth characteristics.
Barking Owl	The Barking Owl utilises Dry sclerophyll forests and woodlands of tropical, temperate and semi-arid zones, often dominated by Eucalyptus, and containing many large trees suitable for roosting or breeding. The owl utilises large hollows in large old trees; usually living Eucalyptus for nesting.	The fundamental management concern for is to ensure that prescribed burns do not impact on nest locations particularly during the breeding period between July and November There is less concern for roosting and foraging habitat that may be burned outside of this period based on the species home range areas. Recorded nesting trees should be provided with a buffer to ensure core roosting habitat during nesting is maintained.

Species	Habitat characteristics	Fire response
Powerful Owl *Ninox strenua*	Suitable habitats are limited predominantly to sclerophyll forest and encompass large permanent territories that range from 800 to 1,000 ha. Live in pairs and roost in tall forest trees by day. Each pair has a number of roosting trees and roost on different trees on different days, not always together but within calling distance. Nests in tree hollows. The hollows range from 50 to 180 cm deep and are usually 12 to 40 m above ground in the trunk of a towering eucalypt. Prey predominantly on arboreal small to medium-sized mammals and birds, particularly the Great Glider (*Petauroides volans*) and the Common Ringtail Possum (*Pseudocheirus peregrinus*).	Fire is unlikely to impact on adults, however, there is potential for inappropriate fire regimes to reduce habitat and prey availability and or diversity of resources. There is potential for moderate to high intensity fire to impact on reproduction between July and September. Clearing by fire is likely to temporarily increase foraging habitat. In accordance with the *Bushfire Environmental Assessment Code* (2006) no burning is allowed around known nesting sites at any time. Reliant on arboreal mammals, which attain their highest density under long fire intervals.
Masked Owl *Tyto novaehollandiae*	Inhabits open forest & woodlands with cleared areas for hunting. Prefers deep gullies for nesting in large tree hollows and dense vegetation for roosting. Preys on terrestrial mammals, especially rodents. Foraging range similar to the Powerful Owl.	Fire is unlikely to impact on adults. However, inappropriate fire regimes have the potential to reduce prey available and or diversity of resources. Clearing by fire is likely to temporarily increase foraging habitat. There is potential for moderate to high intensity fire to impact on reproduction, particularly between autumn and winter.
Varied Sittella	Varied Sittellas inhabit open eucalypt woodlands/ forests (except heavier rainforests), mallee, inland acacia, coastal tea-tree scrubs, and moderately disturbed landscapes. They feed mainly by gleaning arthropods from crevices on tree trunks or small branches and twigs in the tree canopy. They prefer rough or decorticating bark barked trees like Stringybark's and ironbark's, standing dead trees, or mature trees with hollows or dead branches. It builds a cup-shaped nest of plant fibres and cobweb in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years.	As nests are usually high the main consideration in fire management is the breeding period which is between July-December but can also be between March-April. Protect known habitat from fires of a frequency greater than that recommended for the retention of biodiversity.
Scarlet Robin	The Scarlet is found in foothill forests, woodlands, scrubs and along watercourses. In autumn-winter, they are found in more open habitats.	This species breed from August-January and builds its nest often low 1-3m above ground for fire management consideration.

Species	Habitat characteristics	Fire response
Spotted-tailed Quoll	The southern subspecies of Spotted-tailed Quoll inhabits a range of treed habitats including rainforests, wet and dry sclerophyll forests, woodland and coastal heathland, scrub and dunes, swamp forest, mangroves, on beaches and sometimes in grassland or pastoral areas adjacent to forested areas. Relatively high densities of the species have been recorded from both wet and dry forest types. Quolls favour areas with dense over storey and understorey and use hollow-bearing trees, hollow-tree buttresses, fallen logs, small caves, rock crevices, boulder fields, rocky-cliff faces and underground burrows as den sites for shelter / breeding.	Of fire management concern is that these locations are generally difficult to locate.
Southern Brown Bandicoot	Utilises a range of habitats containing thick ground cover - open forest, woodland, heath, cleared land, urbanised areas and regenerating bushland.	Bandicoots are capable of surviving the immediate impact of low to moderate intensity bushfires. Indirect impacts from loss of vegetation cover (predation) are likely to have more severe long-term implications for populations. Undertake mosaic burns. Aim to maintain more than 80% of the bandicoot habitat within an area of contiguous habitat to be greater than 4years since last burnt. This species has demonstrated habitat preference in the short to medium term regeneration after a bushfire event.
Koala	Koalas are recognised to occupy both forest and woodland communities that contain a canopy cover of between 10 and 70%, and given that the suitable eucalypt tree species are present. The home range of Koalas varies according to the quality of habitat and number of available food trees, more so than food tree density. Spend most of their time in trees, but will descend and traverse open ground to move between trees. Home range size varies with quality of habitat, ranging from less than two ha to several hundred hectares in size.	Apply low intensity, mosaic pattern fuel reduction burns in or adjacent to Koala habitat. The Koala is able to take high refuge from low intensity surface and low shrub burns, otherwise observations for presence prior to burns should be undertaken

Species	Habitat characteristics	Fire response
Eastern Pygmy Possum	The Eastern Pygmy Possum is found from rainforest through sclerophyll forest to tree heath. Banksia and myrtaceous shrubs and trees are favoured. Eastern Pygmy Possums usually shelter alone in tree cavities, rotten stumps, holes in the ground, disused bird nests and possum dreys and in vegetation thickets such as *Xanthorrhoea* species. The home ranges of males, about 0.65ha are larger than those of females with home ranges broadly overlapping.	This species may prosper from regeneration following fire however high intensity burns are likely to impact on isolated populations.
New Holland Mouse	Occurs in heathlands, woodlands, open forest and paperbark swamps and on sandy, loamy or rocky soils. Coastal populations have a marked preference for sandy substrates, a heathy understorey of leguminous shrubs less than 1 metre high and sparse ground litter.	Recolonisation of regenerating burnt areas occurs after one to two years. Populations become threatened if the habitat becomes grossly altered or if no refuge patches remain from which colonisation can occur. The species constructs burrows up to 5 metres long for daytime refuge and may be protected from low intensity burns. Too frequent burning however has been noted as being detrimental to populations.
Grey-headed Flying-fox *Pteropus poliocephalus*	Found in a variety of habitats including rainforest, mangroves, paperbark swamp, wet and dry open forest and cultivated areas. Forms camps commonly found in gullies and in vegetation with a dense canopy.	Buffers to any identified camps would need to be strictly enforced.
Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris*	Suitable habitats encompass a variety of environments that range from rainforest to arid shrubland. Roost in small hollows during the day, usually singly, but sometimes in groups of up to 10. Preys on relatively large flying insects, such as beetles and moths, flying above the tree canopy or in clearings.	Prolonged absence of fire may cause a decline in roosting hollow regeneration. Frequent fires near roosting habitat may impact upon breeding success and foraging areas may be affected. It is difficult to locate bat roosting locations, however these species typically do not roost down low and thus it is expected that these species will typically be well protected in hollows during diurnal mitigation burns that are maintained below canopy level.

Species	Habitat characteristics	Fire response
Eastern Bentwing-bat *Miniopterus orianae oceansis* *and* Little Bentwing-bat *Miniopterus australis*	Suitable habitats include a variety of environments that are generally well-watered. Roosts during the day, in colonies that may reach thousands in caves or similar spaces, such as mines or equivalent artificial excavations. Preys on small flying insects beneath the tree canopy. Maternity colonies are formed in spring and a single young is born late in the year. It is left in the roost while the mother is feeding.	Frequent fires near roosting habitat may impact upon breeding success. Foraging areas may also be affected by fire. The *Bushfire Environmental Assessment Code 2006* indicates that no burns should be undertaken around known roost sites Utilise buffer around known roosts.
Eastern Freetail-bat	Occur in dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range. Roost mainly in tree hollows but will also roost under bark or in man-made structures. Usually solitary but also recorded roosting communally, probably insectivorous.	Protect large and hollow-bearing trees where species occurs. Avoid high intensity fires that consume canopies and fallen logs in locations where this species is known to occur. Avoid inter-fire intervals of <10 years in locations where this species is known to occur.

3.8 Garigal National Park

The adjoining Garigal National Park provides a significant potential for bushfires to enter the residential landscapes of the proposed subdivision. The landowner and manager for the Garigal National Park is the Office of Environment & Heritage (OEH). OEH will undertake fuel management works on their lands in accordance with the principles outlined in their fire management plan.

3.9 Riparian corridors and catchment values

There are a number of tributaries and streams within the community association land and the adjoining *MLALC* land – see Figure 1. In accordance with the *Bushfire Environmental and Assessment Code* all mechanical work is to be excluded from vegetation adjacent to creek lines and within riparian buffer zones. The distance is measured from the highest bank or shore on either side of the water body as follows:

Table 8 – Protection distance for riparian zones

Water body	Use of hand tools and hand held machinery (metres)	Use of slashing machinery (metres)	Use of graders, ploughs and dozers (metres)	Removal of trees (metres)
1st Order and unmapped streams	5	5	10	5
2nd Order Streams: Wetlands, Lakes and Lagoons greater than or equal to 0.1ha but less than 0.5ha	5	10	15	10
3rd Order Streams: Wetlands, Lakes and Lagoons greater than or equal to 0.5ha but less than 2ha	10	15	20	15
4th Order Streams & greater: Estuaries, Wetlands, Lakes and Lagoons Greater than or equal to 2ha	10	20	20	20

The forest cover is important in maintaining stream flow, preserving water quality and ensuring a high level of erosion prevention. Prescribed burning can have positive impacts -on water quality. For example, Scott and Schulze (1992) recommend that fuel management programs be implemented in eucalypt forested catchments to prevent extreme soil heating during wildfires and subsequent accelerated erosion.

Soil heating can have a deleterious impact upon soil microbes and thus the efficient return of soil health to equilibrium.

Maintenance of full vegetation cover in and adjacent to drainage lines, is achieved by exclusion of fuel reduction burning, or by strategic burning under mild conditions, using the moisture gradient from upper slope to gully. Scott *&* Schulze (1992), report that unburnt riparian strips are effective soil and ash traps following wildfire, and would be even more effective following low intensity prescribed fire.

No lighting of a prescribed burn is permitted within the riparian buffer zone distances specified in the following table. The distance is measured from the highest bank or shore on either side of the water body.

All reasonable steps should be taken to ensure that the fire does not burn within the riparian buffer zone. Fires should be lit under conditions so that if they do burn within the zone they are patchy and low intensity.

3.10 Impact on soil nutrients

Removal of fuel on a regular basis may cause long term loss of soil enrichment and surface vegetative cover from rain, sun and wind. Research on the impact of soil nutrient loss from fires is in its infant stage and no definite statements can yet be made. However, it is known that repetitive fires will deplete nutrient availability for plants (Gill 1986) which in turn interrupts nutrient cycling (Raison et. al 1990).

Most native vegetation is intolerant of excess nutrients, particularly nitrogen and phosphorus. Exotic species, particular weedy species, are adapted to higher nutrient status soil. Following fire, there is often establishment of weed species, but the influence of fire on soil nutrient availability is difficult to quantify.

However, it is known that the loss of phosphorus from the soil may occur through either transfer into the atmosphere in particulate (ash) or volatile forms (Walker et. al 1986; Raison et. al 1990). Nitrogen loss is replenished by nitrogen-fixing species such as the woody plants e.g. *Acacia* and *Allocasuarina*.

3.11 Soil erosion

The impact of soil erosion can be significant following fire events. The degree of soil erosion is greatly influenced by the time period between the fire and the first erosive rainfall. Steep slopes have the greatest potential for mass soil movements. The timing of prescribed burning programs should ideally consider potential post-fire rainfall. For example, in Belrose, the wettest period of the year is typically late summer to early autumn.

In accordance with the *BEAC*, if a moderate intensity burn is being used conditions must be applied to ensure that moderate intensity fire is not used on soil surface slopes greater than 18 degrees.

Research by Leitch (1983) in the central highlands of Victoria found that following an intense thunderstorm of short duration following a fire, gross erosion occurred for a period of six (6) days. Leitch concluded that burnt forests can remain in a highly erosive state for protracted periods until soils are again bound and are regrowing vegetation.

Additionally, sediment loads carried by streams were found to increase greatly after fire in the Snowy Mountains Region (Brown 1992). Similarly, Good (1973) found that notable erosion was also caused by fire trails and other access trails. The latter is a by-product of management requirements and any negative impact must be aligned with the positive impact of suppression capability. However, good design and regular management of fire trails and adequate drainage controls can prevent this damage.

The potential for soil erosion in the post-fire landscape is also increased where strong winds prevail. The Coastal Sector supports heathland that grows in shallow soils. The potential for soil loss is high in this environment. Thus, fire management of coastal lands needs to address this added destructive hazard.

3.12 Cultural resources

Dominic Steel Consulting Archaeology prepared an *Aboriginal Archaeological Due Diligence Assessment* in December 2012. The report concluded that the Ralston Avenue rezoning proposal is unlikely to have an adverse impact upon the Aboriginal archaeological heritage values of the place and that no 'clear or obvious' archaeological constraints are apparent at this time.

In addition to that document, an Aboriginal cultural heritage assessment is currently being undertaken. Any identified Aboriginal sites of significance will need to be protected with all hazard reduction activities following the *Bushfire Environmental Assessment Code* '*Conditions for hazard reduction and aboriginal heritage*' as part of the environmental assessment process.

Protection of assets & infrastructure 4

The major mitigating factor that limits the effects of wildfire is the amount of fuel available to burn. By reducing the amount of fuel there will be a reduction in the intensity of the fire.

4.1 Management of asset protection zones

The area in which the fuel reduction occurs for protection of an asset is referred to as an asset protection zone (APZ). The APZ can be further classified into two sub-zones with each having a specific role. These sub-zone areas are called the inner protection area (IPA) and the outer protection area (OPA).

4.1.1 Inner protection area (IPA)

This area is *almost free* of all fuels and usually takes the form of grassy areas, car parks, roads, concrete areas, tracks or trails. It does not imply or require the wholesale removal of every tree - see 5.2.2 below.

This zone is intended to stop the transmission of flame and reduce the transmission of radiant heat by the elimination of available fuel. This area also allows airborne embers to fall safely without igniting further outbreaks.

This zone also provides a safe fire-fighting position and is operationally important for implementation of clear fire control lines.

A recommended performance standard for the fuel load of an IPA is between 0–4 t/ha. Shrubs may occur within an IPA commensurate with a spatial distribution of 15-25%. For example, an area of 100m2 (10mx10m) can have up to 25% of this area composed of shrubs.

The vegetation surrounding the nest and roost tree sites within Stages 9, 12 & 14 are to be retained for ecological purposes (refer to Annexure 1 for details). The area forming the IPA surrounding this vegetation (within Stage 14) is to be managed to 4 tonnes per hectare and requires the following specific management:

- trees to remain unaffected, canopy separation of 2m is required
- regular raking of surface fuels (3 x per year) to remove 80% of litter fuels
- shrubs to be reduced in density to 20-30%
- grasses and herbs require regular mowing
- regrowth trees and shrubs to be culled.

4.1.2 Outer Protection Area (OPA)

This zone is designed to stop the development of ‘intense’ fires and the transmission of ‘severe’ radiated heat.

The OPA assumes most trees will remain but with a modified shrub / grass and litter layer. In some sparse vegetation communities the shrub layer may not require modification e.g. the heath vegetation. The fire fighting advantage will manifest in reduced fire intensity. It achieves this by denying fire a significant proportion of the fuel to feed upon.

A recommended performance standard for the fuel load of an OPA is between 4-6 t/ha.

The IPA is managed as a fuel free zone while the OPA is managed as a fuel reduced zone. This means that the fuel free zone has little fuel available to be consumed in the event of a fire whilst the fuel reduced zones has less than normal fuel levels that could be consumed in the event of a fire.

Fuel management can be undertaken via various means. The means are varied and costs are quite significantly different for each treatment option chosen. The methods are described and annexed to this report and include, slashing, mowing, burning (including localised pile burning) and physical clearing.

Other fuel management strategies may be prescribed in very limited circumstances. These include:

1. Grazing: using animals to eat vegetation and therefore reduce fuel loads.

2. Pruning: removing the lower branches of tress to create a vertical fuel discontinuity to reduce the chance of surface fires developing into crown fires.

3. Fuel replacement: replacing highly flammable vegetation types with less flammable vegetation types.

4. Selective tree removal: removing selected trees to reduce the continuity of tree canopies to reduce the chance of crown fire development.

Biodegradable chemicals such as *Roundup* may be used on individual plants where considered environmentally and / or ecologically appropriate.

The vegetation surrounding the nest and roost tree site within Stage 14 is to be retained for ecological purposes (refer to Annexure 1 – APZ 1 for details). The area forming the OPA surrounding this vegetation is to be managed to 6 tonnes per hectare and requires the following specific management:

- trees are to remain unaffected
- regular raking of surface fuels (3 x per year) to remove 60% of litter fuels off site or reconstituted as fines
- shrubs to be reduced to 30%
- grasses and herbs can remain unaffected
- regrowth trees and shrubs to be culled.

4.2 Presence of trees in the inner protection area (IPA)

Trees may occur within an IPA if the general canopy is not linked. The RFS advise that canopy trees should be at least 2m apart. In general though, a canopy should have no vertical or horizontal links with other vegetation. The reason for this is to lessen any chance for fire to extend vertically into the canopy from shrub vegetation.

It is a basic premise in the understanding of fire behaviour that fire cannot occur in a canopy if there are no surface fuels, such as grasses or shrubs, to feed fire vertically from the ground into the canopy. However, under extreme conditions, significant wind strengths may enable transfer of flame across a canopy.

This is more likely on steep slopes, and / or where wind may sheer across the top of a forest leading to flames skipping across the canopy. This phenomenon is rare and only occurs where there is a significant ember attack fanned by strong winds. In the case of the Belrose landscape this phenomenon is highly likely.

4.2.2 Ecological and asset protection zone management matters

The initial planning for the residential development of the lands involved a holistic assessment of the competing requirements for ecological maintenance and bushfire protection.

Field assessment of ecological variables was undertaken between 2002 and 2017 in order to establish the floristic structure of all living and dead vegetation to analyse the presence and or absence of plants species on site. Floristic sampling was then undertaken to establish plant species composition within quadrats.

Other environmental characteristics were also recorded. Information was analysed to determine the vegetative hazards that are able to be manipulated to achieve acceptable environmental and ecological retention.

4.3 Access issues

The provision of a perimeter road means that access to the APZ will be available at all times.

The provision of adequate fire trail access within the offset areas is required to be undertaken to best practice. Fire trail works will be undertaken in accordance with the design specifications outlined in *PBP 2006* and in accordance with construction standards set by the RFS and or Warringah Pittwater bushfire management committee.

This requires that fire trails have a minimum trafficable width of 4m with an additional 1m wide strip on each side of the road kept clear of bushes and long grass, a maximum grade of 15º (preferably 10º) and a minimum clearance of 4m to any overhanging obstructions, including tree branches. These guidelines have been applied in the proposed development designs.

Managing the environment 5

5.1 Bushfire management zones

The landscape has been divided into 'management' zones. The zones enable varying management principles to be applied based on areas of similar environmental, cultural and social characteristics - see Figure 7. These include APZs x 3, Strategic Fire Advantage Zones x 5 and Land Management Zones x 2; see Tables 5.1 - 5.3.

Bushfire risk and bushfire behaviour also tend to be similar within each zone. Zone descriptions provide information on assets that need protecting and guidelines that need to be considered during bushfire suppression operations. The following identifies the characteristics of each zone.

Each zone has fire management objectives, strategies and actions specific to the area within its boundary. For example, LMZs with fire sensitive communities will have fire exclusion objectives and a SFAZ on the fire prone side of the residential development will have objectives that specifically provide for protection of assets.

This management flexibility is essential for achieving conservation of biodiversity in situations such as the isolated occurrence of rare plant and animal species. The boundary of fire management units is typically delineated by strategically located roads, trails, or tracks or by natural fire barriers such as creeks and water bodies.

It should be noted that threatened species issues for each zone have been identified according to records for particular species within each zone. Some fauna species, such as owls and bats, forage widely over large areas of land. As such, a record for the Powerful Owl within APZ 2 is likely to relate to all zones within the site. Therefore all zones should be treated as potential habitat for such species, and management objectives designed to accommodate these issues. In that regard it is not in the interests of this plan to be absolutely specific in relation to each zone.

Note: It is the case that upon this FMP being approved the implementation, works for APZs 1-3 will require tuning to ensure that the matters graphically displayed in Figure 6 and expressed in Table 3 will be protected.

The following information is provided to inform about the management of the APZs, SFMZs and HMZs. This is generic information about the zones and not specific to a part of the development application.

Table 9 – Asset protection zones

Asset protection zones

Functional element	Explanation
Primary fire management objectives	To protect human life, including permanent residents, visitors and fire fighters from bushfires. To protect identified high-risk assets which may include residential areas, utilities, day use areas, urban interface, cultural heritage sites and other built assets.
Prevention & mitigation objectives	To instigate, where appropriate, community education and community fireguard type programs.
Locations	Areas adjacent to visitor congregation areas or built assets, as described above, which are exposed to a high level of bushfire risk
Standards	The width and fuel standards as specified in *PBP 2006* are applied to APZs around new developments. The APZ is to be managed in accordance with RFS guidelines *Standards for Asset Protection Zones* (RFS, 2005), with landscaping to comply with Appendix 5 of *PBP*.
Tactics	Prescribed burning, under scrubbing, herbicide application, watering, trail construction and radiation shield construction.
Management intensity	APZs are the most intensively managed fire management zone with a large percentage of each zone treated per treatment cycle. Treatment cycles in APZs are short.
Impacts	Such intensive management may have significant negative impacts on a wide range of natural and cultural values. Strategies are modified to protect natural and cultural values only if it does not compromise the protection of life and property (which is the primary fire management objective in APZs).

Table 10 – Strategic fire advantage zones (SFAZs)

Strategic fire advantage zones

Functional element	Explanation
Primary fire management objectives	To restrict the movement of bushfires between fire management zones. To restrict the movement of bushfires from other land onto *MLALC* land and from *MLALC* land onto neighbouring land. To break up large continuous areas of high bushfire behaviour potential to reduce the probability of large 'landscape' scale bushfires.
Prevention & mitigation objectives	Promotion of the fire and fuel management activities.
Locations	Within large continuous areas of high bushfire behaviour potential. In areas with a proven history of bushfire ignitions. In large areas of high bushfire behaviour potential occurring along the boundaries of *MLALC* property. Adjacent to existing fire control advantages or to link existing fire control advantages together. Adjacent to APZs. Other strategic areas for controlling the spread of bushfires
Standards	Fire management strategies specify the fuel standards that apply to each strategic fire advantage zone.
Tactics	Prescribed burning under-scrubbing and trail construction.
Management intensity	Management intensity is moderate with a moderate percentage of each zone treated per treatment cycle. Treatment cycles are typically intermediate between those in APZs and heritage management zones.

Functional element	Explanation
Impacts	The strategies implemented in strategic fire advantage zones are likely to have only a minor impact on most natural and cultural values but may have a significant negative impact on sensitive natural and cultural values. Strategies are modified to protect these values only if it does not compromise achieving the objectives of reducing the occurrence of human caused unplanned fires and preventing the spread of fire within, from and into *MLALC* property.

Table 11 – Land management zone (LMZ)

Land management zones

Functional element	Explanation
Primary fire management objectives	To prevent the extinction of all species which are known to occur naturally within the site. To protect Aboriginal sites, historic heritage sites and other culturally significant features from fire.
Prevention & mitigation objectives	Promotion and awareness of the values that may be threatened by bushfires or inappropriate fire regimes within the zone.
Locations	Areas not satisfying the criteria for inclusion in APZs or SFMZs.
Standards	As far as possible, fire regimes maintained within the specified biodiversity fire regime thresholds. As far as possible, the specified threatened species guidelines implemented. As far as possible, the specified cultural heritage management guidelines implemented.
Tactics	As appropriate to conserve biodiversity and cultural heritage (may involve suppressing bushfires, allowing bushfires to burn and prescribed burning).
Management intensity	Low; determined by the vegetation communities, threatened species and cultural heritage sites present within the zone.
Impacts	The strategies implemented in this zone are designed to conserve natural and cultural heritage and will not have a negative impact on these values.