FIRE MANAGEMENT PLAN MUNMORAH STATE CONSERVATION AREA

INCORPORATING
BIRD ISLAND NATURE RESERVE

NSW National Parks and Wildlife Service
Central Coast Hunter Range Region
February 2003

NSW NATIONAL PARKS AND WILDLIFE SERVICE

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The principal authors of this plan were Ranger Vince Moult, Sarah Warner (Newcastle University), and Donald Macdonald at the Central Coast Hunter Range Region of the NSW National Parks and Wildlife Service.

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Ross Bradstock NPWS (Senior Research Scientist), has also provided specialist advise and guidance in the development of this plan.

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EXECUTIVE SUMMARY

Planning and Consultative Process

This Fire Management Plan has been developed to provide direction for fire management activities, including bushfire suppression, in Munmorah SRA and Bird Island NR. The plan will emphasise the protection of life and property as well as providing direction for land managers in the protection of the natural and cultural heritage of Munmorah SRA and Bird Island NR.

In consultation with Wyong District Bush Fire Management Committee, volunteer Rural Fire Brigades, park neighbours and other stakeholders, areas have been prioritised for fuel management treatment by assessing bush fire threat to assets.

The co-operation of the community and implementation of *Community Fire Guard* will be important for the success of the plan. Neighbours will need to manage fuels near their own assets to complement work undertaken in the park.

Although every effort has been made to ensure accuracy of details from existing databases, additional information is continually being collected and management concepts and practices evolving. Therefore, it is proposed that this plan will have a shelf life of five years before a review is undertaken.

Fire Management Objectives

In accordance with Sections 63 & 64 and Part 1, Section 3 of the ***Rural Fires Act (1997)*** and also in accordance with the ***National Parks and Wildlife Act (1974)***; the primary objectives for fire management in Munmorah SRA and Bird Island NR are:

- To prevent the occurrence of human caused unplanned bushfires on the reserves.
- To suppress unplanned bushfires occurring on the reserves.
- To minimise the potential for spread of bushfires on, from, or into the reserves.
- To protect from bushfires, persons and property on, or immediately adjacent to, the reserves.
- To manage bushfires to avoid the extinction of all species which are known to occur naturally within the reserves.
- To prevent damage by bushfires to all known Aboriginal sites, Historic places and culturally significant features known to exist within the reserves.

Strategies for Fire Management

Fire in Munmorah State Conservation Area will be managed in accordance with the *Wyong District Bush fire Management Plan Operations, Wyong District Bush Fire Risk Management Plan* and the *Munmorah State Conservation Area Plan of Management*. Emphasis will be placed on co-

operative fire management involving liaison between the NSW National Parks and Wildlife Service, Wyong Fire Control and residents of the area.

Strategies for Life and Property Protection

Strategies for life and property protection are to:

- immediately suppress or contain wildfires investigate arson and promote neighbourhood watch.
- maintain reduced fuel in Strategic Fire Management Zones (SFMZ) and Asset Protection Zone (APZ) locations to protect assets and assist with control of wildfire;
- maintain a strategic network of fire trails and slash trails in preparedness for rapid response following detection;
- advise residents of appropriate risk management in fire prone areas and implement Community Fire Guard in co-operation with the community in priority areas such as Elizabeth Bay Drive;
- encourage consent authorities to take into consideration the need for fire radiation zones and fire trail access to be built into development proposals off park in accordance with DBFS 1991, “Planning for Bush Fire Protection”, and Australian Standards, “Construction of Buildings in Bushfire-Prone Areas”; AS3959-1991.
- protect visitor use areas within the park from wildfire; and
- develop a process of fuel level monitoring in asset and strategic fire management zone areas.

Strategies for Heritage Management

Strategies for heritage management include:

- application of fire regime guidelines for vegetation communities;
- maintenance of a diversity of fire regimes for the purpose of creating a mosaic of communities with different ages and structures;
- prevention of a single wildfire event burning the entire reserve which will affect all known or potential habitats of threatened species or species of high conservation significance;
- Data recording of fire history in geographic information system;
- monitoring and protection of fire sensitive plant communities,
- promotion of ecological research on the effects of fire on the natural resources of the reserves and disseminating findings to fire management authorities, and
- to ensure cultural and geodiversity conservation within the Reserves

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1.0 Introduction

1.1 Scope and purpose

Under the *Rural Fires Act* 1997, the National Parks and Wildlife Service (NPWS, or the Service) is a prescribed fire organisation and is responsible for the control and suppression of all fires on areas that it manages. This responsibility also extends to fuel management with the Service being responsible for the implementation of fuel management programmes to protect life and property. The Service may also under the Act, suppress or assist in the control and suppression of fires within eight kilometres of any land that it manages.

Section 50 of the *Rural Fires Act* 1997 sets up provisions for the establishment of District Bush Fire Management Committees (DBFMCs) with the task of developing and co-ordinating co-operative fire management between fire authorities across the state. The Service is a member of these committees which are responsible for the development of both co-operative fire-fighting and programs for the reduction of bushfire hazards.

Within the scope of this plan the Service is an active member of Wyong District Bush Fire Management Committee.

Under Section 52 of the Rural Fires Act, each Bush Fire Management Committee is to prepare two kinds of bush fire management plans for the rural fire district or other part of the state for which it is constituted. These plans are:

- A plan of operations, and
- A bush fire risk management plan.

In addition to the above, under the *Rural Fires Act* the Fire Control Officer for a Rural Fire District, when a fire occurs on 'prescribed land', must comply with the conditions set out by the agency for that prescribed land, in any relevant bush fire management plan or "other relevant plan" agreed to by the authority responsible for the prescribed land (Section 38 s4) and to which the Fire Control Officer is aware of. This Fire Management Plan is such a plan under Section 38 s4 of the *Rural Fires Act* 1997.

1.2 The planning environment

1.2.1 Legislation

The Service has statutory obligations under the *Rural Fires Act 1997* to protect life and property on its lands and to prevent fire from leaving its property. Under the *National Parks and Wildlife Act 1974* the Service is empowered with the authority to conserve the natural and cultural heritage of NSW.

This authority extends to the protection of heritage off reserve and is given greater legislative backing through the *Threatened Species Conservation Act 1995*. High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition has recently been listed as a key threatening process under this act and has important implications for fire management. These obligations, though not mutually exclusive, require a flexible approach to fire management.

The Service must give appropriate consideration in its fire management planning to the requirements of protection for both human life and property as well as the protection of the environment. Thus by its fire management policies the Service must not only safeguard the direct protection of human life, it must also ensure the protection, for future generations, of the natural and cultural values of NSW.

Under the *Rural Fires Act 1997* the NPWS is a recognised Fire Authority. The Act provides for the authority to undertake appropriate measures to prevent fire from entering or leaving its estate. As a prescribed organisation the NPWS is required to implement the provisions of Bush Fire Management Plans. The Service can act to suppress fires up to eight kilometres from its reserve boundaries in collaboration with local brigades and park neighbours in accordance with provisions of local Bushfire Management Plans.

1.2.2 Management objectives of the reserve

The management of Munmorah State Conservation Area and Bird Island Nature Reserve are prescribed by objectives stated in the *National Parks and Wildlife Act, 1974.* It is a requirement under the Act that no operations and actions are to be taken which are contrary to the plan of management. The Plan of Management for Munmorah State Conservation Area has been prepared and is currently under review.

The Munmorah State Conservation Area Plan of Management states the following general objectives:

- the protection and preservation of scenic and natural features;
- the conservation of wildlife;
- the maintenance of natural processes as far as is possible;
- the preservation of Aboriginal and historic features;
- the provision of appropriate recreation opportunities; and
- the encouragement of scientific and educational inquiry into environmental features and processes, prehistoric and historic features and public use patterns.

In addition, the Plan of Management identifies the following specific management objectives for Munmorah State Conservation Area and Bird Island Nature Reserve:

- To protect the diversity of coastal native plant communities which occur within the park with emphasis on protecting and restoring the habitat of threatened species, populations and ecological communities
- To protect the island as an important nesting place for migratory sea birds.

1.2.3 Fire management policies of the NPWS

Service policies concerning fire and fire management include the following:

- The Service regards fire as a natural phenomenon; one of the continuing physical factors of the Australian environment.
- The Service recognises the evolutionary adaptation of many native species of plants and animals to fire regimes.
- The Service accepts that fire can be a useful management tool.
- Fire is and will be used as a fuel reducing agent where this does not conflict with management objectives.
- Where life and property are directly threatened by fuel conditions, all steps will be taken to minimise risks, with other management needs regarded as secondary considerations.

All prevention and suppression works will, where possible, be pre-planned and coordinated with neighbour and other agencies likely to be affected by Service activities. The Service will undertake fire prevention programmes, through public education and through local supervision and enforcement of the Acts and regulations applying to fires.

The Service supports the principle of co-operative approach to fire suppression to most effectively use fire-fighting resources within the community. The 2000/2003 *NPWS Corporate Plan* identifies that the Service should maintain as a minimum the current resource commitment to fire management (Conservation Management Objective 4).

The strategy is reflected in the NPWS Fire Management Manual which offers a structure for fire management plans and provides that:

- Fire management operations will take into account the protection of natural resources.
- The Service will collect information on the biology of native plants in relation to fire.
- Databases on the conservation requirements of species in relation to fire may be established and reviewed as new information is acquired.
- Research should provide data that will be of value in making management decisions.
- Researchers should make available the practical application of research.

1.2.4 Local-Regional environmental plans

The Munmorah State Conservation Area and Bird Island Nature Reserve lie entirely within the Wyong Local Government Area and are therefore covered by the Wyong LEP 1997.

Draft Development Control Plans No 14(Vegetation), 23(Caravan Parks), 30(Wetlands), 48(Guidelines Rural Dwellings), 50(Advertising), 57(Commercial Centres), 61 (Carparking), 66 (Residential Sub Divisions), relate to the Munmorah geographic area and provide additional guidelines for development in accordance with the provisions of the Draft LEP. No Regional Environmental Plans affect the area.

1.2.5 State environmental planning policies

These policies generally only apply when development consent is being sought from Wyong Shire Council and does not apply to land dedicated or reserved under the NP&W Act. The Service has adopted a process of environmental assessment, which is consistent with the principles, for environmental protection outlined under various SEPP's (See Table 1).

Table 1: State Environmental Planning Policies

Planning instruments	Areas where policy applies
SEPP 14 Wetlands	Munmorah and Moonee wetlands (not applicable under NPW Act)
SEPP 19 Urban Bushlands	Not applicable
SEPP 44 Koala Habitat Protection	Not applicable

1.2.6 Fire management policies-regulations of involved organisations

The *Rural Fires Act 1997* requires each Bush Fire Management Committee to prepare and submit a Bush Fire Risk Management Plan and Operational Plan, to co-ordinate the activities of organisations for the prevention, control and suppression of bush fires.

The Wyong District Bush Fire Management Committee has adopted co-ordinated fire fighting policies based on the Policy Statement of the Co-ordinating Committee and the Manual of Procedures for Co-ordinated Fire Fighting.

The Munmorah SRA Fire Management Plan will form part of the NPWS input into the Operational Plans for the Wyong Shire.

1.2.7 NSW biodiversity strategy

The *Draft NSW Biodiversity Strategy (1997)* was developed by the New South Wales Government and develops a collaborative approach to biodiversity conservation. It's over-riding goal is: "to protect the native biological diversity of NSW and maintain ecological processes and systems".

To this end inappropriate fire regimes has been identified as one of the seven key threatening processes that is effecting the biological diversity of NSW. This issue is targeted within the Biodiversity Strategy by Objective 3.4 'Improve fire management regimes', and requires the following actions;

Action 72: Identify and implement fire management regimes that promote the recovery and survival of native flora and fauna.

Action 75: Encourage and assist land managers to include biodiversity as a consideration in the development of Fire Management Plans.

This document is intended to assist managers in achieving the above goals listed in the Draft NSW Biodiversity Strategy.

1.3 Definitions and principles

Most definitions described below come from the Australian Fire Authorities Council (AFAC) ***Glossary of Rural Fire Terminology*** *(March 1996).*

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, eg north-east. 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, park 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 (eg water catchment quality).

Backburning A fire started intentionally along the inner edge of a fireline 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.

Bush Fire Management Unit (FMU) Management areas of a variable size that define containment blocks in the event of a wildfire. Alternatively they have also been designated as areas of specific ecosystem types defined by management authorities in order to monitor the long-term effects of fire upon those areas.

Bush Fire Management Zone (BFMZ) Management areas (usually sub-sets of fire management units) where a specified fire management operational objective, strategy and performance indicator has been developed to mitigate against the threat of a wildfire.

special note about the above: *an* ***FMU*** *is usually a monitoring and containment block whilst a* ***BFMZ*** *is a sub-unit of an* ***FMU*** *where fire managers undertake activities such as prescribed burning, in order to achieve a set outcome (such as provide protection or slow the advance of a wildfire).*

Keetch-Byram Drought Index (KBDI) 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.

Coarse Fuels Dead woody material, greater than 25mm in diameter, in contact with the soil surface (fallen trees and branches).

Controlled Burning *see Prescribed Burning*.

Crown Fire A fire burning in the crowns of trees and usually supported by fire in ground fuels. Its is a fast travelling fire that usually consumes all available fuels in its path.

Drought Index A numerical value, such as the Byram-Keetch Drought Index, reflecting the dryness of soils, deep forest litter, logs and living vegetation.

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 Grass, leaves, bark and twigs less than 6mm in diameter.

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.

Fire Break Any natural or constructed discontinuity in a fuel bed used to segregate, stop and control the spread of a wildfire, or to provide a fireline 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 effect 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.
At the regional scale, the season may be introduced or extended by one month dependant 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 indrafts, 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 wildfire's.

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.
Organisms within the 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 sever 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.

NPWS The National Parks and Wildlife Service of New South Wales.

NSWFB The New South Wales Fire Brigades.

MSRA Munmorah State Conservation Area

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 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.

Service, the The National Parks and Wildlife Service of New South Wales.

SF State Forests of New South Wales.

Scorch Height The height above ground level up to where foliage has been browned by a fire. This height is roughly ten times the actual flame height of the 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 units 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.

SRA State Conservation Area

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 firefighting vehicle equipped with a water tank, pump, and the necessary equipment for spraying water and/or foam on wildfire's.
Under NSW Dept. of Rural Fire Service guidelines, bushfire fighting tankers have been designated into nine 'Categories' delineating water carrying capacity and whether the unit is two or four wheel drive capable.

Topography The surface features of a particular area or region, ie the lay of the land, and includes mountains, rivers etc.

Unplanned Fire *see Wildfire*

Urban/Rural Interface The line, area, or zone where structures and other human development adjoin or overlaps with undeveloped bushland. Also known as the urban/bush interface, urban interface or just the interface.

Wildfire An unplanned fire. A generic term which includes grass fires, forest fires and scrub fires.

2. DESCRIPTION OF THE RESERVE

2.1 Location

The *Munmorah State Conservation Area Fire Management Plan* covers an area of 1444 ha, starting at Budgewoi in the south and extending to Catherine Hill Bay in the north and west to the Pacific Highway. The reserve is located in Wyong Shire LGA on the Central Coast of New South Wales (Lat. 33^{o}18'S, Long 151^{o}33'E.), approximately 40km north of Gosford (Map 1). Bird Island Nature Reserve is located adjacent to Munmorah State Conservation Area 1.6km offshore, incorporating an area of approximately 7.3 ha (Map 1).

The predominant land use within the southern portion of the Munmorah geographical area is residential housing with a few small semi rural-holdings. Developments are concentrated in the Lake Munmorah, Elizabeth Bay and Budgewoi areas. The northern section contains the Moonee Colliery and Coal Preparation Plant. Isolated houses or sheds occur along the Pacific Highway adjacent to the North-West perimeter of the reserve. Two in-holding portions occur at the southern end of the park and are in the ownership of the Darkinjung Local Aboriginal Land Council and are not part of the park.

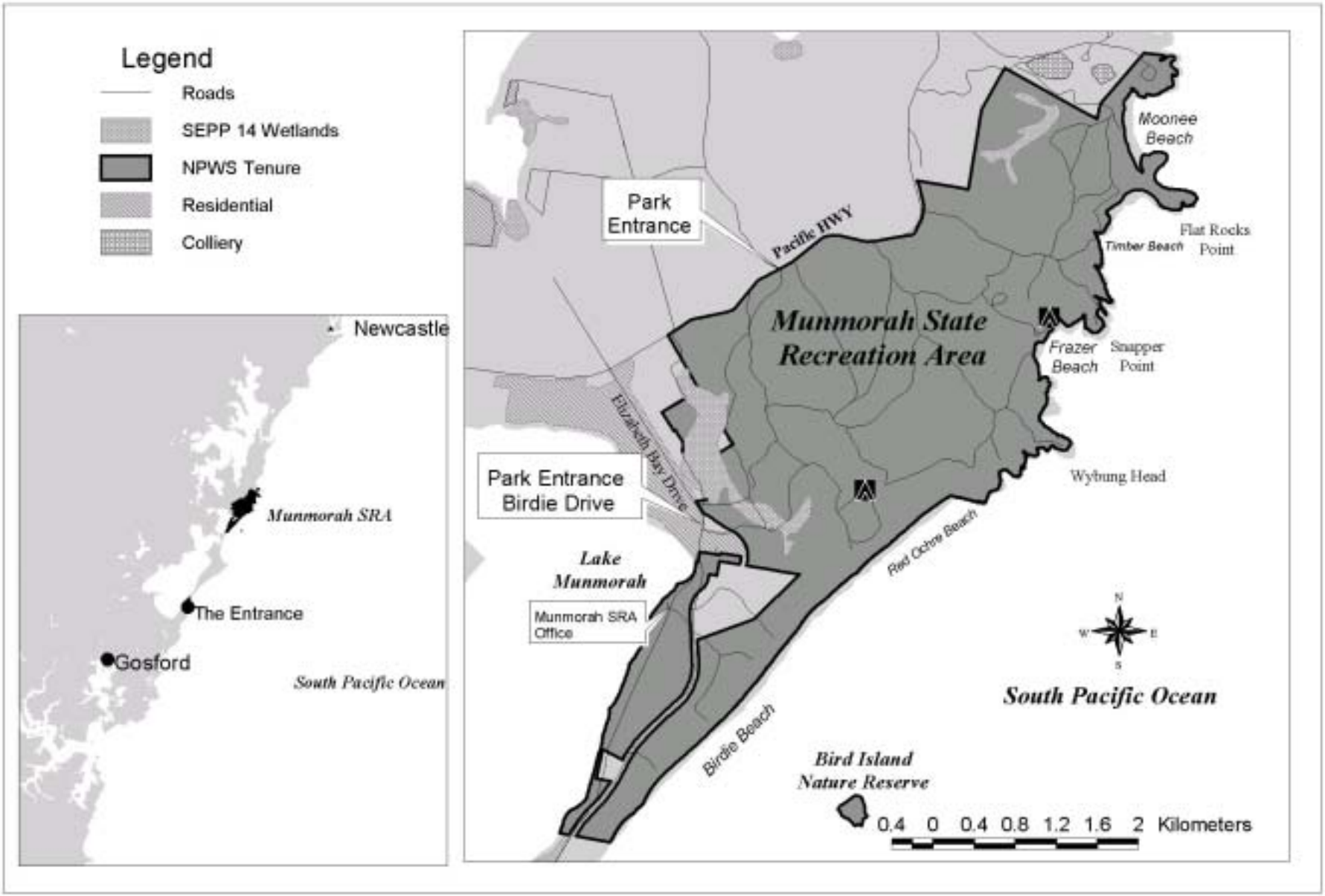
2.2 Terrain

Munmorah SRA is a section of the Sydney Basin IBRA Bio - Region, lying on the north-eastern coastal margins of the Hornsby Plateau. The area is noted for it's coastal terrain which is the result of sea level fluctuations during the Pleistocene Period 125, 000ya. Perched sand masses that occur in the area provide evidence of a sea level approximately 4 – 6 m higher than present and are of conservation and scientific interest.

The topography at the southern end of the SRA is characterised by gently undulating to rolling dunefields of a low lying barrier dune complex. Local relief is generally less than twenty metres and dune gradients range form 5% to 45% with a north south orientation governed by prevailing southerly winds. Much of this landscape has been disturbed by sand mining along Birdie beach. This environment is prone to wind erosion along illegal trails created by 4WD vehicles and motor cycles, and walkers.

The remainder of the park is a reasonably undulating landscape of low rolling hills and includes four main ridges with gradients from 10 to 25%. Local relief is 20 – 80m with peaks reaching heights of 98 metres at Bongon head and 95 metres Wybung Head. The coastal terrain is generally steeper with some localised steep slopes up to 60%.

Drainage patterns of creeks have formed two swamps both of which are SEPP 14 Wetlands area and are of special conservation significance.



Map 1 Location of Munmorah SRA and Bird Island Nature Reserve.

2.3 Biodiversity

2.3.1 Flora

Major Vegetation Communities

Munmorah State Conservation Area has some particular challenges for fire management as it incorporates extensive areas of fire prone woodlands, palm dominated gullies, coastal heathland, a littoral remnant rainforest on the parks southern boundary and SEPP14 Wetlands areas.

Vegetation surveys conducted in Munmorah SRA and the surrounding study area (see McRae & Benson 1986, Payne 1993, Payne & Wellington, 1995 and Payne, 1997), have stated that the area is extremely diverse, in terms of plant communities, and that it is also quite vulnerable due to it's long and narrow shape. Payne (1997) identified twelve major plant communities within the reserve. The floral associations, and fauna habitat attributes of each of the dominant vegetation communities have been provided in Appendix 1. The structural vegetation map (Map 2) shows the distribution of major plant communities.

Management of fire in Munmorah SRA is targeted towards desirable fire regimes in order to conserve the biodiversity of the reserve. This will be achieved by using the thresholds outlined in Table 2 as a guide for conserving the vegetation represented in then area. Map 3 provides a visual description of the maximum fire frequency tolerance (minimum inter-fire period) for the vegetation communities in the area.

Table 2: Fire regime guidelines For vegetation communities of Munmorah SRA (Adapted from Bradstock *et al* 1995 and Smyth & binning, 1999)

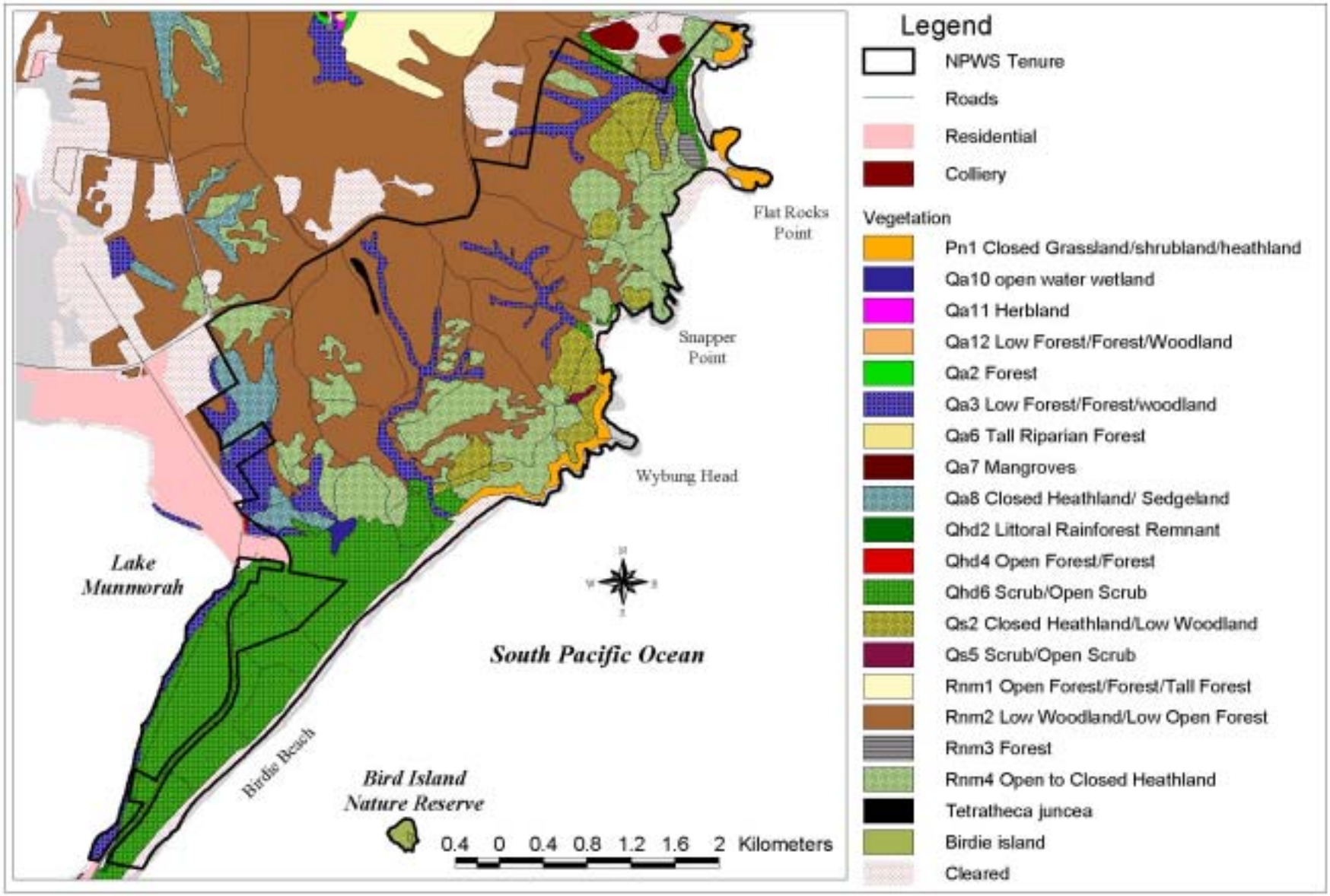
Community Type[1]	A decline in biodiversity is predicted if[2];	Fire regime	Area of Park (ha)	Fuel Group[3]
Qa3 Low Forest\ Forest to Woodland (Swamp Forest/ woodland on Quaternary Alluvium)	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	C	114.02 (7.85%)	Moderate (2)
Qa8 Closed Heathland/ Sedgeland (Quaternary Swamp Alluvium)	• Three or more consecutive fires, with each of the fires less than 8 years apart. • Three or more consecutive fires, with each of the fires more than 15 to 30 years apart. • No fire for more than 30 years.	D	38.84 2.67%	Very High (4)
Qa10 Open Water Wetlands with fringing vegetation (Quaternary Alluvium)	• No fire regime applicable	E	32.32 (2.22%)	N/A (0)
Qs2 Closed Heathland/ Low Woodland (high level aeolian Pleistocene sands)	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	C	90.54 (6.23%)	Very High (4)
Qs5 Scrub to open Scrub (high level aeolian Pleistocene sands)	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	C	1.6 (0.11%)	Very High (4)

Community Type[1]	A decline in biodiversity is predicted if[2];	Fire regime	Area of Park (ha)	Fuel Group[3]
Qhd2 Closed Forest (littoral Rainforest Remnant on Holocene Barrier Sands)	• Any fire	A	0.31 (0.02%)	Moderate (2)
Qhd4 Open Forest to Forest (Red Gum forest on Holocene Barrier Sands)	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	C	0.15 (0.01%)	High (3)
Qhd6 Scrub to Open Scrub (on Holocene Barrier sands)	• Three or more consecutive fires, with each of the fires less than 8 years apart. • Three or more consecutive fires, with each of the fires more than 15 to 30 years apart. • No fire for more than 30 years.	D	276.22 (19.0%)	Very High (4)
Rnm2 Low Woodland to Low Open Forest (Munmorah conglomerates)	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	C	544.49 (17.5%)	High (3)
Rnm3 Low Closed Forest (Munmorah conglomerates)	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	D	8.16 (0.56%)	High (3)
Rnm4 Dry Open to closed heathland. (Munmorah conglomerates)	• Three or more consecutive fires, with each of the fires less than 8 years apart. • Three or more consecutive fires, with each of the fires more than 15 to 30 years apart. • No fire for more than 30 years.	C	286.64 19.7%	Very High (4)
Pn1 Closed grasslands \shrubland to closed Heathland	• Three or more consecutive fires, with each of the fires less than 8 years apart. • Three or more consecutive fires, with each of the fires more than 15 to 30 years apart. • No fire for more than 30 years	D	4.52ha (0.31%)	Very High (4)
Tet/Ju *Tetratheca Juncea*	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	C	2.67 0.18%	High (3)

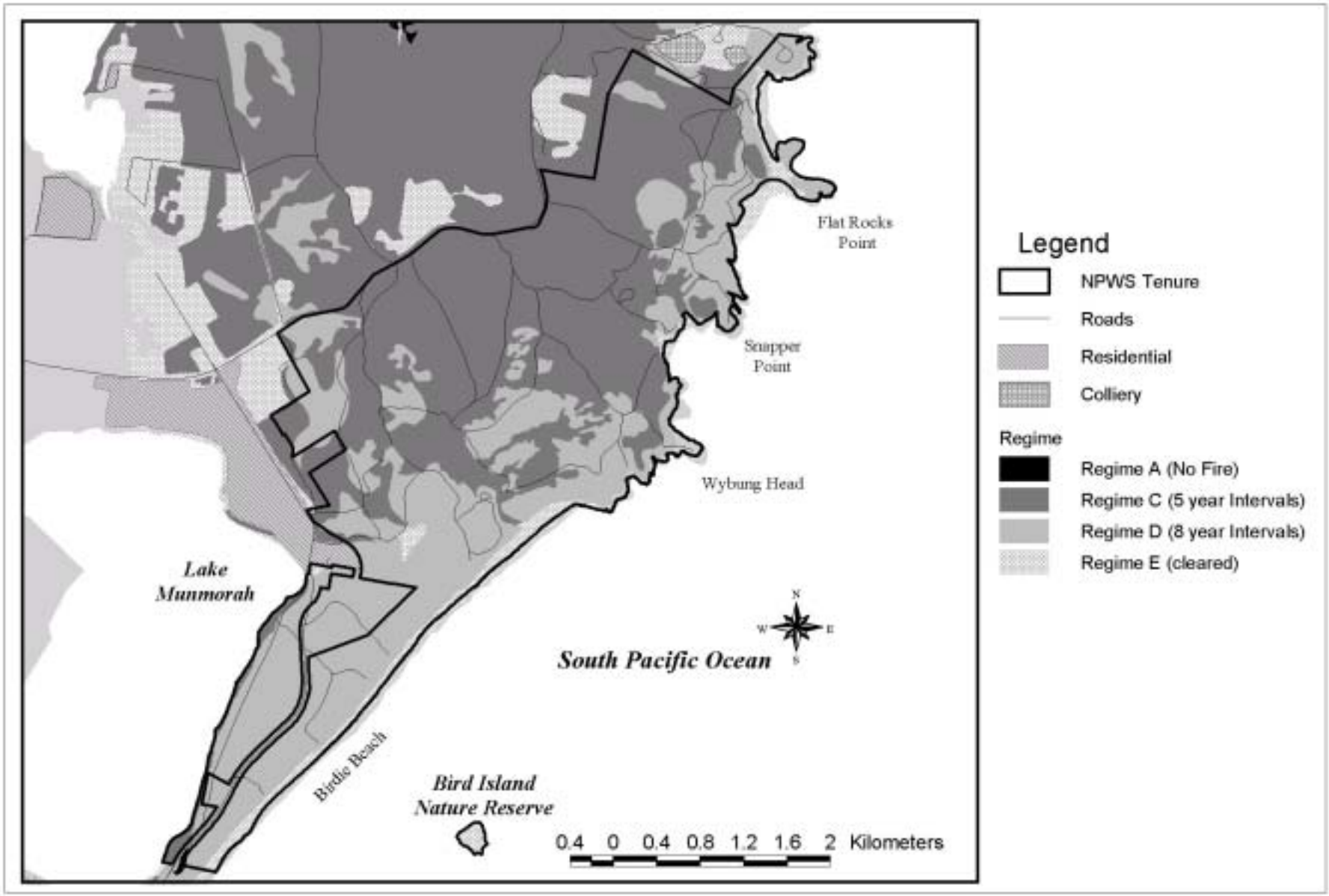
***1 Community classification based on Payne, R., (1999)**
***2 Fire regime based on Bradstock *et al* 1995 and Smyth & binning, 1999**
***3 Fuel Group based on Conroy, (1993) see section 3.4.4**

Threatened Flora species

Several vulnerable species listed under Schedule 2 of the *Threatened Species Conservation Act 1995*) are residents within Munmorah SRA. Fire management of the reserve aims to minimise the possible risk of extinction from adverse fire regimes. Provided in Table 3 are the known fire responses, and the proposed fire management guidelines for significant species within Munmorah SRA.



Map 2 Vegetation Communities of Munmorah SRA (Payne, 1997).



Map 3: Maximum fire frequency tolerance (minimum inter-fire period) for the vegetation communities of Munmorah SRA.

Where management requirements differ significantly from the regime applied to the surrounding vegetation, site specific fire management strategies are provided to sustain the species' local population (see section 4.4).

Table 3: Vegetation species of Munmorah SRA listed under Schedule 3 *Threatened species Conservation Act* 1995

Species & common Name[1]	Status[2]	Habitat/ Fire Response[3]/ and proposed management
Caladenia tessellata	Vulnerable	• Likely to occur in Rnm4. • Unknown fire response. Flowers in spring • If species is encountered in the field attempts will be made to considerer its response to fire by assessing site disturbance history. The plan provides for fire to be managed according to regime "D".
Syzygium paniculatum Magenta Lilly-pilly	Vulnerable	• Known to occur in littoral rainforest communities Qhd2 at southern end of the reserve. • Unknown fire response. Species may coppice after fire. Flowers summer and Autumn • The plan provides for fire to be excluded from the community (Regime A) in which this species occurs.
Tetratheca juncea *Black--eyed Susan*	Vulnerable	• Restricted to the Central Coast, sandy heath and scrub country. Likely to occur in Rmn2. • Perennial Herb that will survive 100% scorch, however resprouting mechanism unknown. Flowers winter and spring. • Threatened by too frequent fire (<9year intervals). Infrequent fire may also threaten species survival through shading by and competition with other species. Autumn to summer fire desirable with moderate to high intensity. The plan provides for fire to be managed according to regime "D".

*1 Source NPWS GIS database and Wildlife atlas
*2 Listing under the *Threatened Species Conservation Act* 1995(NSW)
*3 Fire Response Gill & Bradstock (1992)

2.3.2 Fauna

To date one hundred and fifty birds, nine mammals, nine reptiles and eleven amphibians have been recorded within the Munmorah SRA (Payne & Wellington, 1996). In general, knowledge of the fire management requirements for animal species is not as advanced as that for plants. Despite this, NPWS fire management considers animals and plants to be interrelated. In implementing the fire regime guidelines for vegetation communities it is understood that vegetation cover and structure forms an important component of habitat and refuge for animals during fire events.

This plan provides for minimising the occurrence and severity of large wildfires, and enhancing burn patchiness. Furthermore, it is understood that establishing a mosaic of burns, including recently burnt and long unburnt areas at different ages will enhance flora biodiversity of the reserve.

Mammals

The impact of fire on mammals depends on the specific habitat requirements, life history characteristics of the animal and on the scale, intensity and patchiness of the fire (Whelan 1995). The only fauna survey of Munmorah SRA (Payne and Wellington, 1995) revealed that the area was moderately rich in fauna but generally lacking in arboreal mammal species. The presence of aeolian dune habitats provides habitats for a number of small mammal

species including the New Holland Mouse (*Pseudomys novaehollandiae*). Table 4 outlines the mammal species of Munmorah SRA listed under Schedule 3 *Threatened species Conservation Act* 1995 and the proposed prescribed fire management guidelines.

Table 4: Significant mammal species of Munmorah SRA listed under Schedule 3 *Threatened species Conservation Act* 1995

Species/ Common Name[1]	Status[2]	Habitat/ Home range/ breeding season & Prescribed fire management guidelines[3]
Miniopterus australis Little Bent-wing Bat	Vulnerable	• Roosts in caves, old mines, storm water channels and comparable structures. Favours paperbark swamps woodlands and closed forests, foraging above the tree canopy for insects. • Unlikely to be effected by prescribed burning activities, as it hibernates in winter and can utilise a range of forest types.
Miniopteris schreibersii Common Bent-wing Bat	Vulnerable	• Roosts in caves, old mines, storm water channels and comparable structures. Favours well timbered valleys, foraging above the tree canopy for insects. • Unlikely to be effected by prescribed burning activities, as it hibernates in winter and can utilise a range of forest types. Modification from frequent wildfires in coastal heath is likely to be a threat to population of this species (NPWS 1998)
Petaurus norfolcensis Squirrel glider	Vulnerable	• Rnm2 Low Woodland to Low Open Forest, Qa2 & Qq3. Favours either wet or dry sclerophyll forests and woodlands. • Home range @ 20 – 30ha • Breeds May to December. • For prescribed burns protect hollow – bearing den trees, during mop-up avoid felling potential habitat trees. Known den trees plotted on GIS.
Pseudomys gracilicaudatus Eastern Chestnut Mouse	Vulnerable	• Found in Qa3 & Qhd6. Inhabits heathland and woodland with a dense understorey (Strahan, 1995). • Breeds April to March • Known to favour vegetation regenerating after fire, where as populations are low in mature communities.

*1 Source NPWS GIS database and Wildlife atlas
*2 Listing under the *Threatened Species Conservation Act* 1995(NSW)
*3 Fire management guidelines

Amphibians

An amphibian survey (Payne & Wellington 1995) found that the SRA has a diverse amphibian component of 11 species. In particular, there is major habitat for the Wallum Froglet (*Crinia tinnula)* and possibly the Green and Golden Bell Frog.

Table 5 overviews significant amphibian species of MSRA listed under Schedule 3 *Threatened species Conservation Act* 1995 and proposed fire management guidelines.

Table 5: Significant amphibian species of MSRA listed under Schedule 3 *Threatened species Conservation Act* 1995

Species Common Name[1]	Status[2]	Habitat/ breeding season & Fire Management Guidelines[3]
Litorea aurea *Green and* *Golden Bell Frog*	Endangered	• Littoral vegetation by swamps, lagoons, often under debris of closed sedgeland communities Qa8 Qa10. • Breeds during summer • Prescribed burns should avoid burning habitat during breeding season. Potential for any fire in littoral wetland areas to decrease habitat quality and breeding success
Crinia Tinnula Wallum Froglet	Vulnerable	• Confined to paperbark swamp (Wallum country) (Cogger, 1996) Communities Qa3. • Prescribed burns should avoid burning habitat during breeding season. Potential for any fire in littoral wetland areas to decrease habitat quality and breeding success

*1 Source NPWS GIS database and Wildlife atlas
*2 Listing under the *Threatened Species Conservation Act* 1995(NSW)

Birds

The severity and duration of impact on bird populations has been directly correlated with the size and intensity of the fire. Small, patchy fires of low intensity have little long-term impact but birds take longer to recover and recolonise following large, intense fires (Christensen *et al* 1985).

The coastal environment of Munmorah SRA provides important roosting and feeding areas for gulls, terns, migratory waders and herons. Twelve species have been recorded which are listed on the schedules of the Japan-Australian Migratory Bird Treaty and the China-Australian Migratory Bird Treaty. Bird Island is a significant nesting site for migratory seabirds and shorebirds. The Munmorah SRA fire plan does not however, consider coastal species in fire management.

In addition the lake foreshore and the SEPP 14 wetland areas provide refuge and feeding grounds for migratory herons and waders. The coastal forest and tall heaths of the State Conservation Area are important feeding areas for honeyeaters, which spend winter on the Central Coast. The cabbage-tree palm dominated forests provide important food resources for the uncommon migratory fruit-eating pigeons. The fruit of the palm is particularly important as a food source for the topknot pigeon (*Lopholaimus antarcticus)* during late spring and summer.

Table 6: Bird species listed under the Threatened Species conservation ACT 1995

Species/ Common Name[1]	Status[2]	Habitat/ Breeding/Fire management guidelines[3]
Ninox strenua Osprey Powerful Owl	Vulnerable	• Uncommon resident. All forested Areas • Winter Spring • Protection of known breeding sites is required during winter/ spring prescribed burning. Known breeding locations are to be entered into the GIS Database. The survival of this species relies on the survival of it's prey, which are smaller arboreal species more sensitive to inappropriate fire regimes.
Ixobrychus flavicollis Black Bittern	Vulnerable	• Fresh water wetlands Qa10 • Breeds September to January • Avoid prescribed burns in swamp forest habitat where this species roosts and breeds (CHUMA, 1995). Leave >75% of habitat unburned in any year. Known breeding locations are to be entered into the GIS Database
Sterna albifrons Little Tern	Endangered	• Coastal species, Fire management not applicable
Haematopus fuliginosus Sooty Oystercatcher	Vulnerable	• Coastal species, Fire management not applicable
Pied Oystercatcher	Vulnerable	• Coastal species, Fire management not applicable
Pandion halietus	Vulnerable	• Coastal species, Fire management not applicable

*1 Source NPWS GIS database and Wildlife atlas
*2 Listing under the *Threatened Species Conservation Act* 1995(NSW)

2.4 Cultural heritage

2.4.1 Aboriginal

Munmorah SRA lies in the Darkinjung Local Aboriginal Land Council Area. Evidence of Aboriginal occupation is limited and contains relatively few Aboriginal sites compared to other areas along the Central Coast. Members of the Aboriginal community were consulted and a few known areas of cultural significance were identified. The likelihood of sites being found along Birdie Beach has been further diminished by the fact that extensive sand mining was undertaken in the 1970's.

However, during prescribed burning operation and wildfire suppression particular care will be taken to ensure known sites are not damaged by heavy machinery. Furthermore, sacred or carved trees may be adversely damaged by intense fire, and middens and burial grounds may be damaged by the removal of protective vegetation.

2.4.2 Historic

The State Conservation Area does not contain any significant historic places that are likely to be impacted by fire. The most important historic events have been listed in the following table.

Table 7: Historical sites that occur within the Munmorah SRA.

Historic Events	Location
Squatter Sites prior to development of the SRA	Site of Dave Campbell's dwelling at Frazer Beach (removed)
Small pebble extraction industry (1975/76)	Snapper Point Cave and Deadmans Beach
Mineral Sand extraction	- both sides of Elizabeth Bay Drive - dredging at Birdie Beach -SRA office formally the operations office of the centre of Associated Minerals Consolidated
Hull timber remains of the Vessel "SS Allenwood" 1951	-northern end of Birdie Beach in tidal zone buried in sand
Royal Australian Air Force Practice Range WWII	-Bird Island, Birdie Beach

2.5 Recreational use and facilities

The State Conservation Area forms part of a larger outdoor recreation and tourism region that stretches from the Hawkesbury River to the Lake Macquarie area. Each year it is estimated that approximately 350 000 people visit the State Conservation Area (POM 1998). In December and January 1993-94 visitor use dropped as a direct result of major fires in NSW.

It is anticipated that continuing urban expansion along the Central Coast and the reduction in vehicle entry fees will lead to an increase in recreational use of the state conservation area, placing additional demands on the existing facilities.

To minimise the potential for fires starting from Camping facilities, gas BBQ's, are located at Freemans Camping Area (Birdie Beach) and Frazer Camping Area (Frazer Beach). Also located in these areas are septic toilets and cold showers.

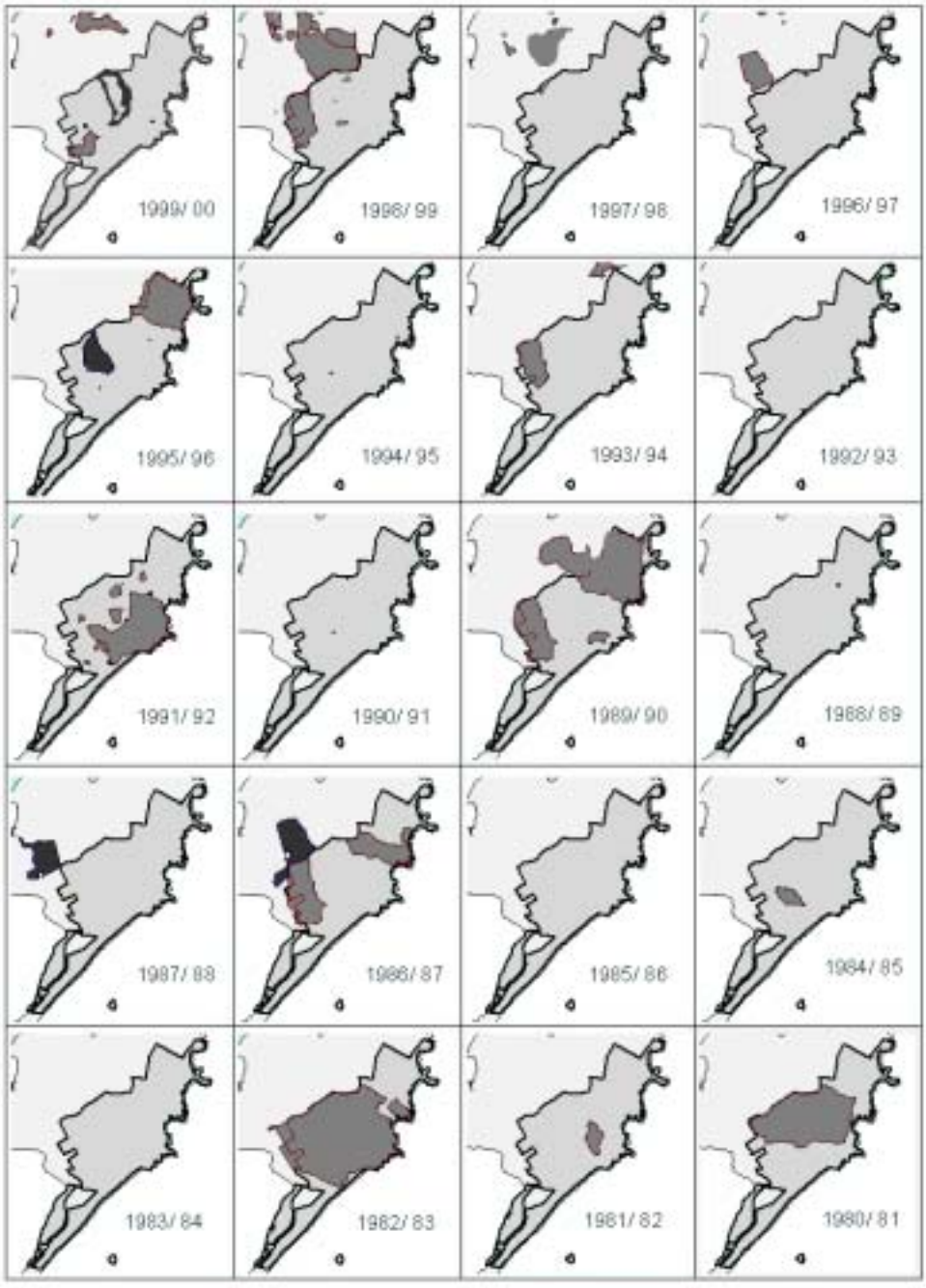
Picnic facilities are located at Frazer Beach, Tea Tree Picnic Area (near Birdie Beach), Elizabeth Bay Drive and the Palms Picnic Area on Frazer Beach Road.

The main walking tracks are the Geebung Heath walking track, the Grass Tree track, the Palms Walking track and the Melaleuca walking track.

3. BUSHFIRE ENVIRONMENT

3.1 Fire history and frequency

The fire history database established for Munmorah State Conservation Area has been compiled onto a Geographic Information System (GIS), based on 20 years of fire records commencing in November 1980 (Map 4). All attempts have been made to gain the most reliable information from various sources including, incident reports, original maps, and anecdotal evidence from local fire brigade members and park neighbours.

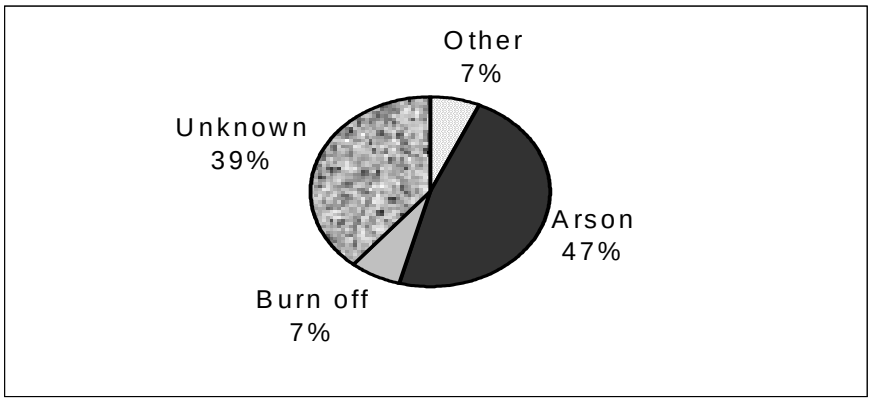


Map 4: Fire History of Munmorah SRA 1980 – 2000. Dark grey patches indicate prescribed burns and moderate grey patches wildfires.

A total of 69 fires (wildfires and prescribed burns) have been recorded in Munmorah SRA in the period between 1980 to 2000. Almost all of the National Park has experienced fires in this period, with 22.4% remaining unburnt since records began.

The main causes of fires in Munmorah SRA are arson, illegal burning off and other miscellaneous causes including camp cooking and motor vehicle accidents (Figure 1). However, the cause of a substantial proportion of wildfires remains unknown. This is due to limited information, particularly for older records and a lack of post fire investigation and reporting. Ignition points for the majority of fires (Figure 1) are associated with access roads, trails, camping areas and adjacent properties neighbouring the reserve.

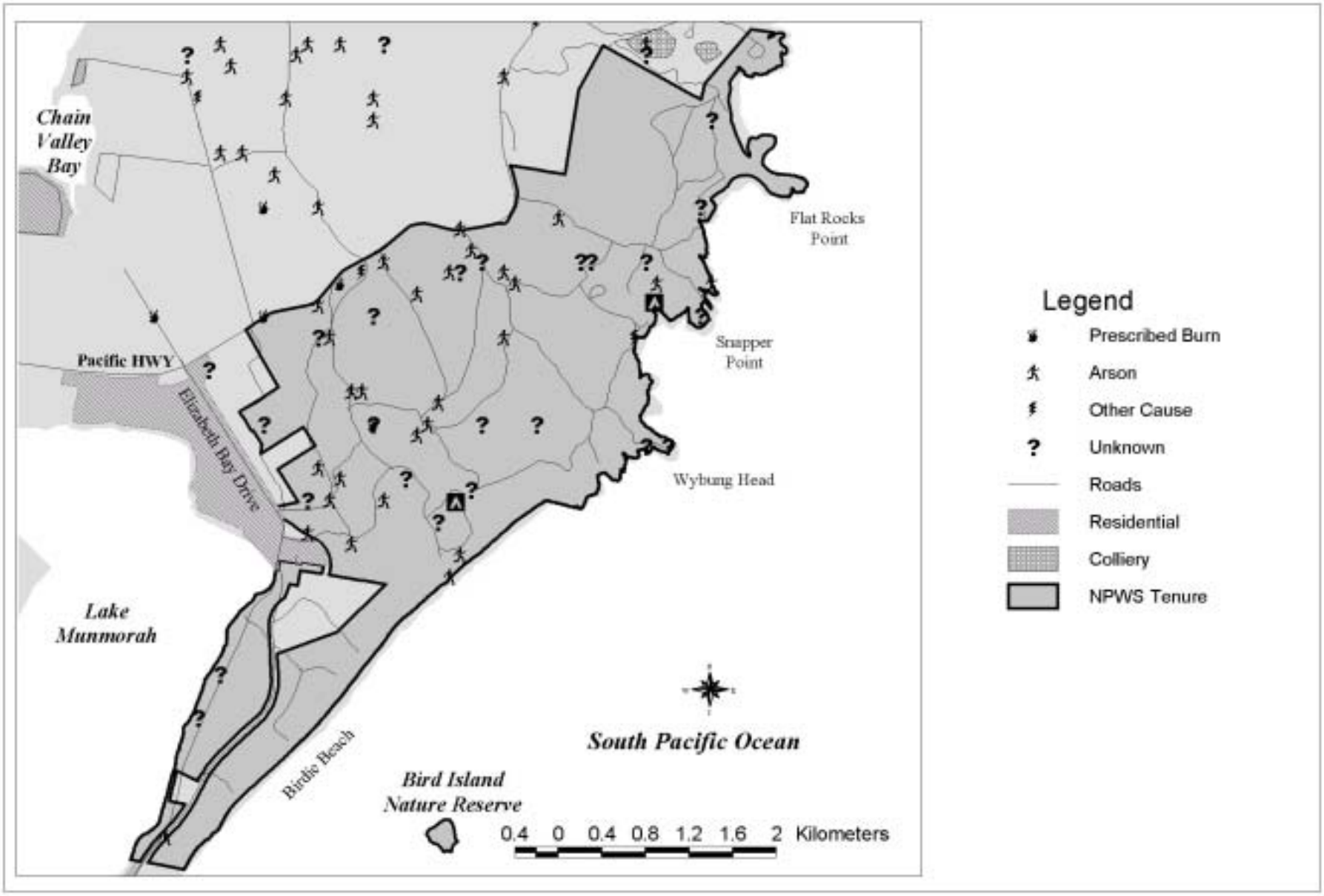
Figure 1: Causes of Fire within the Munmorah SRA study Area (Other causes include Motor vehicles, camp cooking and illegal burning off on properties adjacent to the Reserve)



It should be noted that with age, the accuracy of the fire history records decreases, and therefore, conclusions made from the database have been drawn with caution. In particular, the occurrences of all fires within the study area have not been accurately recorded particularly for small spot fires. Furthermore, the accuracy of mapping for individual fires is likely to have varied considerably.

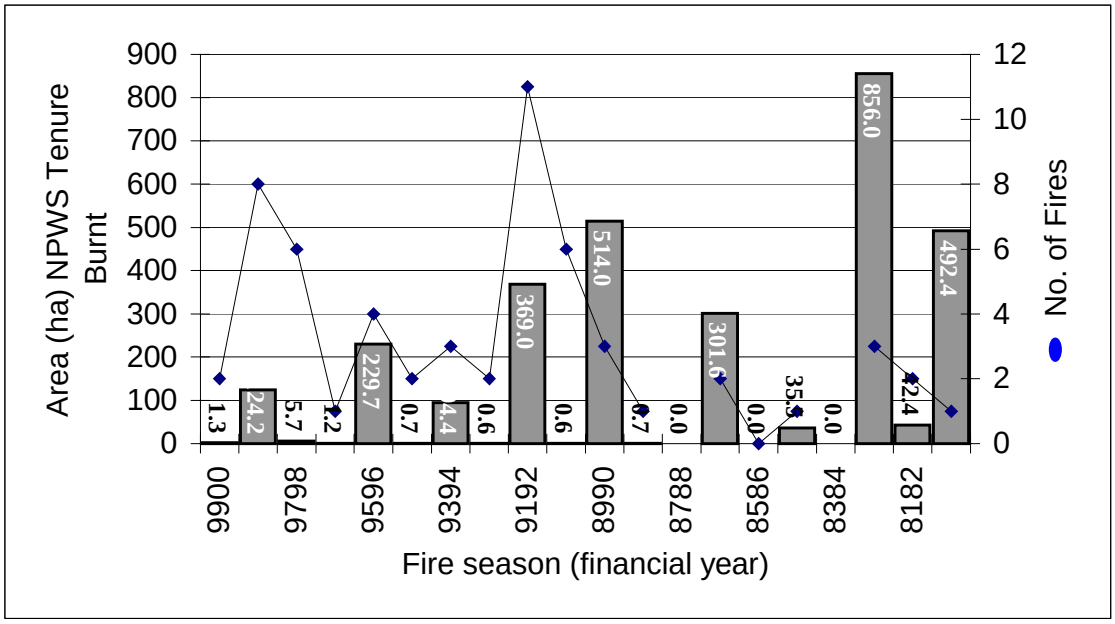
3.1.1 Wildfires

Of the 69 fires recorded in the park 64 have been wildfires, varying from small spot fires (0.002 ha) to severe fires burning 880 ha of the reserve (see Map 4). Figure 2below shows the area of the reserve that has burnt and the number of ignitions that occurred annually from 1980 to 2000. The 1982/ 83 fire season was the most extreme with approximately with 70 percent of Munmorah SRA burnt by one wildfire occurring in November of that season.



MAP 5: Ignition points and cause within Munmorah SRA and surrounding Study area

Figure 2: Hectares burnt each fire season in Munmorah SRA by wildfires since 1980.

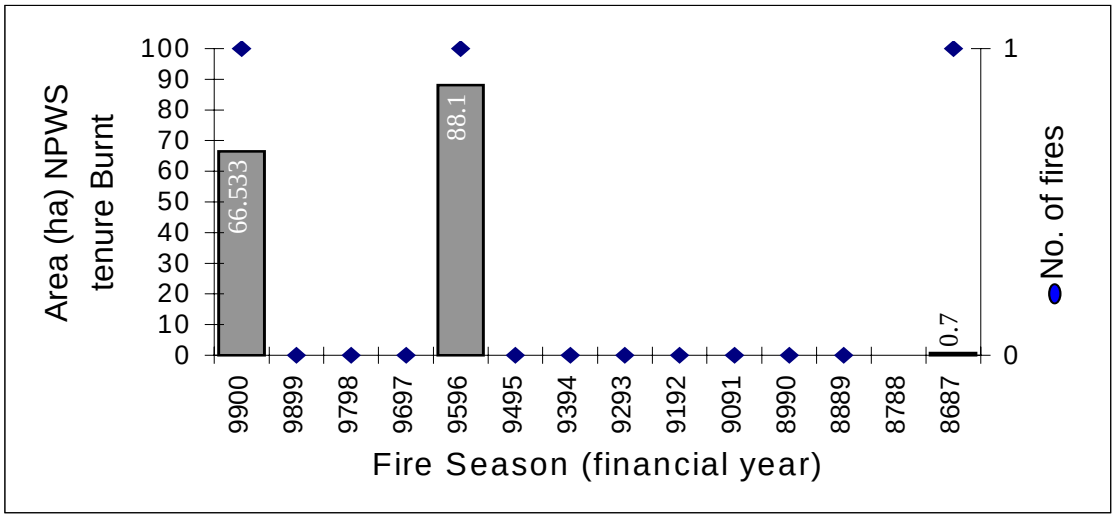


3.1.2 Prescribed burning

Essentially the number of wildfires that have occurred since 1980 within the study area has been considered sufficient to adequately control fuel loads and protect life and property without significant prescribed burning. Fire records show that only four prescribed burns have been carried out in Munmorah SRA study area since 1980 (Figure 3) the last of which occurred in 1999.

In 1982 a prescribed burn was carried out on a small area of private land outside the park boundary and adjacent to the park's southern entrance. No records were kept of this event. (Gifford, G. pers comms).

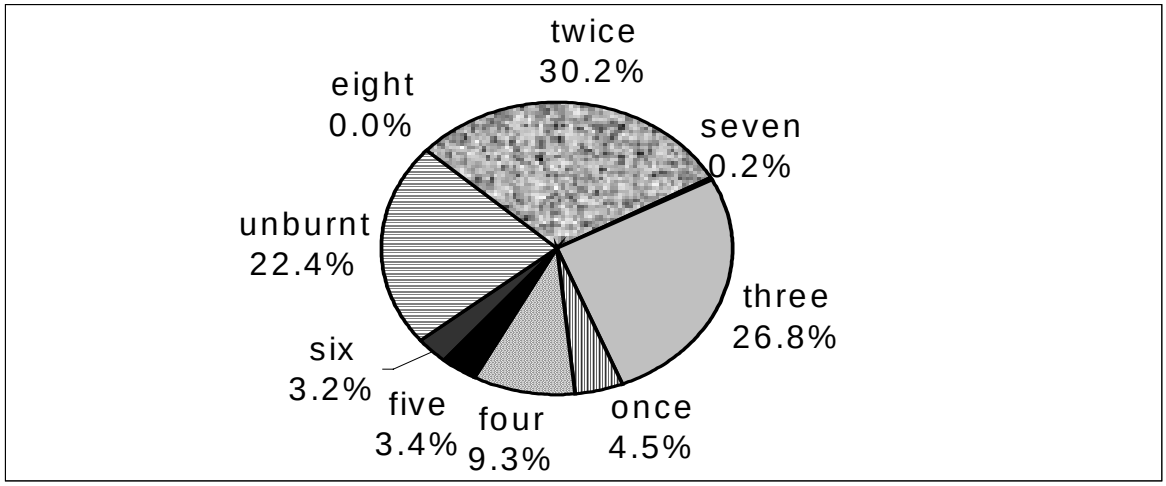
Figure 3: Hectares burnt each fire season in Munmorah SRA by prescribed burns since 1980.



3.1.3 Fire Frequency

Fire frequency is in part a measure of the number of times an area is burnt within a given time period. The percentage area of the Reserve burnt at different frequencies has been outlined in Figure 4 and illustrated in Table 9. Within the National Park, areas along Blue Wren Drive have been burnt up to eight times from unplanned wildfires in the 20 years since records began.

Figure 4: Number of times burnt as a percentage of area for Munmorah SRA 1980 – 2000



Munmorah SRA falls into Walkers' Fire Region 12 (Walker, 1981), which has an average fire interval of 5-12 years based on broad fuel dynamics. Of the areas burnt 6 - 8 times during this period (Figure 4 and Map 6) the average inter fire interval is 4 - 6 years.

3.2 Fire weather

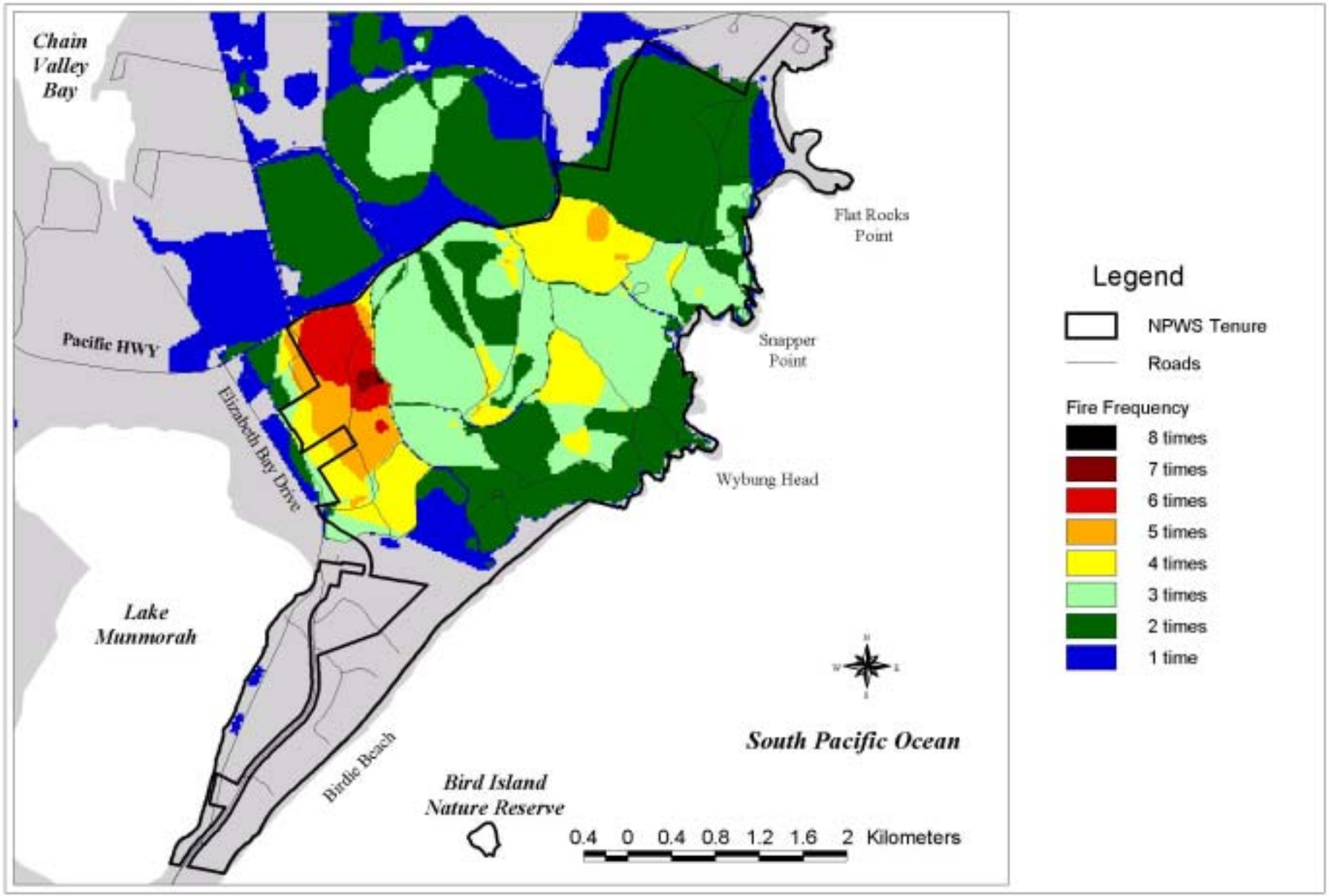
3.2.1 Climate

The climate of the region is generally mild with a strong coastal influence. Seasonal extremes and averages have been provided in Table 8 and Table 9 below indicating the general climate trends experienced by Munmorah SRA over the last ten years. Maximum or minimum values are in bold.

Table 8: Average Seasonal ranges taken from 1987-1996

season	**Max Temp (°C)**	**Min Temp (°C)**	**Max rain (mm)**	**Min rain (mm)**	**Max Hum. (%)**	**Min Hum. (%)**	**Max Wind Speeds (m/s)**	**Min Wind Speeds (m/s)**
Summer	**24.4**	18.98	91.73	64.97	**81.7**	74.4	7.2	5
Autumn	22.02	15.8	122.17	118.1	80.2	74.88	8.9	**3.2**
Winter	17.77	**9.93**	**145.77**	51.4	75.33	**65**	9.1	3.7
Spring	21.36	14.12	115.7	**12.2**	80.75	75.63	**10.6**	5.3

Note - Temperature , rain & humidity data was taken from Norah Head Lighthouse. Wind data was taken from Nobbys signal station, Newcastle.



Map 6: Fire Frequency in Munmorah SRA

Table 9: average (1987-1996) rainfall, temperature and humidity levels from Norah Head Lighthouse.

	Temperature (°C)	average humidity %	average rainfall (mm)	average windspeed (m/s)
Summer	21.76	78.94	115.05	5.9
Autumn	18.63	78.26	122.17	5.53
Winter	13.83	71.73	100.42	5.88
Spring	17.6	69.58	73.44	6.4
Annual	17.96	74.63	102.77	5.9

The average maximum temperatures range from 27 degrees during December through March and 17 degrees from June to August. Days in excess of 30 degrees frequently occur during summer.

The average annual rainfall along the coastal strip is 1400mm with the wettest months traditionally being January through March. Average minimum relative humidity varies from 58% to 72% from January to July and 47% to 58% form August to December. Diurnal variations in relative humidity can have a marked influence on fire behaviour.

Generally wind speeds in the Munmorah study area average 20klm/hr. Winds tend to be more variable in summer and dominated by north-easterly sea breezes. Winter winds are generally, more predictable and associated with a westerly airstream, which swings to the south during the afternoon. Dry north-westerly winds during spring to early summer are of the most concern as these occur during the fire season and have a marked influence on the behaviour of fires.

3.2.2 Conditions associated with bush fires

Climatic and weather conditions associated with serious bushfire seasons and events include;

a) Occurrence of an extended drought period (BKDI >100) and lower than average rainfall through winter drying fuel for spring.
b) Summer rainfall is lower than average (Negative SOI), extending the fire season into autumn,
c) Prolific fuel accumulation from strong growing seasons the previous summer(s), followed by point a),
d) Spring/ summer thunderstorm activity in dry years,
e) Occurrence of particular synoptic patterns that bring persistent W to NW winds in late winter/ early spring and are followed by strong cold fronts or southerly changes (high FFDI).

The bushfire danger period for the region is from 1st October to the 30th March. Wildfire risk is greatest during months with the occurrence of north-west winds, high temperatures and low humidity (Strom, 1986). For Munmorah SRA, precursor conditions for severe wildfires appear to be most

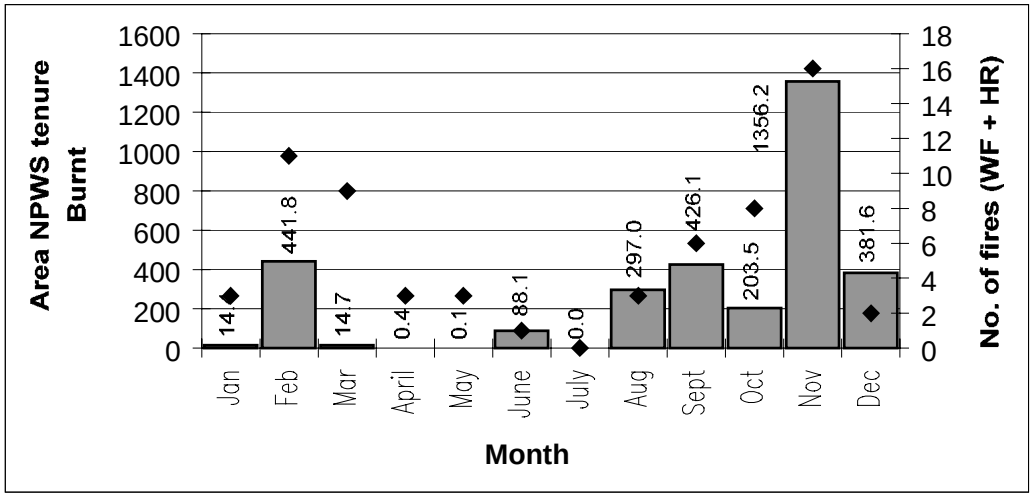
common during spring and early summer (Table 10), however this varies from year to year depending on the prevailing weather cycle.

Table 10: Wildfires that have burnt more than 200ha in the Munmorah SRA.

Location	Pacific Hwy	Pacific Hwy	Frazer Valley	Scout Camp Area	Geebung	Moonee Beach
Date	Nov 1980	Nov 1982	Nov 1982	Oct 89	Sep 1991	Aug 1995
Area Burnt	500ha	880ha	300ha	200ha	320ha	250ha

Figure 5 also indicates that the greatest number of wildfires have occurred predominantly in late spring months. This season experiences the lowest average rainfall and humidity levels. It also experiences comparatively high temperature and wind speeds.

Figure 5: Area burnt and number of wildfires and prescribed burns in Munmorah SRA (1980-2000) as a function of month



Keetch - Byram Drought Index (KBDI) and Wildfire conditions

KBDI is a measure of soil moisture content and increases with prolonged drought and rainfall deficiencies. KBDI however, is highly variable during recorded wildfire events and cannot be taken as a true indication of the likelihood of a wildfire. However, interpreted ranges for wildfire potential are:

0 – 25 (mild); 25 – 63 (average); 64 – 100 (serious); 100 –200 (extreme)

Forest Fire Danger Index (FFDI) and Wildfire conditions

FFDI is a more useful indicator of bushfire potential as it incorporates factors such as wind speed, humidity with the BKDI to greater reflect the likelihood of fire occurrence. However accurate records over an adequate period of time are not available for the study area. Despite this, days of highest FFDI can be expected from spring through to autumn. However, interpreted ranges for wildfire potential are:

0-5(low); 5-12(moderate); 12-24(high) 24 –50(very high); 50-100(extreme)

Southern Oscillation Index (SOI) and Wildfire conditions

Negative SOI (*El Nino* years) are generally associated with below average rainfall along the East Coast of Australia and prolonged drought. Monitoring the index can assist in the early prediction of severe fire seasons. The implication of SOI on Bushfire conditions is for major fire seasons to occur at intervals between 5 and 11years (BOM 1999).

3.2.3 Conditions suitable for prescribed burns

Prescribed burning operations are carried out in accordance with the Wyong District Bush Fire Risk Management Plan. The primary objectives of this plan are to minimise the risk of bushfire to life, property, natural and cultural heritage values.

Season

Fuel Management generally would occur outside the bushfire danger period between 1st April and 30th September. During this time a number of factors allow for a specific prescription to be achieved; these include:

- dry surface fuels;
- a high level of moisture recovery in fine fuels at night; and
- a low probability of dry north-westerly winds.

The main periods of the year during which these conditions may occur are mid-autumn and late winter/early spring.

Prescribed burns could occur outside these periods, with the consent of the Wyong District Bushfire Management Committee, where there are secure boundaries, and the area can be burnt out and made safe before the passage of very high to extreme fire weather.

Weather conditions

Other periods that may be suitable for prescribed burning are those immediately preceding rain depressions and rain bearing troughs during late November to March. These weather systems may completely extinguish any burn, and utilising them requires careful monitoring.

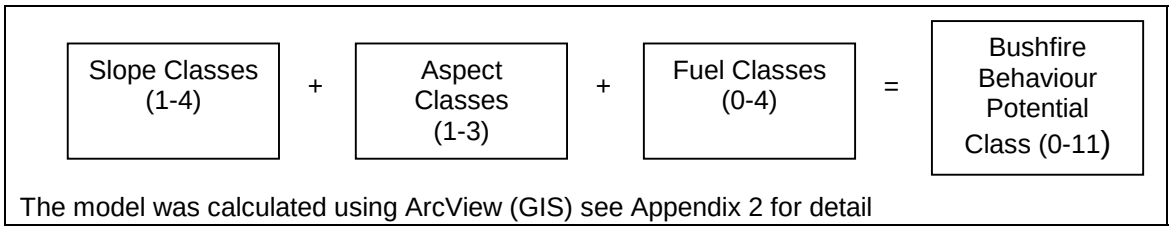
The chief limiting factor for successful burning into winter is the high probability of rain in late autumn and early winter. The prevailing temperatures and humidity may prevent drying of surface fuels. Also, surface fuels on southerly aspects enable greater moisture retention due to shadows from topography and canopy vegetation.

3.3 Fire behaviour potential

Fire behaviour is the manner in which a fire reacts to the variables of fuel, weather and topography (AFAC, 1996). The major fires mapped over the past twenty years suggest that almost all areas of the Munmorah State Conservation Area are susceptible to fire. Various models have been developed to represent fire behaviour (eg Dovey 1994; Bradstock, *et al* 1998; CSIRO, 1998). Outlined in Figure 6 are the elements used to produce a bush

fire potential model for Munmorah SRA that incorporates slope, aspect, and fuel information. The model assumes constant weather conditions and does not factor in past fire history.

Figure 6: Method used to calculate the fire behaviour model for Munmorah SRA



Note: With any combination of slope and aspect, if fuel class is zero (0) Bushfire behaviour Potential is equal to Zero.

3.3.1 Elevation

Munmorah SRA ranges in elevation from sea level to 98m at Bongon Head. The topography primarily governed by Munmorah Conglomerates with overlying perched sand masses. Elevation was not considered as a factor in the fire behaviour model due to the small range in height.

3.3.2 Slope

Slope has a significant effect on bushfire behaviour. Increases in slope generally increase bushfire intensity and rate of spread, and conversely decreases in slope reduce fire intensity and rate of spread. For the purposes of modelling fire behaviour slope has been divided into four classes; flat, level, hilly and steep on the basis of slope gradients (Table 11).

Table 11: slope classes for Munmorah SRA

Slope gradient	Class	Distribution	Hectares	%
0^o	Flat (1)	North-East shore of Lake Munmorah, associated with the Southern SEPP 14 wetland area complex.	142.9	9.9
0^o to 5^o	Level (2)	Extensively throughout the southern peninsula section of the Reserve.	648.3	44.9
5^o to 10^o	Hilly (3)	Extensively throughout the Northern section of the Reserve, associate with the Munmorah conglomerate geology	565.2	39.2
over 15^o	Steep (4)	Found along rocky headlands and more resistant ridges of Munmorah Conglomerate geology such as along Bongon and Wybung head roads	85.9	6.0

3.3.3 Aspect

Estimates of the McArthur Forest Fire Danger Index (FFDI) for all combinations of slope and aspect were conducted by Bradstock *et al* (1997) for the Sydney Region. Summaries showed that high FFDI values occurred on western and to a lesser degree southern aspects (Bradstock *et al,* 1997). Fire intensity and rate of spread tends to increase with drier aspects. In Munmorah SRA three Aspect Classes were modelled for High (170^o – 330^o) Moderate (330^o – 80^o & 145^o - 170^o), and Low (80^o – 145^o) bushfire behaviour potential (Table 12) based on aspect classes derived from Bradstock *et al* 1997 raw data.

Table 12: Aspect classes for Munmorah SRA (adapted from Bradstock etal 1997)

Aspect classes	Hectare	%
High (3) (170^{o} – 330^{o})	637.7	44.2
Moderate (2) (330^{o} – 80^{o} &145^{o} - 170^{o})	573.1	39.7
Low (1) (80^{o} – 145^{o})	231.4	16.0

3.3.4 Fuel

The vegetation of the Munmorah State Conservation Area is comprised mainly of heath/ shrubland (51.49%), and woodland (39.65%) plant communities. The results of a fuel sampling study undertaken within the Sydney Basin (Conroy, 1993) indicate that shrubland had the potential to accumulate 33.25 t/ha after about 30years, followed by woodland (23.57 t/ha), open forest (18.37 t/ha), grassland (10.1 t/ha) and rainforest (8 t/ha). Localised fuel assessment of the area (Lacy, 1996) measured fuel loadings varying from 3.6 to 27.1 tonne per hectare.

The vegetation of the Sydney Region can be separated into 5 major fuel groups (Conroy, 1993) according to their potential to influence fire intensity and rate of spread. These groups provide an indication of the continuity, structure, quantity of fuels and the frequency of fuel availability during the average bushfire season (Table 13).

Table 13: Fuel classes for Munmorah SRA (adapted from Conroy 1993)

Fuel[1]	Vegetation Community[2]	Characteristics of Fuel Group	Hectares	%
Shrubland (class 4)	Pn1 Qa8 Qhd6 Qs5 Qs2 Rnm4 (Qa11)	Will ignite and burn quickly and intensely during an average season. Continuous fuel from ground to canopy in high quantities.	726.0	50.2
Woodland & Forest (dry) (class 3)	Qhd4 Rnm2, Rnm3 Tet/Ju (Qa12, Qa2, Pnm1, Rnm1)	Potential for high intensity bushfires. Generally have live fuel shrub understorey which will burn under a broad range of conditions. Moderate to high surface fuel levels and open canopies allows sunlight and wind to quickly dry available fuels.	554.1	38.3
Forest (wet) (class 2)	Qa3, Qhd2, (Qa6 Qa1)	Fire behaviour varies depending on aspect and FFDI. High fuel moisture levels, limited ground fuel, closed canopies, and relatively fire resistant understoreys. After extended dry periods can support high intensity fires.	116.1	8.1
Sedgeland, Reeds (class 1)	Qa10 (Qa7)	Moist fuels, low medium quantity, unlikely to contribute to high intensity fires during an average season.	4.2	0.3
Cleared/Sand/ open Waterbodies (class 0)	Various areas throughout	Unlikely to burn or will always burn within controllable limits.	45.3	3.1

*1 Fuel classification based on Conroy, 1993.
*2 communities in within brackets occur outside Munmorah SRA tenure

3.3.5 Areas of potential high fire behaviour

Due to the large number of different parameters that contribute to complex fire behaviour, the model provides only a simplistic overview of bushfire behaviour potential in Munmorah SRA. Five classes (Table 14) have been

developed to contrast different areas of bushfire behaviour potential within Munmorah SRA.

Table 14: fire potential classes calculated for Munmorah SRA and environs

Class	Area (ha)	Amount %	Location
Very High	154.5	10.7	On steep slopes especially with a westerly aspect, such as the south east side of Wybung Head Road
High	843.1	58.5	Extensive throughout the Park, often occurring adjacent to areas in the very high class. Occur predominantly on steep slopes of any aspect.
Medium	348.5	24.2	Occurs predominantly along major drainage lines and wetland areas within the park.
Low	51.1	3.5	Very little low bushfire potential areas occur within the reserve other than in the wetland areas adjacent to Elizabeth bay drive.
Cleared/ Mangroves	45	3.1	Mostly located off park. Small cleared areas do occur within the park.

Note: Age since last fire, fire intensity, fire frequency, synoptic weather conditions and other fuel characteristics also contribute to bushfire behaviour.

Within the reserve there are few areas of low to negligible bushfire behaviour potential. 58% of the Munmorah SRA is characterised by a high bushfire behaviour potential (Map 7). It should be noted that under extreme weather conditions almost any fires' behaviour would be potentially very high given the high proportion of shrubland fuels (50.2%) and the high proportion of aspects (44.2%) with potentially high FFDI values. Any major run of fire immediately east of the Pacific Highway under high FFDI conditions, would be potentially too difficult to suppress.

Refuges for visitors and firefighters in the event of a wildfire include the coastal rock shelves and beaches, Lake Munmorah residential areas, and cleared areas adjacent to the park along the Pacific Highway. The existing network of public roads and maintained fire management trails are adequately distributed to ensure accessibility to refuges in the event of a wild fire.

3.4 Damage potential

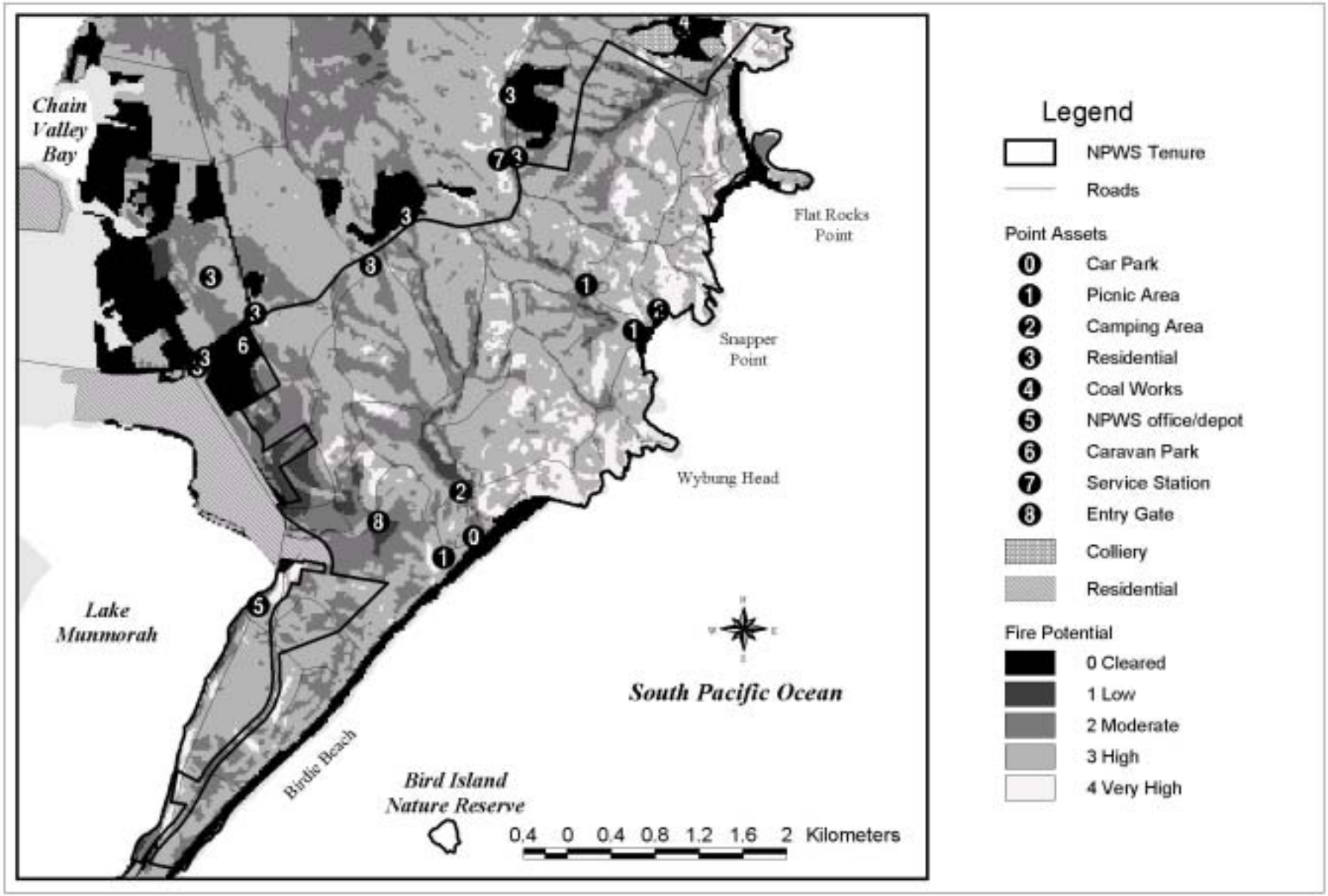
Fire will impact on Historic, Economic and natural heritage assets as a result of direct flame contact, radiant heat, burning debris carried by wind and smoke.

3.4.1 Historical damage

No significant structures were identified

3.4.2 Economic

There are a number of community and NPWS assets within and surrounding the reserve (Map 7) that could be potentially damaged by wildfire events.



Map 7: Bushfire Behaviour Potential and major asset locations for Munmorah SRA

Community Assets

The main development in the area is residential housing which is concentrated in the Elizabeth Bay area and adjacent to the reserve. Isolated houses or sheds and a roadhouse/ petrol station occur along the Pacific Highway adjacent to the perimeter of the park. A large coal mining operation occurs on the northern perimeter of the park at Catherine Hill Bay. The damage potential to these assets has been outlined in Table 15.

Table 15: damage potential and bushfire threat to Community assets that neighbour the Reserve

Community Assets	Damage potential and bushfire threat to community assets at reserve interface
Lake Munmorah & Elizabeth Bay Village	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). Potential for damage as a result of fire radiation smoke and burning embers from wildfires started on reserve in strong NE wind. A large wild fire in 1998/ 99 reduced fuel loadings in much of the area of reserve adjacent to these assets (Map 4), hence reducing the fire intensity potential.
Budgewoi Village	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). The majority of the peninsula section of the reserve has not been burnt in the last 20 years (See Map 4). Would require Strong NE wind to make fire run south toward these assets.
Coal Operations & Moonee Colliery Catherine Hill Bay	High to very high bushfire potential adjacent to asset. Potentially for Westerly winds followed by a strong southerly change. Area of reserve immediately south and west of the asset was last burnt 4 years ago in 1995/69 season.
"Park Trees" Mobile Home & Park	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). Direct impact from wildfire started on park in strong north east wind, or off park in a north or north west wind. Area of reserve adjacent to these assets was burnt out in 1998/ 99 (Map 4).
Isolated Houses or Sheds	Require fire to start off park west of the Pacific Highway in west to Northwest winds. Wildfire started on park in strong E wind
Big T roadhouse	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). Require fire to start off park west of the Pacific Highway in west to North-West winds. Wildfire started on park in strong E winds.
Old Quarry House-Pacific Hwy	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). Require fire to start off park west of the Pacific Highway in west to North-West winds. Wildfire started on park in strong E winds.
House south of Big T	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). Require fire to start off park west of the Pacific Highway in west to Northwest winds. Wildfire started on park in strong E winds.

NPWS Assets and visitor facilities

Within the reserve there a number of roads, access trails and infrastructure that are of value to protect. Other park facilities and utilities have also been identified in section 5.2 & 5.3. These include the Park office and workshop, camping facilities (toilets, barbecues and information boards) and walking tracks.

The main visitor focus areas are located on the coastline. In a major fire there is the potential threat tor visitors to attempting to exit the park via the network of roads through the centre of the reserve. Under several wind directions,

major runs of fire could result in entrapment. Knowledge of visitor use of the park during high bushfire potential conditions will be central to coordinating rescue operations (See Table 16).

Table 16: Potential threat to NPWS assets and Facilities

NPWS facilities	Damage potential & Bushfire threat
Frazer park Camping Area	Located in an area of high to very high bushfire potential. Damage potential to toilets, gas barbecues, shelters and information boards
Freemans camping Area	Located in an area of moderate to high bushfire potential. Damage potential to toilets, gas barbecues, shelters and information boards
Tea Tree Picnic Area	High potential for wildfire adjacent to assets (see Map 7). Damage potential to gas barbecues, shelters and information boards.
Palms Picnic Area	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). Damage potential gas barbecues, shelters and information boards
Office and Works Depot	Moderate to high bushfire potential for wildfire adjacent to assets (see Map 7). Damage potential greatest in North to North West winds

3.4.3 Natural heritage

The Munmorah SRA contains many unique and valuable wildlife communities containing species which are listed under the *Threatened species and Conservation Act 1995*. High fire frequency, altered seasonally and intensities of fire regimes may present a risk of extinction for some sensitive species of flora and fauna. Damage to the physical environment may include soil erosion. Section 3.5 & 6.1 outlines the guiding principles to ensure conservation of natural ecosystems.

3.4.4 Cultural heritage

No significant sites were identified.

4. FIRE MANAGEMENT

4.1 Overview

A bushfire management zoning approach has been developed by the NPWS to assist with the implementation of fire management policies and objectives appropriate for the protection of life and assets, and the conservation of heritage values within and adjoining Munmorah SRA. Practical fire management to achieve these policies will be guided by the objectives and strategies identified in the following sections.

This zoning approach is based on principles developed by the Department of Bushfire Services (1991)(see section 4.2), NPWS fire specialists (Conroy 1996, 1997) and more recently the Bush fire Risk Management Plans (see section 4.1.3). Zoning enables the application of area specific fire management objectives and actions, and will assist with the measurement of fire management performance against the requirements for each zone.

4.1.1 Munmorah SRA Bush Fire Management Zones

Three categories of fire management zones will be managed in and around the Park (MAP 8):

Asset Protection Zones (APZ) (Section 4.2)
Strategic Fire Management Zones (SFMZ) (Section 4.3)
Heritage Area Management Zones (HAMZ) (Section 4.4)

Asset Protection Zones (APZ)

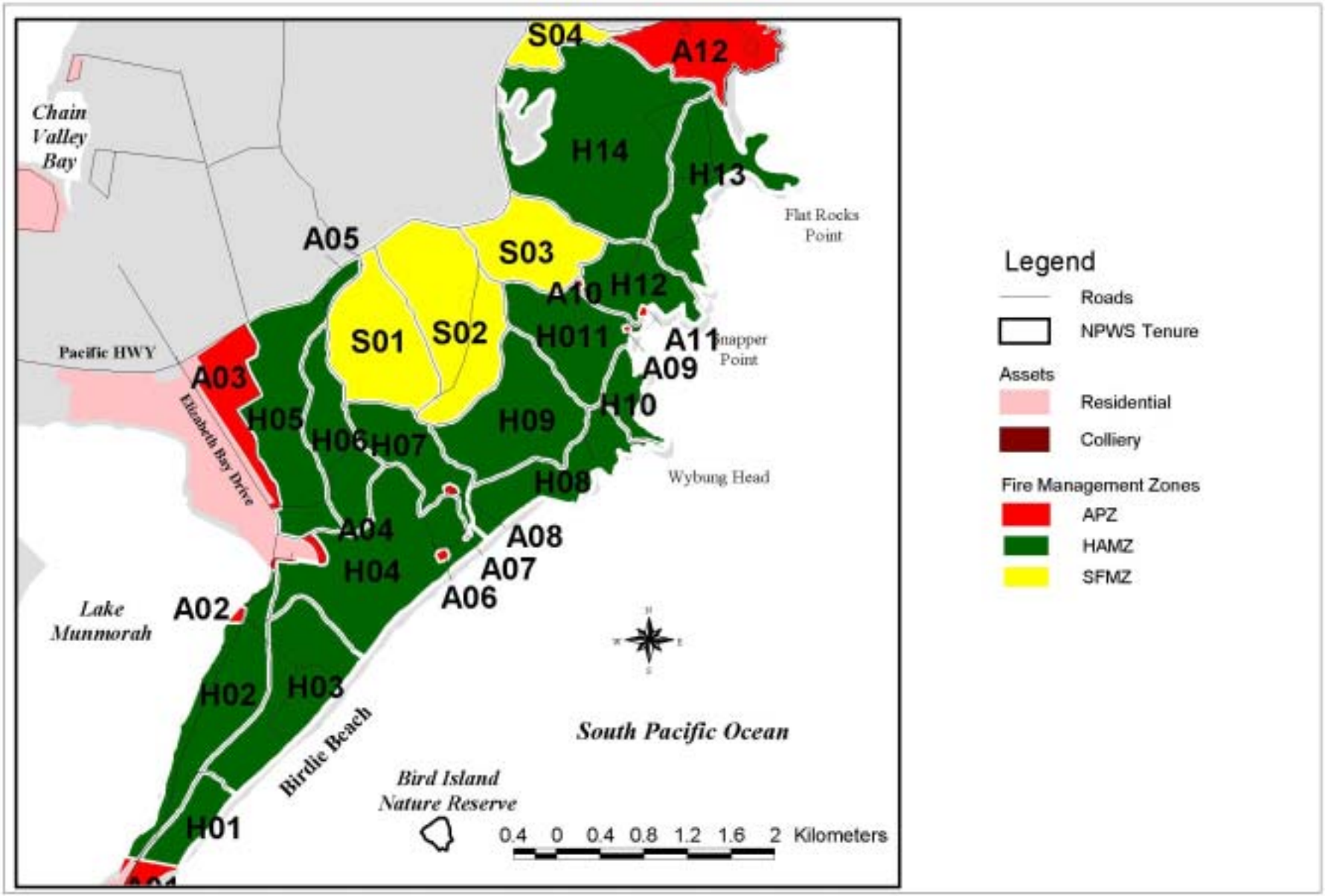
There are 12 APZ encompassing 2% of the reserve and 131 ha of surrounding lands to protect the neighbours, visitors and facilities of the reserve (MAP 8). The objective of APZ is to minimise the risk of wildfire damage to the property of Lake Munmorah, Elizabeth Bay, and Budgewoi residential areas, NPWS office/ depot, utilities, camping areas and day use area facilities and to protect the lives of neighbours, visitors, firefighters and staff.

Strategic Fire Management Zones (SFMZ)

There are 4 SFMZ encompassing 21% the reserve and 36 ha on surrounding lands (MAP 8). The Zone Objective is to provide for the strategic containment of wildfires, provide safe access for bushfire fighters and to assist with the implementation of prescribed burns.

Heritage Area Management Zones (HAMZ)

There are 14 HAMZ encompassing 77% of the reserve to enhance the conservation of biodiversity (MAP 8). The zone objective is to manage bushfire to meet the conservation needs of threatened species of flora and fauna, the maintenance of diversity in vegetation community composition and structure, which may be at risk of long term damage as a result of the application of inappropriate fire regimes.



MAP 8: Fire Management zones of Munmorah SRA

4.1.2 Wyong District Bush Fire Risk Management Plan

A series of bush fire management zones have been identified based on the results of the bush fire risk analysis for Wyong Shire Council area. This co-operative plan was developed by the RFS, NPWS, SFNSW, Wyong Shire Council and NSW FB. The zones in Munmorah SRA and adjoining areas relate directly to the current risk management plan. Both plans use the same terminology except for Land Management Zones. A Heritage Management Zone in Munmorah Fire Plan is the equivalent to the Land Management Zone in the Risk Management Plan. The mapping in this plan is in finer detail than the Risk Management Plan providing greater resolution.

4.1.3 Summary table of fire management zones

Zone	Objectives	Strategies and Methods	Area (ha)
Asset Protection (APZ)	• To protect the residential Areas of Lake Munmorah, Elizabeth Bay, and Budgewoi; • To protect NPWS office/ depot; utilities, camping picnic areas; entry Gates; • To protect the Wallarah Colliery • Minimise the risk of wildfire starting from human activity	• Community fire guard • Fuel free and fuel reduced areas adjacent to structures (DBFS, 1991) • Fire trail construction • Selective shrub removal, clearing • Prescribed burning	133.1
Heritage Area Management (HAMZ)	• Maintenance of diversity in vegetation association and structure of the reserve • To prevent permanent damage or destruction of threatened flora and fauna by an inappropriate fire regime • Consistent with broad area objectives of relevant statutes	• Provide a diversity of fire regimes (frequency, season, intensity, size, patchiness) to maintain age class distributions present within the reserve • Prescribed ecological burns consistent with fire regime guidelines • suppress fires inconsistent with the fire prescription	1273.5
Strategic Fire Management Zone (SFMZ)	• To provide for the strategic containment of wildfires, provide; • Safe access for bushfire fighters and to; • Assist with the implementation of prescribed burns; • Protect and ensure entire reserve is not burnt by a single wildfire	• Prescribed burns consistent with fire regime guidelines • suppress fires inconsistent with the fire prescription • Maintain fire trails / slash trails	335.5

4.2 Protection of neighbours, visitors and facilities

Outlined below are the strategies and actions to protect neighbours, visitors and facilities of Munmorah SRA.

Protection of neighbours

Asset Protection Zones: Responsibility for management of fuel and assets adjacent to the reserve (APZ; A01, A03, and A12 MAP 8) rests primarily with

the adjoining land owners. Works such as selective shrub removal/ clearing may be undertaken as part of an approved activity or under the *Draft Co-operative Arrangements for Fuel Management on Common Boundaries* (NPWS, 1993). The NPWS is an active participant in the risk management planning process through provision of information and carrying out of fuel management works.

Fuel free and fuel reduced areas adjacent to private assets: The NPWS will work with Wyong Shire Council to ensure that all new developments adjacent to the park (in particular APZ; A03 and areas west of the Pacific Highway), take into consideration the need for fuel free and fuel reduced areas and the construction of fire trails for access. These requirements should be built into development proposals in accordance with DBFS 1991, "Planning for Bush Fire Protection", and Australian Standards, "Construction of Buildings in Bushfire-Prone Areas", AS3959-1991.

Fire trail construction: Slash trails and selective shrub removal along the APZ A03 will enable rapid deployment of fire-fighters and back burning along the park boundary for wildfire suppression and control in north east winds.

Prescribed burning**:** The majority of vegetation types allow asset protection to be undertaken by prescribed burning or other techniques as appropriate when available fuel levels exceed maximum prescribed limits. However, the numbers of wildfires that have occurred in areas adjacent to assets have been considered sufficient to reduce fuel loadings.

Protection of Visitors

- The park may be closed to the public when it is considered necessary due to prevailing conditions that create an extreme fire danger or during fire fighting operations,
- Display notices at appropriate locations during total & reserve fire ban periods,
- Notify visitors of prescribed fire operations within the reserve,
- Maintain road network to allow rapid evacuation of park visitors.

Protection of facilities

Fuel free areas adjacent to NPWS assets: Park facilities and infrastructure include camping grounds (APZ; A08, A11), picnic areas (APZ; A06, A09, A10), NPWS office and workshops (A02), reserve entry gates (APZ; A04, A05) (Map 7 & MAP 8). Protection from fire radiation and direct flame contact will be through the establishment and maintenance of adequate fuel free areas assets. Furthermore annual maintenance of buildings will be undertaken to reduce the probability of ignition from embers.

4.3 Strategic Fire Management

The primary objectives of Strategic Fire Management Zones is to assist in the strategic reducing wildfire intensity and spotting potential by managing fuel through prescribed burning, and secondly, to assist in the strategic control and containment of wildfires.

Prescribed burning will be the primary method to reduce wildfire intensity and spotting potential within SFMZ. The program of prescribed burning within the

lifetime of this plan is outlined in section 2.6.1. The regimes of prescribed burning within the SFMZ will be maintained at a higher frequency, however within the thresholds required for the conservation of biodiversity (see Table 17).

The existing network of fire trails (see Section 5.1, Fire Management access) has determined the boundaries of individual zone areas. Strategic Fire Mmanagement will require the maintenance of control lines to provide safe access to bushfire fighters, and the capability to effectively suppress unplanned wildfires.

4.3.1 Arson mitigation

Arson has been a major problem in and around the Lake Munmorah/ Gwandalan area over recent years. Within Munmorah SRA 47% of recorded ignitions have been attributed to arson activity. The local community has been significantly inconvenienced and their property potentially threatened by fires started by arson. Furthermore, the high density of ignitions in many areas of the park, especially along blue wren drive has resulted in areas burnt up to 8 times since 1980 (see section 3.1). Such high fire frequency has the potential to exceed Biodiversity conservation thresholds.

Strategies to mitigate the impacts of arson include;

- Support the implementation of community fire guard,
- Conduct school and community education programs,
- Undertake patrols for arson activity,
- Support the NSW police and RFS motorbike squad patrols.

4.4 Biodiversity conservation

The biodiversity conservation values of the Park become most apparent when viewed in a regional context, particularly in relation to other costal parks in the area. Conservation is about the prevention of the extinction of species, especially extinctions brought about by the action of humans. The nature conservation objective of this plan is to;

> *"Manage fire to retain (avoid extinction of) all native species known to occur within the Reserves*."

4.4.1 Guiding Principles and Thresholds

Contemporary ecological research in fire-prone ecosystems of the kind represented within the Munmorah SRA has established some general principles about the fire regimes needed to avoid the extinction of species and to promote biodiversity. Management of fire for biodiversity conservation within Munmorah SRA will be guided by the following general principles developed by the Service:

Fire management in Munmorah SRA considers the relationship between vegetation community structure and composition and habitat for animals to be interrelated. Appendix 1 outlines the fauna habitat characteristics of the major vegetation communities of the Munmorah SRA study area.

To maintain biodiversity, a diversity of fire regimes is needed within the Munmorah SRA study area. This means that over time there will be a place for fires of high, low and moderate intensity, season, frequency and size. Local extinctions are likely when fire regimes of relatively fixed intensity, frequency and extent occur.

It has been identified from studies that groups of plant and animal species respond similarly to fire according to characteristics of their life-history. Therefore, it is not necessary to individually specify fire regimes for the conservation of every species of flora and fauna. Rather an overview is needed of the requirements for broad groups of species. Requirements for most plant species can be summarised on the basis of a small number of groups. Knowledge of requirements for groups of animals is less advanced.

On the basis of identified groups of biota that have similar responses to fire, thresholds separating desirable and undesirable fire regimes, for conservation, have been defined. Management of fire in Munmorah SRA is targeted towards desirable fire regimes using the thresholds outlined in Table 17 as a guide for the vegetation represented in the area. Map 3provides a description of the maximum fire frequency tolerance (minimum inter-fire period) for the vegetation communities in the area. Management strategies therefore will involve the manipulation of fire regimes.

Table 17: Fire regime guidelines For Munmorah SRA (Adapted from Bradstock *et al* 1995 and Smyth & Binning, 1999)

Vegetation Community (codes refer to vegetation survey Payne, 1993)	**A decline in biodiversity is predicted if there is**	**Regime**
Qhd2 Closed Forest (littoral Rainforest Remnant on Holocene Barrier Sands)	• Any fire	A
No vegetation communities in the study area fall under this regime.	• Three or more consecutive fires with each of the fires less than 20 years apart. • Two or more high intensity fires with a complete scorch of the canopy within a period of one hundred years. • No high intensity fire within a period of one to two hundred years.	B
Qa3 Low Forest\ Forest to Woodland **Qs2** Closed Heathland/ Low Woodland **Qs5** Scrub to open scrub **Qhd4** Open Forest to Forest **Rnm2** Low Woodland to Low Open Forest **Rnm3** Low Closed Forest	• Three or more consecutive fires, with each of the fires less than 5 years apart. • No fire for more than 30 years.	C
Qa8 Closed Heathland/ Sedgeland **Qhd6** Scrub to Open Scrub **Rnm4** Dry Open to closed heathland. **Pn1** Closed grasslands \shrubland to closed Heathland Tet/Ju Tetratheca	• Three or more consecutive fires, with each of the fires less than 8 years apart. • Three or more consecutive fires, with each of the fires more than 15 to 30 years apart. • No fire for more than 30 years.	D
Qa10 Open Water Wetlands with fringing vegetation Cleared/disturbed	• Not applicable	E

Monitoring and 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 community type and prevailing fire regimes) there may be a role for both prescribed fire and/or fire-exclusion in parts of a given Reserve at different times in the future.

4.4.2 Distribution of biodiversity in fire management zones

Table 18 provides a breakdown of the vegetation type in each of the fire management zones and shows that only very small proportions of the major vegetation types are found outside HAMZ's which is desirable for biodiversity conservation.

Table 18: Distribution of vegetation types in the fire management zones

Vegetation community (codes refer to vegetation survey Payne, 1993)	**Percentage of each vegetation community in the fire management zone**		
	APZ	**SFMZ**	**HAMZ**
Qa3 Low Forest/ Forest/ woodland	4.4	17.3	78.3
Qa8 Closed Heathland/ Sedgeland	0.6	-	99.4
Qa10 Open Water Wetland	-	-	100
Qhd2 Littoral Rainforest Remnant	-	-	100
Qhd4 Open Forest/Forest	-	-	100
Qhd6 Scrub/Open Scrub	5.7	-	94.3
Rnm2 Low Woodland/ Low Open Forest	2.5	**45.5**	52.0
Rnm3 Forest	-	-	100
Rnm4 Open to Closed Heathland	4.8	8.7	86.5
Pn1 Closed Grassland/ Shrubland/ Heathland	17.4	-	82.6
Qs2 Closed Heathland/ Low Woodland 2	-	-	100
Qs5 Scrub/ Open Scrub	-	-	100
Tet/ju	-	**100**	-
Cleared/ sand	51.9	0.7	47.3

Table 18 identifies two important considerations for fire management;

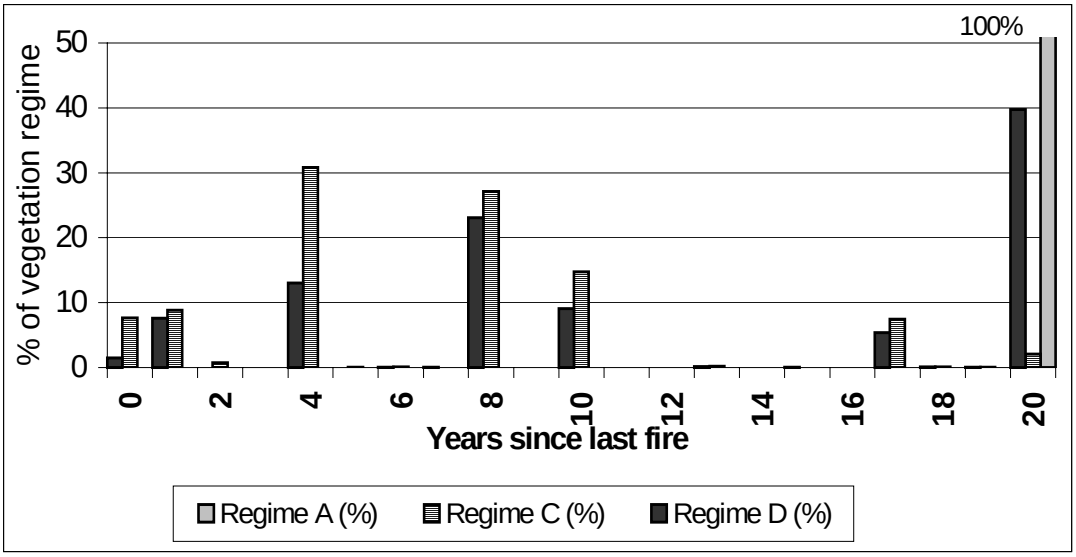
- 100% of the known stands of *Tetratheca juncea* within the reserve found in the Birdie Creek South SFMZ (S01); and,
- 50% of the Rnm2 Low Woodland/ Low Open Forest within the SFMZ.

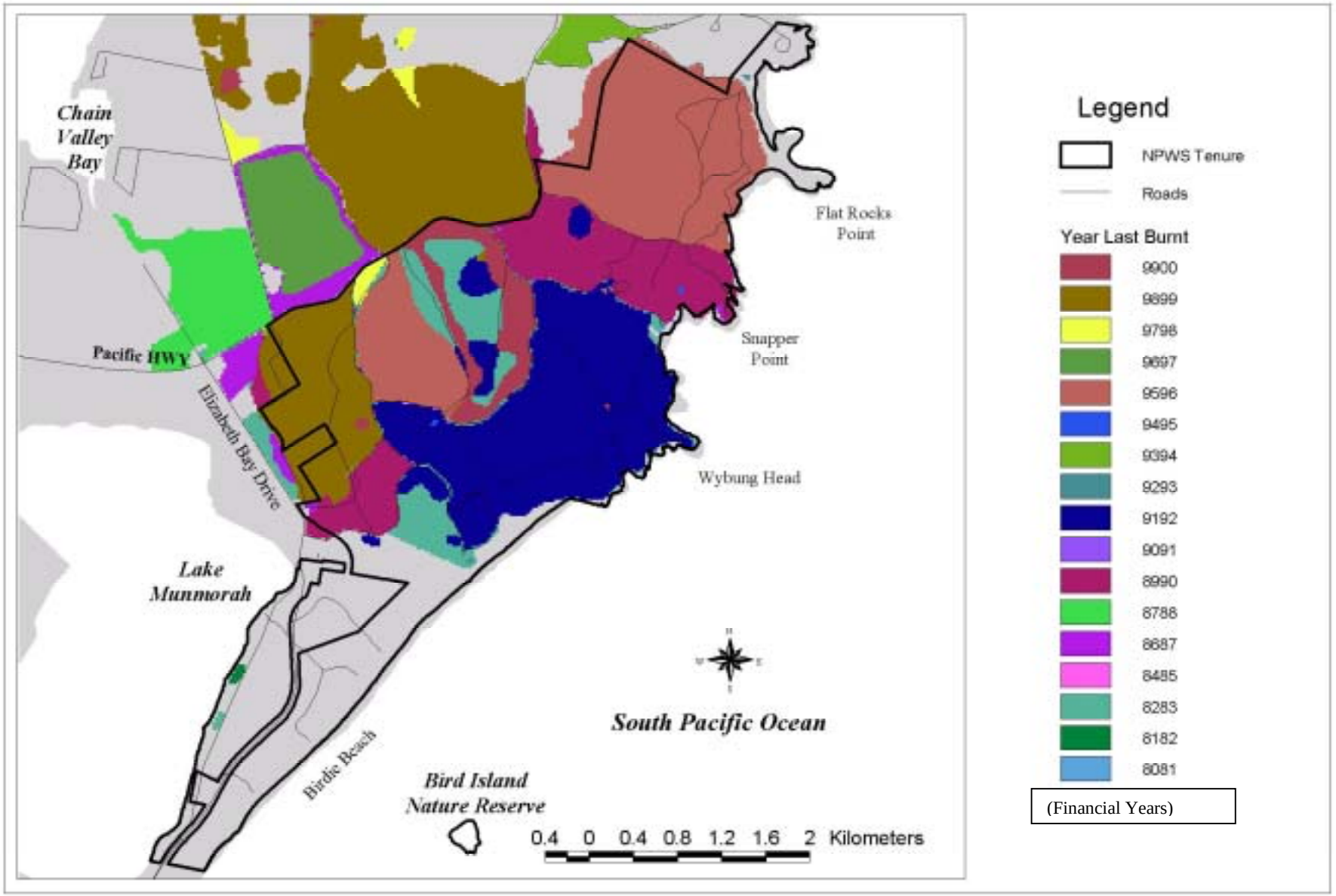
These issues are addressed in Appendix 3, fire management zone, objectives, strategies and methods. The *Tetratheca juncea* population will be managed to ensure fire regimes are in accordance with the conservation requirements on the (see Table 2) in liaison with the bushfire research and threatened species unit of the NPWS. By conducting mosaic burns covering less than 50% of the zone, and primarily burning roadside areas, the majority of the zones will be managed within biodiversity thresholds.

4.4.3 Evaluation of current fire regimes

MAP 9 shows that together, wildfires and prescribed burns have produced a mosaic of vegetation patches at various successional stages of post fire regeneration significant to the ecology of the region. Figure 7 below shows the current age class distribution for vegetation communities managed according to fire regimes A, C and D as per table 17.

Figure 7: Age class distribution (time since last fire) for fire regime vegetation communities of Munmorah SRA

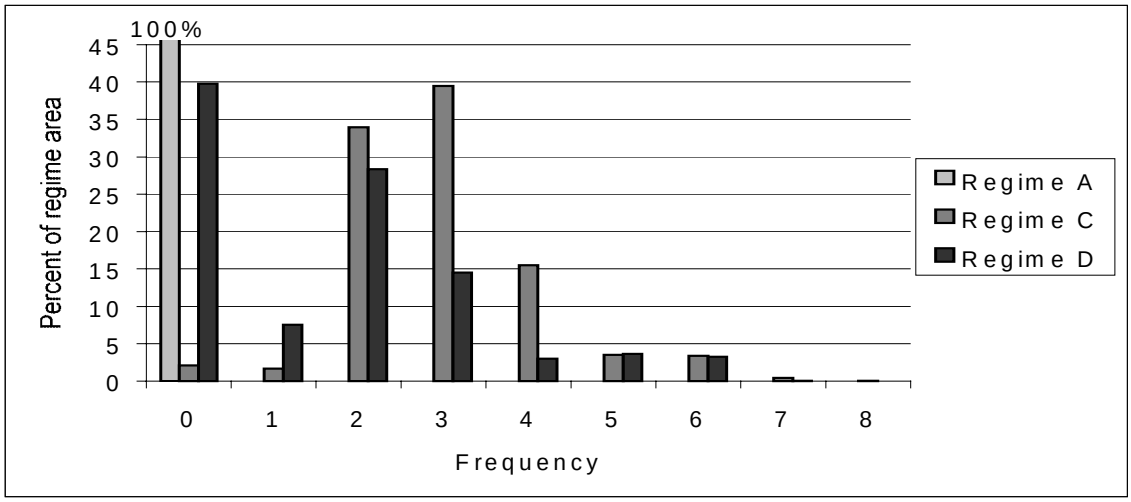




MAP 9: Year Last Burnt In Munmorah SRA

The current frequency class distribution for fire regimes A, C and D of the reserve is shown in Figure 8 below. Areas of high frequency fires may have implications for the local extinction of some species of flora and fauna.

Figure 8: Frequency class distribution (Number of times burnt in the last 20 years 1980-2000) for fire regime vegetation communities



Regime A:

Only the littoral rainforest remnant (0.4ha) Qhd2 the southern end of the park is managed according to regime A and wildfire has successfully been excluded from this community (Figure 7& Figure 8).

Regime C:

Dry woodland, forest communities falling under regime C cover 760ha (53%) of the reserve. Of the communities grouped under regime C approximately 9% have a mean inter-fire interval of less than 5 years, which may be contributing to a decline in biodiversity. Areas of particular concern include the Low forest/ Forest to Woodland -Swamp Mahogany/ Broad-leaved paperbark wetlands of the northern sections of both the and Melaleuca (H05) HAMZ which have been burnt 5 – 6 times since 1980 and were last burnt in the 1998/ 99 fire season. Fraser Park west (S03) has been burnt 4 – 5 times since 1980

Regime D:

Shrubland and heathland communities falling under regime D cover 633ha (44%) of the reserve. Of the communities grouped under regime D approximately 24% have a mean inter-fire interval of less than 6.6 years, which may be contributing to a decline in biodiversity in these areas. Areas of particular concern include the southern sections of both the Farmhouse zone (H06) and the northern section of the Melaleuca zone (H05) which have been burnt 3 – 7times since 1980. Community Qhd6 that covers the majority of the peninsula section of the reserve (Map 2) has not been burnt for greater than 20 years.

4.4.4 Effects of management for human protection and strategic wildfire control on biodiversity

The effects of fire management in Asset Protection and Strategic Fire Management Zones on biodiversity need to be considered and factored into planning for biodiversity conservation.

Within the SFMZ there exists the opportunity to manipulate fire prescriptions so as to cause the least amount of undesirable impact to these communities. Achieving this will require burns of a patchy low intensity nature.

Asset Protection Zones encompass 2% of the reserve. Within APZ no prescribed burning works are scheduled for the next 5-8 years (See section 6.4) due to the high occurrence of wildfires that have reduced fuel loadings adjacent to key assets. The regular slashing of fire trails, will locally affect the structure of vegetation but should not significantly alter the species composition of treated areas. Selective shrub clearing and the adoption of fuel free and fuel reduced areas adjacent to assets as part of an approved Community Fire Guard activity will locally impact on species composition and structure but is deemed acceptable for the protection of life and property.

4.4.5 Fire regime strategies for biodiversity conservation

The vegetation map forms the planning foundation for the preparation of the strategies for biodiversity conservation within the Park. The basis of this approach is the concept of *fire regime thresholds* defining desirable and undesirable fire regimes for conservation of biodiversity.

Due to the high occurrence of arson related fire, strategies will be regularly reviewed, refined and adjusted. Given that a diversity of fire regimes is needed to maintain biodiversity, the assessment of fire regimes (section 4.5.3 above) showed that there might be a role for both prescribed fire and/or fire-exclusion in parts of the reserve at different times in the future. Over time therefore, fires of high, low and moderate intensity, frequency and size will be required to avoid local extinctions.

Vegetation communities

Fire management strategies for vegetation communities is based on the principle of maintaining appropriate fire regimes for the purpose of creating a mosaic of patches with different ages and structures. Furthermore, suppression strategies during wildfire will attempt to minimise burn area by strategically containing fire using existing control lines within the reserve.

In certain circumstances, fire may be excluded in the following vegetation communities/areas and alternatives such as slashing, mowing, selective fine fuel removal will need to be implemented in these areas;

- 50% Rnm2 Low Woodland/ Low Open Forest within the SFMZ
- palm dominated Low forest/ forest/ woodland
- littoral rainforest (community Qhd2)

Given the significantly high fire frequency in the vegetation communities of Farmhouse zone (H06) and the northern section of the Melaleuca zone (H05) fire should be excluded for at least 8 years.

Threatened flora

Given that groups of plant species respond similarly to fire according to characteristics of their life history, it is therefore not necessary too individually specify fire regimes for the conservation of every species. This plan provides for individual species to be conserved according to the fire regime guidelines applied to the communities in which they occur.

However, special consideration will be given to monitoring the *Tetratheca juncea* population within the reserve, as 100% of the known stands are found in the Birdie Creek South SFMZ (S01). Strategies for the conservation of *Tetratheca juncea* within the zone will observe the fire regime guidelines outlined in Table 2. The plan provides for fire with in the zone to be managed according to regime “D”. No Prescribed burning within the zone is proposed within the lifetime of the plan.

Threatened fauna

Knowledge of fire regime requirements for groups of animals are less advanced as that between fire and flora. The severity and duration of impact on fauna populations is directly correlated with the size and intensity of the fire. Small, patchy, low intensity fires have little long-term impact, whereas recovery and recolonisation following large, intense fires will take substantially longer.

There is insufficient knowledge of the fire ecology of resident animal species to formulate comprehensive fire regime guidelines for their management. Section 6.1.1 outlines ongoing fire management research where deficiencies in knowledge occur.

This plan provides for minimising the occurrence and severity of large wildfires, and enhancing burn patchiness. Furthermore, it is understood that establishing a mosaic of burns, including recently burnt and long unburnt areas at different ages will enhance fauna biodiversity of the reserve.

4.5 Aboriginal heritage

Aboriginal sites can be damaged by fire fighting equipment, particularly heavy earth moving equipment, and inappropriate fire regimes. Munmorah SRA contains sites only located in dunes and rock platforms so they are unlikely to be affected by fire. Procedures for the use of earth moving equipment are detailed in the *Fire Management Manual*. Where possible existing fire trails and/or control lines will be used during prescribed burning operations or wildfire suppression to reduce impact on any unidentified sites.

4.6 Historic heritage

The Munmorah SRA does not contain any significant historical places or human evidence that would be susceptible to damage in the event of a fire, and associated suppression activities.

4.7 Special purpose management

4.7.1 Fire and pest and exotic species management

Fire disturbance may advantage introduced species and increase the rates of predation from foxes, cats and wild dogs (Catling, 1991). Predator control programs may be implemented after fire to reduce the impact by feral animals on native populations.

Weed invasion is generally minor in extent and severity, however occasionally locally severe around urban areas and along roadways. Payne (1997) identified approximately 50 weed species. Of these 17 species were considered able to invade natural bushland while other species occurred only after disturbance including clearance, too frequent burning or nutrient enrichment.

Research into fire as an important management tool for the primary removal of weeds is scheduled for fire management research. Consolidation and long term maintenance are required to remove weeds competing with native regenerating plants.

4.8 Smoke management

Smoke sensitive areas of the Munmorah SRA include the urban / residential areas of Elizabeth Bay and Lake Munmorah, as well as isolated houses on the fringes of reserve boundaries. A number of measures to reduce the impact of smoke created by prescribed burning operations in these locations are outlined in *Smoke Management Guidelines - Draft* (Conroy 02/96).

4.9 Summary of operational guidelines

The NPWS has statutory responsibility to protect human life, property and natural and cultural heritage from the adverse effects of wildfires on its land. The NPWS has developed a wildfire suppression policy (10/98) to ensure fire suppression operations are undertaken in such a way as to minimise the potential adverse impacts and where possible foster community support for the NPWS fire management practices.

The priorities of the Service in wildfire suppression are:

- the safety of all incident personnel
- the effective protection of human life and community assets
- the conservation of biodiversity
- the conservation of cultural heritage
- the cost effectiveness of strategies
- the achievement of community support

The protection of human life including the safety of personnel engaged in wildfire suppression will be the first priority in fire suppression followed by protection of community and environmental assets. These priorities will be the basis for determining wildfire suppression objectives, strategies and tactics. Safety of park visitors and campers is a significant issue for wildfire

suppression in Munmorah SRA. Park closure and control or evacuation of visitors is a very important consideration during a high intensity wildfire. Strategies for the protection of visitors in the main public focus areas will depend on fire behaviour and weather conditions.

The management of wildfire suppression and prescribed burns in MSRA will be in accordance with the Incident Control System (AIIMS). An Incident Action Plan will be prepared for all fire operations in MSRA. The type of plan will be in accordance with the size and complexity of the incident but will include suppression objectives, strategies, tactics and tasks together with an incident map, resources and organisational structure.

Fire suppression and prescribed burning operations have the potential to impact on the environmental values of Munmorah SRA. The following management guidelines apply in accordance with the NPWS Wildfire Suppression Policy.

- Strategies and tactics selected will be those that will be effective whilst causing least adverse environmental impacts.
- Whenever possible existing built and natural features will be used instead of the construction of new control lines.
- Where temporary access for firefighting vehicles is required, whenever possible existing tracks will be used and the construction of new trails avoided. The guidelines listed in Table 19 will assist in avoiding or mitigating impacts.
- Where construction of control lines is required, wherever possible use of heavy earth moving equipment will be avoided. Handtools, air blowers or slashers will be preferentially employed.
- Where construction by heavy earth moving equipment is necessary, wherever possible side cutting should be avoided, a NPWS approved operator should be used and construction work should be under the direct supervision of an NPWS officer at all times.
- Control lines must be carefully planned to avoid environmentally sensitive areas, visibility impacts and to minimise soil instability.
- Where backburning and burning out are necessary the area burnt will be the minimum necessary to achieve wildfire suppression objectives.
- The need for post fire rehabilitation will be assessed by the Incident Controller as part of the incident management process.
- The cost effectiveness of fire suppression will be taken into account in determining bushfire suppression objectives, strategies and tactics.

Table 19 summarises further guidelines specific to Munmorah SRA.

Table 19: Operational guidelines for MSRA.

Area/resource	Operational guidelines
Vegetation communities where the time since last fire is below the lower level threshold	• minimise burn area, if possible
Vegetation communities where the time since last fire is approaching or exceeding the higher level threshold	• consider a broader containment strategy within the fire management area with consideration to: 1. management of Heathland includes maintaining appropriate fire regimes for the purpose of creating a mosaic of communities with different ages and structures, 2. the fire will be contained within fire management area boundaries in an economic manner, and 3. after consultation with neighbours and the Executive of the appropriate Bush Fire Management Committees
Threatened species of flora	• brief all personnel involved in control line construction on the location of sites and required control line route • exclude sites from burn area if the fire-free interval has not reached the lower level threshold
Threatened species of fauna	• Retain hollow/ habitat trees where possible • Consider conducting post fire feral animal baiting programs to reduce the impact by predators on native populations where appropriate.
Aboriginal site locations	• brief all personnel involved in control line construction on the location of sites and required control line route
Earth moving machinery	• where possible restrict use to existing or previous trail or control line routes • exclude machinery from slopes greater than 30% • close and rehabilitate all new tracks constructed for emergency operations immediately after the incident • incorporate remedial works for erosion control • brief all personnel involved in control line construction / maintenance on the location of aboriginal sites and threatened species
Fire fighting chemicals	• wetting & foaming agents are permitted for use in wildfire control • exclude the use of wetting & foaming agents in environmentally sensitive areas (eg. 20m of creek lines and SEPP14 Wetlands) • exclude use in threatened species sites that are sensitive • avoid the use of retardants where reasonable alternatives are available and follow procedures in *Fire Management Man*ual • salt water permitted for water bombing operations in all areas
Smoke management	• Prescribed burning is to be conducted by best practice guidelines described by Conroy, 02/96.
Visitor safety	• the park may be closed to the public when it is considered necessary due to conditions which create a very high to extreme fire danger or during fire fighting operations • Evacuation or control of campers and visitors may be required during wildfires.

4.10 Guidelines for cooperative fire fighting arrangements

Under the Wildfire Suppression policy, the NPWS will assist other agencies to suppress wildfires threatening to enter NPWS reserves or which may have escaped from NPWS lands.

The Wyong District Bush Fire Management Committee has adopted coordinated fire fighting policies based on the Policy Statement of the Co-

ordinating Committee and the Manual of Procedures for Coordinated Fire Fighting. These coordinated fire fighting policies are documented in the Wyong District Bush Fire Management Plan Operations (1999).

Policies that directly relate to the reserve include;

- Any authority may make the first response to an observed bushfire in Munmorah SRA. The responding authority will take immediate steps to advise NPWS of the fire and what action is being taken.
- All bush fire suppression activities will, as far as practicable, be carried out in consultation with a senior officer from NPWS.
- Under current arrangements for Class One or Two fires within MSRA the officer-in-charge will generally be an Incident Controller from NPWS. This will depend on the nature of the fire and resource commitments from the fire agencies.
- For Class three fires the Commissioner of the Rural Fire Service will appoint an Incident Controller under Section 44 of the Rural Fires Act (See Table 20)

Table 20: Fire classes (*Rural Fires Act 1997)*

Class	Description
Class 1	A fire under the control of the responsible fire authority, whether or not incidental/ low level assistance is provided by other agencies
Class 2	A fire by which necessity, involves more than one agency and where the Bushfire Management Executive have appointed a person to take charge of fire fighting operations
Class 3	A major bushfire or bushfires where an appointment has been made or is imminent under the provisions of Section 44 of the Rural Fires Act, 1997

5. FIRE MANAGEMENT ASSETS

5.1 Fire management access

Fire Management access includes all roads, vehicular trails and walking tracks that can be used for strategic fire management and wildfire control operations. Existing roads and trails form the boundaries of the fire management zones of Munmorah SRA. The principal main road access to Munmorah SRA is from Elizabeth Bay Drive and the Pacific Highway. Within the reserve a network of internal public roads exist. A number of locked Fire management trails and walking tracks also exist with their usage being restricted to walkers and authorised vehicles only.

A detailed trail register is maintained by the NPWS Central Coast Hunter Range Region, which describes vehicle accessibility, condition and maintenance requirements for roads and trails located in Munmorah SRA. The classification system for these roads and trails within and adjacent to Munmorah SRA is described in Table 21. Track names and their classifications are listed in
Table 22, and illustrated by Map 10. The maintenance requirements for infrastructure will be covered in section 6.3.1.

Table 21: Trail classification used by the NPWS

Track Classification	Description	Track Classification	Description
1	Highway	9	(Park) 4WD Road
2	Sealed Major Public Road	10	(Park) 2WD Management Access
3	Sealed Minor Public Road	11	(Park)4WD Management Access
4	Unsealed Public Road	12	(Park) Walking Track
5	4WD Public Road	13	Closed Track
6	Walking Track (off Park)	14	Horse Trail
7	(Park) Sealed Road	15	Other Authorities Access
8	(Park) Unsealed Road	16	Private Access

Table 22: Location and description of fire management trails within Munmorah SRA. (Central Coast Hunter range asset track register)

Track	Section	Length	Road	Width Formed	Width Selected	Class
Birdie Beach Carpark	Loop	0.40	Sealed	15.00	15.00	7
Birdie Beach Drive	Boundary To Carpark	2.80	Sealed	10.00		7
Blue Wren Drive	Birdie Beach Drive To Pacific Highway	2.40	Sealed	8.00	6.00	7
Frazer Carpark	All	0.04	Sealed	0.02		7
Campbell Drive	Blue Wren To Frazer Intersection	3.30	Sealed	7.00	5.00	7
Flat Island Lookout	Snapper Point Road To Carpark	0.10	Gravel	5.00		8
Frazer Beach Road	Campbell Drive to Carpark	0.90	Sealed	6.00	5.00	7
Freemans Camping Area Loop Road	Freemans Entry Road to camping area	0.60	Sealed	6.00	4.00	7
Elizabeth Bay Picnic Area	Elizabeth Bay Drive To Gate	0.20	Sealed	5.00	5.00	7
Farmhouse Trail	Blue Wren Drive To Paddock	0.60	Natural	3.00		11
Moonee Beach Entry Road	Catherine Hill Bay to Gate Park Boundary	0.90	Gravel	6.00		15
Moonee Beach Trail	Snapper Point Road To Gate Moonee Beach	2.40	Natural	3.00		11
Depot Entry Road	Elizabeth Bay Drive To Park Office	0.40	Gravel	8.00		8
Old Snapper Trail	Snapper Point Road To Pacific Highway	1.00	Natural	7.00		11
Geebung Track	Campbell Drive to Wybung	2.50	Natural			8

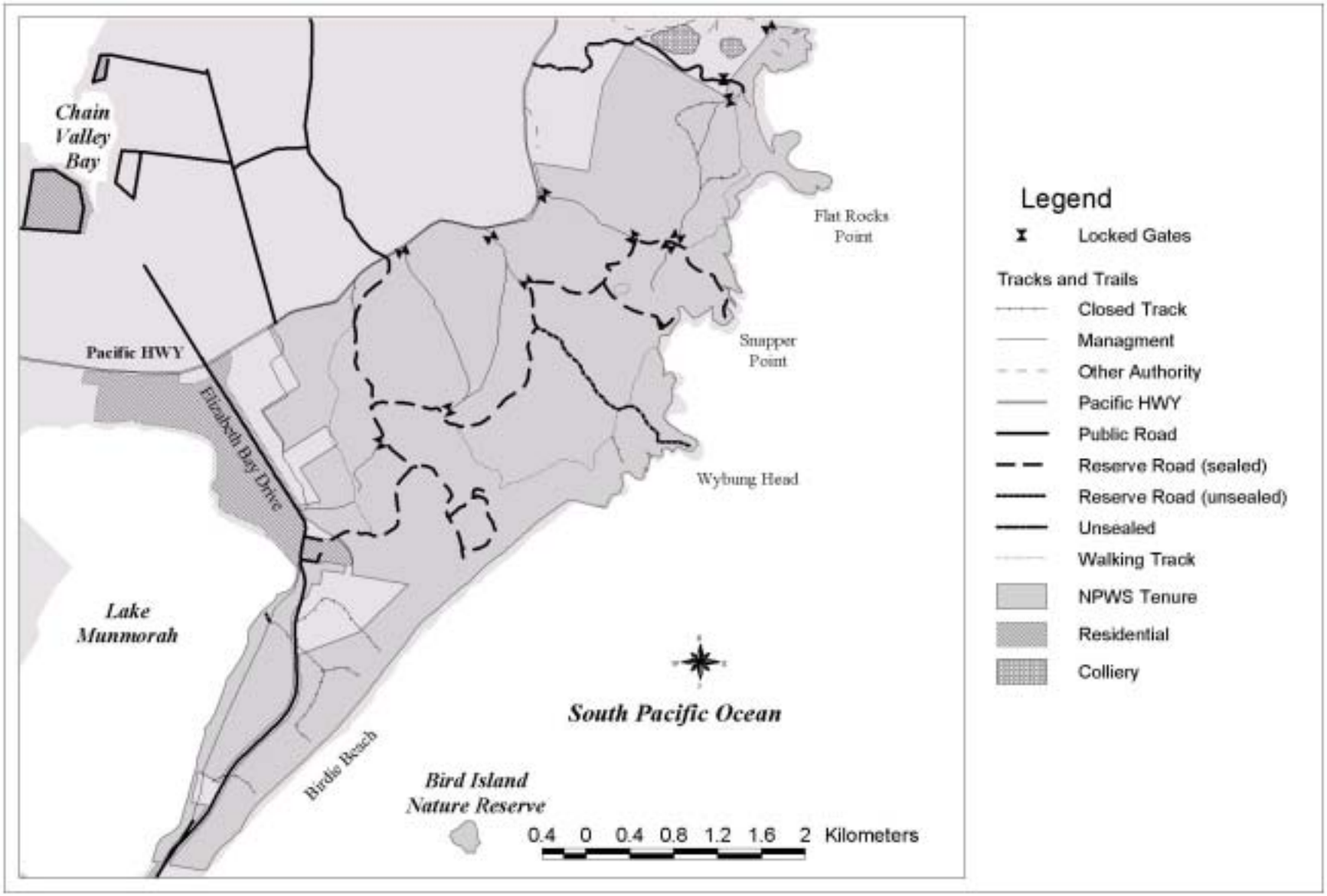
Track	Section	Length	Road	Width Formed	Width Selected	Class
Quarry Road	Campbell Drive to Pacific Highway	0.7	Natural	6.0		11
Snapper Point Road	Frazer intersection to End of seal	0.6	Sealed	7.00	5.00	7
Snapper Point Road	End Seal To End	1.20	Natural	6.00		8
Tea Tree Car Park	All	0.04	Sealed			7
Tea Tree Entry Road	Birdie Beach Drive To Carpark	0.10	Sealed	7.00	5.00	7
Water Tank Track	Snapper Point Road To Tank	0.40	Natural	2.00		11
Melaleuca Track	Birdie Drive to Blue Wren Drive	2.00	Natural	2.00		7
Birdie Creek Trail	North Entry Box To Geebung causeway	2.00	Natural	4.00		7
Wybung Head Road	Campbell Drive To Carpark	1.60	Gravel	6.00		8

5.2 Fire management utilities, equipment and facilities

Fire management utilities includes infrastructure that assists in the detection and control of wildfire. Utilities include watering points for helicopters and vehicles, communications towers, helipads and aerodromes. Detailed maps of hydrant locations are held at Wyong council.

Fire management equipment is a resource shared across the state and includes a variety of vehicles, aircraft, communication equipment, radios, Global Positioning Systems (GPS), Geographic Information Systems (GIS), predictive weather systems and ground support (eg catering).

Fire Management facilities assists in fire management operations. Facilities include Wyong Emergency Control Centre and the NPWS Central Coast Hunter Range operations room located at the Gosford office.

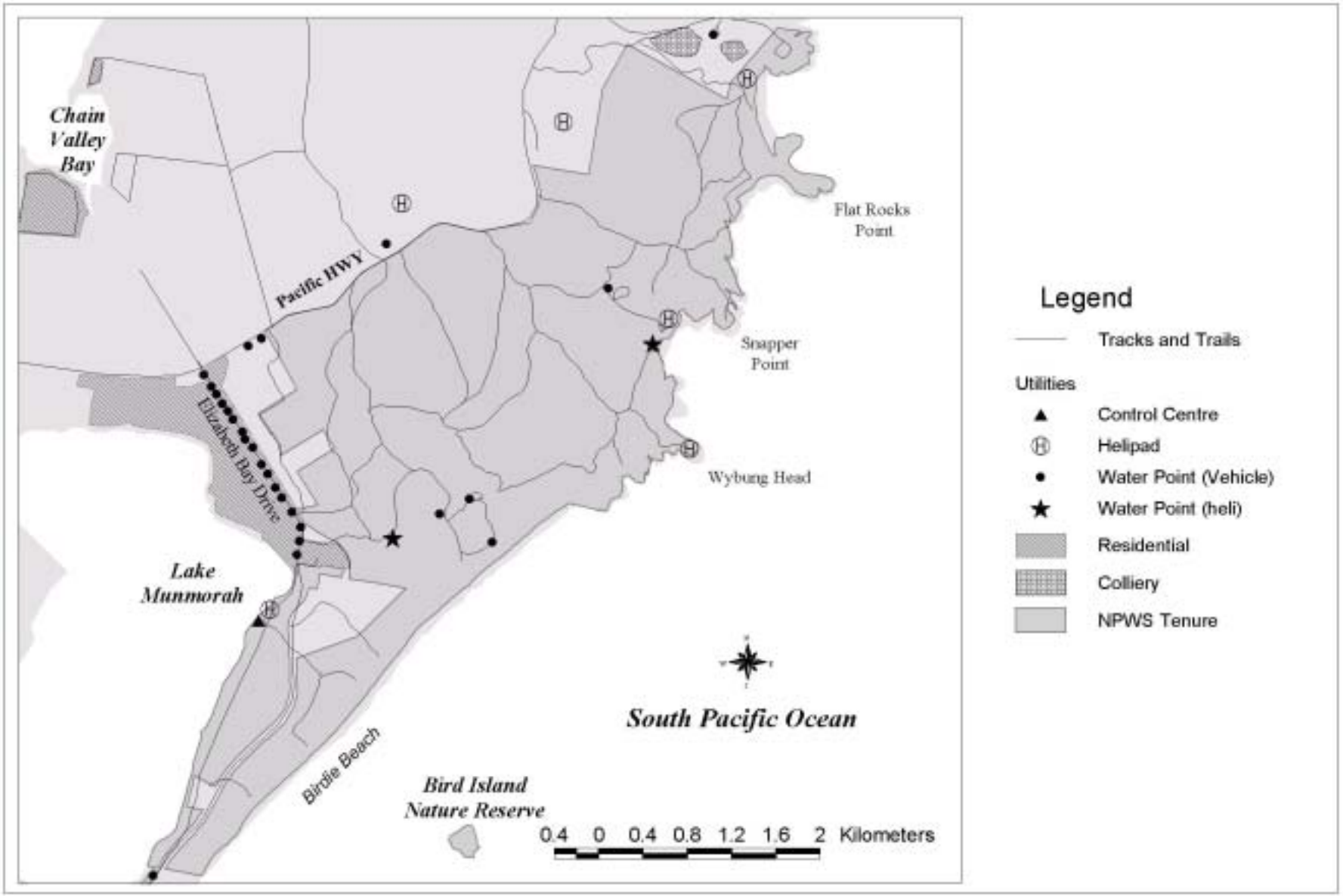


Map 10: Road and Track types within Munmorah SRA and Environs

An overview of the fire management utilities, equipment and facilities in the immediate location of Munmorah SRA is described in Table 23 and illustrated in Map 11. Other infrastructure available for this purpose is outlined in the Wyong District Bush Fire Management Committee plan of operations and the Central Coast Hunter Range Region Fire Fighting Resource List - Logistics Folder.

Table 23: Location of NPWS infrastructure for fire management

Infrastructure	Location
Incident Control System	
Control Centres	Wyong Fire Control, Charmhaven NPWS region Office, Gosford
Aviation	
Aviation Unit	Girrakool workshop, Somersby
Mast Trailer	Munmorah SRA depot
11000 litre bouywall	Girrakool workshop, Somersby
ARMS software	NPWS Region Office
Emergency Helipads	Munmorah State Conservation Area Depot Frazer Beach Birdie Beach Gravel Quarry, Campbell Drive and Pacific Highway
Boating	
4.5m aluminium punt	Munmorah State Conservation Area workshop, Elizabeth Bay
Communications	
DVS Portable repeater & generator	NPWS Region Office
9 GRN Radios	NPWS command Vehicles
45 Midland handhelds & chargers	NPWS fire crews
Earth Moving Equipment	
Bulldozer Bogy Tipper 1.5 t tipper with hiab crane Skid steer loader with backhoe attachment 4WD tractors	NPWS works depots (subject to availability)
Weather Systems	
Innovative Research Remote Weather Stations	Kariong , Kulnura, Charmhaven, Gwandalan
Manual Weather Stations	Girrakool, Mill Creek, Munmorah
Internet Weather Details	Region Office Gosford
MetFax	Region Office Gosford
Watering Points	
For helicopters	Major Water Bodies
For Vehicles	Numerous water hydrants (map held by WSC)
Fire Equipment	
2 Tankers 3000 l bulk water cart (4WD) 12 Slip-on units 7 Command Vehicles Incendiary shot gun, and injection equipment and ancillary equipment Catering Unit	NPWS works depots (various)



Map 11: Munmorah SRA Fire management Utilities

6. WORKS SCHEDULE

6.1 Biodiversity works schedule

6.1.1 Fire management research

There is a need to continue further research to provide details where major deficiencies in knowledge occur in understanding how to manage and conserve the biodiversity within the reserve. Briefly these are:

- knowledge of animal fire responses, particularly the smaller vertebrates and invertebrates, especially in relation to habitat characteristics;
- a basis for classifying the responses of animals to fire as a function of life-history attributes;
- a basis for predicting the long-term responses of animal populations to fire regimes, not just a single fire;
- a better understanding of the requirements for refuge, post-fire dispersal and recolonization of animal species which are depleted by fires in the short-term with a view to defining the thresholds of fire size and shape needed for conservation.
- Knowledge of plant species (*Tetratheca juncea*) response to fire regimes to maintain populations.

6.1.2 Fire mapping and database management

Mapped fire history of Munmorah SRA has been compiled onto a Geographic Information System which is now updated after each incident. Linked to individual mapped fires are attributes tables incorporating significant information relating to fires. This information is also recorded on 1:25000 topographic map sheets and in incident reports. The Wyong Rural Fire Service Fire Control Centre at Charmhaven also maintain records of bushfires and prescribed burns.

6.1.3 Monitoring fuel

Fuel sampling will be conducted before any fuel reduction activity using the visual assessment technique (Morris,1997). In addition twenty permanent monitoring sites have been established in Munmorah State Conservation Area to further monitor fuel loads. (Lacey, 1996).

The objectives of the fuel-sampling program will be to:

- determine the accumulation and distribution of fuel in selected fuel types according to age since fire;
- measure the effectiveness of prescription burns; and
- give areas priority for prescribed burns.

6.1.4 Monitoring fire regimes and changes to biodiversity

At this stage no fire regime monitoring program in Munmorah SRA is being undertaken. A Comprehensive Regional Assessment survey was completed in March 1997, providing valuable data towards understanding biodiversity and fire regimes. The Region will continue to encourage further research. A Region volunteer program (Pyroversity) has been established to encourage

university students to study biodiversity across the entire region. The Central Coast hunter range region staff will assist by providing staff and resources to implement the projects.

6.1.5 Biodiversity works summary table

Table 24: 5-year requirement for research and monitoring

Requirements	2000	2001	2002	2003	2004
1. development of a computer-based system for the annual updating of fire history and its effects on biodiversity thresholds and prescribed burning requirements	√				
2. accurate keeping of fire history, on-going analysis of trends shown by fire ignition point data and wildfire paths to determine further site specific fire prevention and mitigation strategies	√	√	√	√	√
3. more detailed evaluation of the fire regime and recovery plan requirements of the threatened species identified within the Park and a more complete survey, particularly of those zones that currently have no records.		√	√		
4. evaluation of the need to burn the localities where fire frequency appears to be less than the guidelines of Table 17. Specific monitoring and evaluation of the effects of short -interfire periods in the Farmhouse and Melaleuca HAMZ			√		
5. in association with Regions in the directorate, evaluate the effectiveness of *El Nino* indicators as early warning of fire season severity and preparedness requirements				√	

6.2 Operations Works Schedule

6.2.1 Prescribed burning

This works schedule specifies the program for prescribed burning for Munmorah SRA. The ability of the Service and assisting organisations to implement each planned burn will be affected by seasonal conditions, wildfire and vegetation community thresholds for fire regimes.

Individual burn plans containing the details of objectives and prescriptions will be prepared prior to each prescribed burn. The works program will be submitted to Wyong District Bush Fire Management Committee for approval.

Table 25: Prescribed burning schedule for the Munmorah asset management zones

Zone name	Zone No.	2000	2001	2002	2003	2004	Beyond the life of plan
Birdie creek Sth	S01						Burn 2005
Birdie Creek Nth	S02						Burn 2010
Frazer Park West	S03						Burn 2007
Crangan	S04			Burn			
Total hectares*				@129ha			

6.2.2 Fuel free areas

Fuel free and fuel-reduced areas will be maintained as part of each Asset Protection Zone. Fuel reduction will need to be carried out by the private land holders, NPWS and other land managers including Council. Maintenance should be in accordance with recommendations outlined by the RFS. Methods such as mowing, slashing, burning, selective shrub removal or raking may be used with any required approvals.

6.3 Infrastructure Works Schedule

6.3.1 Fire management access

Trail maintenance will be undertaken by the NPWS Plant Crew or by contractors allocated by the NPWS. The works schedule (Table 26) specifies the maintenance program for all existing fire management infrastructure and fire trails required each year. New infrastructure to be constructed at Munmorah State Conservation Area includes slash trails behind assets at Elizabeth Bay Drive.

Table 26: maintenance work for Existing infrastructure and trails.

Infrastructure, trail or area to be treated	Works to be conducted	Scheduled completion or maintenance period
Elizabeth Bay Trail	slashing	Twice a year
Farmhouse Trail	slashing	Twice a year
Freemans Camping Area	slashing/mowing	As required
Tea Tree Picnic Area	slashing/mowing	As required
Frazer Picnic/ Camping Area	mowing	When needed
Melaleuca track	slashing	Twice a year
Birdie Creek Trail	grade	Twice a year
Quarry Trail	grade	Twice a year
Big “T” Trail	grade	When needed
Moonee Trail	grade/slash	Twice a year
Campbell Drive	slash roadside	When needed
Blue Wren Drive	slash roadside	When needed
Birdie Drive	slash roadside	When needed

6.3.2 Fire management utilities equipment and facilities

Prior to the fire season, field staff will ensure that access to, and extraction from, all watering points is possible and to a standard suitable for the rapid refill of fire control vehicles. Radio communication equipment will be checked prior to the fire season and attention paid to the adequacy of portable units including batteries and chargers. The availability of fire suppression equipment kits will be checked, and shortcomings attended to prior to each fire season as part of standard operational procedures (See Table 27.

Table 27: 5-year Works Schedule

Requirements	2000	2001	2002	2003	2004
1. Utilities mapped	GIS updated	GIS updated	GIS updated	GIS updated	GIS updated
2. Utilities functionality check	annual	annual	annual	annual	annual
3. Update fire history on GIS	in March and August	in March and August	in March and August	in March and August	in March and August
4. Update fire exclusion areas on GIS	August	August	August	August	August
5. Review prescription burn requirements on GIS	February	February	February	February	February
6. Submit burning proposals to BFMC	February	February	February	February	February
7. Complete EA 1 on burning proposals	February	February	February	February	February
8. Local Bush Fire Risk plan includes this Plan	February	February	February	February	February

6.3 Arson mitigation

A school and community education program will be developed jointly with the RFS and NSW Police as a high priority. Programs will be implemented before each fire season.

Ranger staff will participate in joint agency patrols when arson activity is occurring. Assistance to RFS and Police motorbike patrols will be given when required.

Post fire investigation and reporting will focus on the cause of fires such that more detailed analysis of arson activity can be undertaken.

Prescribed burning mosaics will focus on edges of trails and roads to reduce the potential for arson related ignitions to turn into uncontrollable wildfires.

7. PLAN ADMINISTRATION

7.1 Management of works

The works programmed for the next five years will be identified in the *Central Coast Hunter Range Region Operations Plan* which lists all park management works to be conducted in the Region, and the *Wyong District Bush Fire Risk Management Plan.*

The performance of the works will be monitored by the Central Coast Hunter Range Region Manager. An annual report on the works will be completed, which will be submitted to:

- Wyong District Bush Fire Management Committee
- NPWS Regional Manager and Director Central

7.2 Environmental assessment of scheduled works

An Environmental Impact Assessment (EIA) will be prepared in consultation with Sydney Zone for fire management works scheduled in Section 6.2 (Operations Work Schedule).

The EIA will be prepared according to specifications listed in the publication *Is an EIS required? Best Practice Guidelines for Part 5 of the Environmental Planning and Assessment Act, 1979*, prepared by the NSW Department of Planning, 1995. The relevant sections of the EIA will be forwarded to Zone for determination. Where the fire management works are assessed as likely to significantly affect the environment, an EIS is required.

7.3 Plan review

This plan will be placed on public display for a period of three months for community comment.

There may be a need to review fire management strategies as further research into the management of animals and plants develops. To ensure that regular reviews are undertaken this fire plan has an operational life of five years. At the end of the operational life of this plan, the plan will be reviewed via a similar process as outlined above.

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Appendix 1: summary of Vegetation communities distribution, fuel characteristics and fire regime guidelines for Munmorah SRA.

Community Type[1]	Distribution and Status	Floristic associations/ Fauna Habitat[2]	Area of Park (ha)	Fuel Group[3]	Fire Regim[4]
Qa3 Low Forest\ Forest to Woodland (Swamp Forest/ woodland on Quaternary Alluvium)	Located along major watercourses, both SEPP 14 wetland communities. Not invaded by weeds. Community Regionally important.	• **Flora:** *Melaleuca quinquenervia* and *Casuarina glauca. Swamp Mahogany Eucalyptus robusta* occurs occasionally, which is considered the most important winter flowering habitat tree in the region. • **Fauna:** Most valuable winter habitat for; Squirrel Glider, Koala, Little & Common Bent wing Bat, Greater Broad Nosed Bat, Regent Honeyeater, Swift Parrot, Wallum Froglet, Green-thighed Frog	114.02 (7.85%)	Moderate (2)	C
Qa8 Closed Heathland/ Sedgeland (Quaternary Swamp Alluvium)	Southern SEPP 14 wetland. Not invaded by weeds.	• **Flora:** *Leptospermum sp. – Banksia sp. – Hakea sp.* Occasionally Melaleuca sp. Habitat for *lepidosperma quadrangulatum* • **Fauna:** Wallum Froglet, Green-thighed Frog	38.84 2.67%	Very High (4)	D
Qa10 Open Water Wetlands with fringing vegetation (Quaternary Alluvium)	Restricted to the eastern end of the southern SEPP 14 wetland area. Prone to invasion by a number of exotic weeds.	• **Flora:** Occasional *Melaleuca quinquenervia* and *Casuarina glauca & Eucalyptus robusta*. Reedland *Eleocharis sp. Phragmites.* • **Fauna:** Significant habitat for amphibians and water birds; Green & Golden Bell Frog, Black Bittern, Australian Bittern, Black Necked Stork, Great egret.	32.32 (2.22%)	N/A (0)	E
Qs2 Closed Heathland/ Low Woodland (high level aeolian Pleistocene sands)	Common throughout Munmorah SRA, distributed widely, however small in area therefore sensitive populations.	• **Flora:** *Angophora costata, Eucalyptus sp. Banksia sp. – Leptospermum sp.* Provides habitat for threatened species *Eucalyptus camfieldii & Caladenia tessellata,* • **Fauna:** New Holland Mouse	90.54 (6.23%)	Very High (4)	C
Qs5 Scrub to open Scrub (high level aeolian Pleistocene sands)	Restricted to Wybung Head in the northern end of Munmorah SRA. Not invaded by weeds.	• **Flora:** *Banksia integrifolia. – Hakea sp. – Leptospermum laevigatum, Melaleuca nodosa.* • **Fauna:** New Holland Mouse	1.6 (0.11%)	Very High (4)	C
Qhd2 Closed Forest (littoral Rainforest Remnant on Holocene Barrier Sands)	Confined to the 'Old Pump Station Site' on Wilfred Barrett Drive at the Southern tip of the SRA. *(outside park).*	• **Flora:** *Cupanipsis anacardioides, Ficus fraseri, Banksia integrifolia.* Contains vulnerable sp: Magenta Lilly Pilly, *Syzigium paniculatum* • **Fauna:** No significant Fauna Attributes	0.31 (0.02%)	Moderate (2)	A
Qhd4 Open Forest to Forest (Red Gum forest on Holocene Barrier Sands)	Small community near the Southern park entrance. Rare community having been reduced by sand mining activities.	• **Flora***: Angophora costata* (Red Gum) • **Fauna:** New Holland Mouse	0.15 (0.01%)	High (3)	C

Community Type[1]	Distribution and Status	Floristic associations/ Fauna Habitat[2]	Area of Park (ha)	Fuel Group[3]	Fire Regim[4]
Qhd6 Scrub to Open Scrub (on Holocene Barrier sands)	Extensively covers the Southern Peninsula section of the SRA. Some areas previously sand mined & invaded by Bitou Bush *(Chrysanthemoides spp.)*	• **Flora:** *Banksia integrifolia. – Banksia serrata. – Leptospermum laevigatum* • **Fauna:** No significant faunal attributes	276.22 (19.0%)	Very High (4)	D
Rnm2 Low Woodland to Low Open Forest (Munmorah conglomerates)	Forms a major part of Munmorah SRA. *Seldom invaded by weeds, however rabbits are obvious in some areas.*	• **Flora:** *Eucalyptus sp. Angophora Sp. Tetratheca juncea (Black - eyed Susan), Angophora inopina.* • **Fauna:** Large Footed Myotis, Squirrel Glider, New Holland Mouse. Significant numbers of tree hollows. Important for nectar feeders	544.49 (17.5%)	High (3)	C
Rnm3 Low Closed Forest (Munmorah conglomerates)	Confined to Little Beach and Moony Beach Areas within Munmorah SRA. Contains Bitou Bush	• Flora: *Eucalyptus sp*. • Fauna: Winter Flowering habitat for nectivorous fauna. No significant Faunal attributes	8.16 (0.56%)	High (3)	C
Rnm4 Dry Open to closed heathland. (Munmorah conglomerates)	Widely Distributed through the Munmorah SRA. Variable structure and composition (see Rnm2), Bitou Bush is invasive in to this community.	• **Flora:** Contains regionally significant populations of *Hakea bakeriana* • **Fauna:** Known feeding habitat for the Little Bent-wing Bat	286.64 19.7%	Very High (4)	D
Pn1 Closed grasslands \shrubland to closed Heathland	A narrow imprecisely defined strip occurs between Little Bumpy And Red Ocher Beach and on Flat Island. Floristic and structural variation due to sea salt and soil moisture. Contains Bitou Bush, and some areas have been denuded by rabbits	• **Flora: No significant flora attributes** • **Fauna:** No significant faunal attributes	4.52ha (0.31%)	Very High (4)	D
Tet/Ju *Tetratheca Juncea*	Known populations confined to Rnm2, on ridge tops.	• **Flora:** *Tetratheca juncea (Black -eyed Susan* • **Fauna:** No significant faunal attributes	2.67 0.18%	High (3)	C

***1 Community classification based on Payne, R., (1999)** ***2 Flora habitat based on Payne, R., (1999)**
***3 Fuel Group based on Conroy, (1993) see section 3.4.4** ***4 fire regime based on** Table 2

Appendix 2: Bushfire Behaviour Model for Munmorah SRA

Introduction

Fire behaviour is the manner in which a fire reacts to the variables of fuel, weather and topography (AFAC 1996). The major fires mapped over the past twenty years suggest that almost all areas of the Munmorah State Conservation Area are susceptible to fire. Various models have been developed to represent fire behaviour (eg Dovey 1994, Bradstock, et al 1998 and CSIRO 1998). Following are the elements used to produce a bush fire potential model for Munmorah SRA that incorporates slope, aspect, and fuel information. The model assumes constant weather conditions and dose not factor in past fire history

2.0 Method

Arcview/ Spatial Analyst GIS package was used to create a raster model of fire behaviour. Slope and Aspect values were derived from a 25m Digital Elevation Model (DEM). Fuel values were derived from Payne 1999 vegetation Survey of Munmorah SRA and Environs.

2.1 Slope Classes

Slope	Class	Expression	Hectares	Percent	Rank
0	Flat	([Slope1] = 0.AsGrid)	142.9	9.9	1
0 to 5	Level	(([Slope1] > 0)) and ([Slope1] < 5)	648.3	44.9	2
5 to 10	Hilly	(([Slope1] >= 5)) and ([Slope1] < 15)	565.2	39.2	3
Over 15	Steep	([Slope1] >= 15)	85.9	6.0	4

Arc View Equations:
Classes generated using map query
Each group was then reclassed and merged based on the rank
[Reclass of flat] .merge({[Reclass of level] ,[Reclass of hilly] ,[Reclass of steep]})

2.2 Aspect Classes

Aspect	Expression	Hectares	Percent	Rank
High	([Aspct1] <= 330) and ([Aspct1] > 170)	637.7	44.2	3
Moderate	([Aspct1]<= 80) and ([Aspct1] >= -1) ([Aspct1] <= 360) and ([Aspct1] > 330) ([Aspct1] <= 170) and ([Aspct1] > 145)	573.1	39.7	2
Low	([Aspct1]<= 145) and ([Aspct1] > 80)	231.4	16.0	1

Arcview equations:
Classes generated using map query
Each group was then reclassed and merged based on the rank
[Reclass of low] .merge({[Reclass of mod 3] ,[Reclass of mod 2] ,[Reclass of mod 1] ,[Reclass of high]})

2.3 Fuel Classes

Fuel	Vegetation Community
Shrubland	**Pn1** Closed Grassland/ Shrubland to Closed Heathland **Qa8** Closed Heathland sedgeland (Quaternary alluvium) **Qhd6** Scrub to Open Scrub(Holocene) **Qs5** Scrub to Open Scrub (Pleistocene) **Qs2** Closed Heathland/ Low Woodland **Rnm4** Open to Close Heathland (Munmorah Conglomerates) {**Qa11** Herbland (Quaternary alluvium)}
Woodland & Forest (dry)	**Qa3** Low Forest/ Forest to Woodland (Quaternary alluvium) **Qhd4** Open Forest**/** Forest Rnm2 **Low Woodland to Low Open Forest (** **Rnm3** Low Closed Forest **Tet/Ju** *Tetratheca juncea* {**Qa12** Low Forest/ Forest to Woodland} {**Qa2** Forest} **{**Rnm1 **Open Forest to Forest/ Tall Forest}** {**Pnm1** Woodland}
Forest (wet)	**Qhd2** Littoral Rainforest **Qa3** Low Forest/ Forest to Woodland {**Qa1** Forest} {**Qa6** Tall Riparian Forest}
Sedgeland, Reeds	**Qa10** Open water wetlands with fringing vegetation {**Qa7** Mangroves}
Cleared/Sand/open waterbodies	

*Communities in brackets are found off park.

Fuel Rank

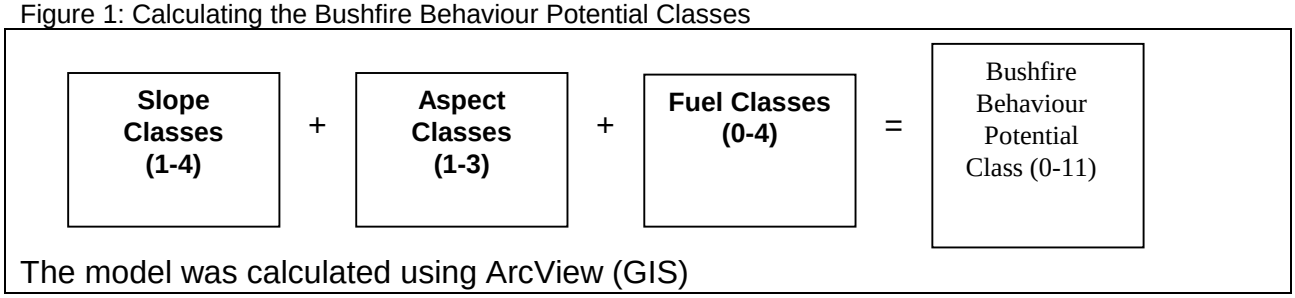
Fuel	Vegetation community	Hectares	Percent	Rank
Shrubland	Pn1, Qa8, Qhd6, Qs5, Qs2, Rnm4, {Qa11}	726.0	50.2	4
Woodland and forest (dry)	Qhd4, Rnm2, Rnm3, Tet/Ju, {Qa12, Qa2, Rnm1, Pnm1}	554.1	38.3	3
Forest (wet)	Qhd2, Qa3, {Qa1, Qa6 }	116.1	8.0	2
Sedgeland, Reeds	Qa10 Qa7	4.2	0.3	
Cleared/sand	Variable throughout	45.3	3.1	0

NB: Composite vegetation communities were classified with the highest rank value.

Bushfire Behaviour Potential

Each parameter was then added together
[aspectclass] + [slopeclass] + [Fuelclass]

Figure 1: Calculating the Bushfire Behaviour Potential Classes



The model was calculated using ArcView (GIS)

The table below provide a summary of the results derived from the from the bushfire potential model.

Class	Rank	Amount %	Location
Very High	10-11	10.71289	On steep slopes especially with a westerly aspect, such as the eastern side of
High	8 – 9	58.46154	Extensive throughout the Park, often occurring adjacent to areas in the very high class. Occur predominantly on steep slopes of any aspect.
Medium	6 – 7	24.16468	On gentle slope especially those with an easterly aspect.
Low	4 – 5	3.540628	Occurs mostly in sedgelands and reeds, on gentle slopes with an easterly aspect.
Cleared/ Mangroves	0	3.12026	Mostly located off park. Small cleared areas do occur within the park.

Appendix 3: Fire Management zone objectives, strategies and methods

Asset protection zones (APZ) of Munmorah SRA.

Asset Protection (APZ)	**Objectives**	**Strategies and Methods**	**Dominant Complex**	**Area (ha)**
Budgewoi A01	➢ Protection of the Budgewoi residential community. ➢ Provide safe rapid fire fighter access to control fires in areas immediately adjacent to properties	➢ Maintain fuel free areas behind assets adjacent to reserve (DBFS, 1991) by slashing and selective shrub removal. ➢ Maintain existing fire management slash trail access behind assets to provide safe access to firefighters, ➢ Provide a control line to begin back burning or hazard reduction. ➢ Park neighbours should be informed of Community Fireguard.	**Cleared**: 2.4ha (18.5%) **Qa3:** 0.3ha (2.4%) **Qhd6:** 9.9ha (74.8%)	13.2
NPWS Depot/ Office A02	➢ To protect NPWS office and depot facilities.	➢ Maintain fuel free areas behind assets adjacent to reserve (DBFS, 1991) by slashing and selective shrub removal	**Qa3**: 1.0ha (79.2%) **Qhd6**: 0.3 (19.8%)	1.3
Lake Munmorah A03	➢ To protect residential areas of Lake Munmorah and Elizabeth Bay. ➢ Provide safe fire fighter access to control fires in areas immediately adjacent to properties	➢ Maintain fuel free areas behind assets adjacent to reserve (DBFS, 1991) by slashing and selective shrub removal. ➢ Maintain existing fire management slash trail access behind assets along Elizabeth bay drive to provide safe access rapid access to firefighters, ➢ Provide a control line to begin back burning or hazard reduction. ➢ Park neighbours should be informed of Community Fireguard	**Cleared**: 31.3ha (66.4) **Qa3**: 4.4ha (9.4%) **Rnm2**: 8.9ha (19%) **Qhd6**: 2.3ha (4.9%) **Qa8**: 0.2ha (0.4%) **Rnm4**: 0.2ha (0.4%)	47.1
South Entrance Gate A04	➢ Minimise the risk of wildfires starting from human activity. ➢ To protect NPWS Facilities	➢ Maintain 6m fuel free areas around Asset.	**Cleared**	0.1
North Entrance Gate A05	➢ Minimise the risk of wildfires starting from human activity. ➢ To protect NPWS Facilities	➢ Maintain 6m fuel free areas around Asset.	**Cleared**	0.1

Asset Protection (APZ)	**Objectives**	**Strategies and Methods**	**Dominant Complex**	**Area (ha)**
Tee Tree Picnic Area A06	➢ Minimise the risk of wildfires starting from human activity. ➢ To protect NPWS Facilities	➢ Provide Gas Barbeques for visitors ➢ Maintain fuel free areas around facilities	**Cleared**	0.7
Birdie carpark A07	➢ To protect NPWS Facilities. ➢ Provide refuge during wildfires.	➢ Maintain existing cleared areas	**Cleared**	0.2
Freeman's Camping Area A08	➢ Minimise the risk of wildfires starting from human activity. ➢ To protect NPWS Facilities	➢ Provide Gas Barbeques for visitors ➢ Maintain fuel free areas around facilities	**Cleared**	0.8
Frazer Park Picnic Area A09	➢ Minimise the risk of wildfires starting from human activity. ➢ To protect NPWS facilities	➢ Provide Gas Barbeques for visitors ➢ Maintain fuel free areas around facilities	**Cleared**	0.2
The Palms picnic area A10	➢ Minimise the risk of wildfires starting from human activity. ➢ To protect NPWS Facilities	➢ Provide Gas Barbeques for visitors ➢ Maintain fuel free areas around facilities	**Cleared**	0.3
Frazer Park Camping Area A11	➢ Minimise the risk of wildfires starting from human activity. ➢ To protect NPWS Facilities	➢ Provide Gas Barbeques for visitors ➢ Maintain fuel free areas around facilities	**Cleared**	0.5
De Soto A12	➢ To protect coal works facilities from Wildfire.	➢ Maintain Fuel Free Zones to DBFS 1991 standards	**Cleared:** 28.3 (41.2%) **Rnm2:** 6.5ha (9.5%) **Rnm4:** 13.8ha (20%) **Pn1:** 5.6ha (8.1%) **Qhd6:** 5.7ha (8.3%)	68.6

Strategic Fire Management Zone (SFMZ)

Strategic Fire Management Zone	**Objectives**	**Strategies and Methods**	**Dominant Complex**	**Area (Ha)**
Birdie Creek South Birdie creek South S01	➢ To reduce the wildfire intensity and spotting intensity; ➢ to assist in the strategic control and containment of wildfires ➢ Ensure Fire Regime is consistent with the conservation of *Tetratheca* populations ➢ To minimise the spread of arson related fires from roads and trails	➢ suppress wildfires inconsistent with the fire prescription ➢ maintain fire trails / slash trails ➢ manage fuels by prescribed burning within the fire regime thresholds. Exclude fire until 2005. ➢ Primarily burn road side perimeters leaving centre of zone with older age class ➢ Liase with Bushfire research and threatened species unit regarding the management of *Tetratheca sp*.	**Rnm2:** 85ha (87%) **Rnm4:** 12.5ha (12.8%) **Tet/ju:** 0.3 (0.3%)	97.7
Birdie Creek North S02	➢ To reduce the wildfire intensity and spotting intensity; ➢ to assist in the strategic control and containment of wildfires started on park or West of the reserve ➢ To minimise the spread of arson related fires from roads and trails	➢ suppress wildfires inconsistent with the fire prescription Exclude fire until 2010 ➢ maintain fire trails / slash trails ➢ manage fuels by prescribed burning within the fire regime thresholds ➢ Primarily burn road side perimeters leaving centre of zone with older age class	**Rnm2:** 97.7ha (75.4%) **Rnm4:** 13.2ha (10.2%) **Qa3:** 17ha (13%) **Tet/ju:** :2.4ha (1.8%)	129.6
Frazer Park West S03	➢ To reduce the wildfire intensity and spotting intensity; ➢ to assist in the strategic control and containment of wildfires ➢ To minimise the spread of arson related fires from roads and trails	➢ suppress wildfires inconsistent with the fire prescription Exclude fire until 2007 ➢ maintain fire trails / slash trails ➢ manage fuels by prescribed burning within the fire regime thresholds Primarily burn road side perimeters leaving centre of zone with older age class	**Rnm2:** 66.5ha (91.3%) **Qa3**: 6.4ha (8.7%)	72.9
Crangan S04	➢ To reduce the wildfire intensity and spotting intensity; ➢ to assist in the strategic control and containment of wildfires ➢ To minimise the spread of arson related fires from roads and trails	➢ Consider mosaic burn depending on fire frequency in adjacent zone ➢ assess effectiveness of prescribed burn in 2002	**Cleared:** 0.9ha (2.5%) **Rnm2:** 33.9ha (95.9%) **Rnm1:** 0.3ha (0.9%)	35.3

Heritage Area Management (HAMZ) of Munmorah SRA

Heritage Area Management (HAMZ))	**Objectives**	**Strategies and Methods**	**Dominant Complex**	**Area (ha)**
Lake Munmorah H02	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime C & D ➢ Exclude fire until 2005	**Clear:** 0.9ha (1.0%) **Qa3:** 13.3.ha (13.6%) **Qhd6:** 83.2ha (85%)	47.1
Birdie H03	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime C ➢ Exclude fire until 2005	**Clear:** 9.4ha (9.1%) **Qhd6:** 93.3ha (90.6%)	102.9
Tee Tree H04	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Clear:** 10.4ha (6.7%) **Qa3:** 1.3ha (0.8%) **Qhd6**: 115ha (74%) **Qa8**: 0.1ha (0%) **Rnm4**: 24,.5 (15.8%) **Qa10**: 4.3ha (2.7%)	154.9
Melaleuca H05	➢ Maintain Fire regimes within biodiversity thresholds SEPP 14 wetland areas significant winter flowering community	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Clear**: 0.7ha (0.6%) **Qa3**: 30.9ha (25.8) **Qhd6**: 1.1.ha (0.9%) **Qa8**: 38.6ha (32.2%) **Rnm4**: 16.1ha (13.4%) **Rnm2**: 31.4ha (26.2%)	119.9
Farm House H06	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Qa3**: 9.0ha (13.6%) **Qhd6**: 0.6ha (0.9%) **Qa8**: 6.2ha (9.3%) **Rnm4**: 17.4ha (26.2%) **Rnm2**: 32.9ha (49.6%)	66.3

Heritage Area Management (HAMZ))	**Objectives**	**Strategies and Methods**	**Dominant Complex**	**Area (ha)**
Freemans H07	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Qa3**: 9.4ha (16.7%) **Qhd6**: 3.3.ha (5.8%) **Rnm4**: 12.8ha (22.7%) **Qs2**: 0.3ha (0.4%) **Rnm2**: 30.3ha (54%)	56.1
Little Birdie H08	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Cleared**: 7.4ha (10.6%) **Qa3**: 0.9ha (1.2%) **Qhd6**: 5.7ha (8.1%) **Rnm4**: 26.1ha (37.2%) **Pn1**: 1.8ha (16.8%) **Qs2**: 12.1ha (17.3%)	70.3
Geebung H09	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Qa3**: 1.4ha (1.4%) **Rnm4**: 55.6ha (52.6%) **Qs2**: 9.1ha (8.6%) **Rnm2**: 39.5ha (37.4%)	105.7
Wybung H10	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Cleared**: 0.2ha (0.8%) **Rnm4**: 0.1ha (0-5%) **Pn1**: 6.0ha (26.1%) **Qs2**: 11.9ha (52%) **Qs5**: 1.6ha (7.1%)	23.0
Frazer Park south H11	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Cleared**: 1.8ha (2.3%) **Qa3**: 8.0ha (10.4%) **Qhd6**: 1.8ha (2.4%) **Rnm4**: 4.4ha (5.8%) **Qs2**: 12.2ha (15.8%) **Rnm2**: 48.8ha (63.4%)	77.0

Heritage Area Management (HAMZ))	**Objectives**	**Strategies and Methods**	**Dominant Complex**	**Area (ha)**
Frazer Park North H12	➢ Maintain Fire regimes within biodiversity thresholds ➢ Cabbage tree palm ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Cleared**: 0.4ha (0.7%) **Qa3**: 0.9ha (1.6%) **Qhd6**: 0.1ha (0.1%) **Rnm4**: 24.4ha (44.2%) **Qs2**: 4.0ha (7.2) **Rnm2**: 25ha (45.3%)	55.2
Flat Rock H13	➢ Maintain Fire regimes within biodiversity thresholds ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Cleared**: 5.8ha (6.5%) **Qa3**: 0.6ha (0.6%) **Qhd6**: 6.8ha (7.5%) **Rnm4**: 44.6ha (49.6%) **Pn1**: 8.6ha (9.6%) **Qs2**: 10.6ha (11.7%) **Rnm2**: 2.6ha (2.9%) **Rnm3**: 8.1ha (9.0%)	90.0
Moonee H14	➢ Maintain Fire regimes within biodiversity thresholds ➢ SEPP 14 wetland areas significant winter flowering community ➢ Exclude fires for periods that enable recovery from past fire regimes ➢ To maintain scenic and recreational values ➢ To protect cultural sites.	➢ Suppress fires inconsistent with the fire regime ➢ Exclude fire until 2005	**Cleared**: 13ha (5.8%) **Qa3**: 28.7ha (12.9%) **Qhd6**: 4.9ha (2.2%) **Rnm4**: 29.8ha (13.4%) **Qs2**: 30.2ha (13.5%) **Rnm2**: 116.1ha (52.1%)	222.8

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