

**DHARAWAL NATURE RESERVE AND
DHARAWAL STATE CONSERVATION AREA
PLAN OF MANAGEMENT**

NSW National Parks and Wildlife Service

Part of the Department of Environment and Conservation (NSW)

July 2006

This plan of management was adopted by the Minister for the Environment on 26th July 2006.

Acknowledgments: This draft plan of management was prepared by staff of the Illawarra Area of the NSW National Parks and Wildlife Service.

The assistance of the Sydney Catchment Authority, Department of Primary Industries - Mineral Resources and BHP Billiton in the preparation of this plan is acknowledged.

Cover photograph: one of the many waterholes along the creeklines in Dharawal SCA by Helen Jessup, NPWS.

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ISBN 1 74122 057 2

FOREWORD

Dharawal Nature Reserve and Dharawal State Conservation Area are contiguous reserves encompassing a combined area of approximately 6,613 hectares. The reserves are situated generally between the Illawarra Escarpment and the Georges River, north-west of Wollongong. The reserves together comprise almost the entire catchment of the O'Hares and Stokes Creeks.

The area has been actively protected since dedication of the O'Hares Creek Special Area in 1927. The majority of the area of the two reserves remains a Schedule 2 Special Area and management of the reserves is undertaken jointly with the Sydney Catchment Authority.

The reserves contain significant biodiversity values. Extensive upland swamps, containing some of the highest species-rich values in the world, characterise a large proportion of the reserves. Major populations of three nationally significant flora species have been recorded and eleven species reach their southern limit of distribution in the reserves. Some twenty endangered or vulnerable fauna species have also been recorded, including the Koala and Eastern Pygmy Possum.

The area has cultural significance as the home of the Dharawal Aboriginal people and the reserves contain a high density of Aboriginal sites.

Reflecting the need to protect the high conservation significance of the reserves and compatibility with their status as a Special Area, the emphasis of management of the reserves will be scientific research, environmental monitoring and educational use, and a range of generally self-reliant recreation opportunities.

The *National Parks and Wildlife Act 1974* requires that a plan of management be prepared for each area. A draft plan of management for Dharawal Nature Reserve and Dharawal State Conservation Area was placed on public exhibition from 18 June until 1 October 2004. The exhibition of the plan attracted 29 submissions that raised 48 issues. All submissions received were carefully considered before adopting this plan of management.

This plan of management establishes the scheme of operations for Dharawal Nature Reserve and Dharawal State Conservation Area. In accordance with Section 73B of the *National Parks and Wildlife Act 1974*, this plan of management is hereby adopted.

Bob Debus

Minister for the Environment

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1. INTRODUCTION

The *National Parks and Wildlife Act 1974* requires that a plan of management be prepared for each nature reserve and state conservation area. A plan of management is a legal document outlining how an area will be managed.

Dharawal Nature Reserve (NR) and Dharawal State Conservation Area (SCA) are contiguous and share related objectives of management and management policies, whereby management of the reserves will focus on natural and cultural heritage management, self-reliant passive recreation opportunities, education and research.

Prior to its reservation, the majority of the area of the two reserves was Crown land under the care, control and management of the Sydney Water Corporation and its predecessors. It remains a Schedule Two Special Area (O'Hares Creek Special Area) under the *Sydney Water Catchment Management Act 1998* and is also subject to the *Sydney Catchment Management (General) Regulation 2000*.

Underground coal mining in the O'Hares Creek Special Area preceded reservation under the *National Parks and Wildlife Act 1974* and this use will continue as an existing interest in the state conservation area for some time. The state conservation area and nature reserve boundary reflects the existing mining and exploration interests rather than any difference in conservation values of the two reserves.

While the O'Hares Creek Special Area has not been developed for water supply purposes, the Sydney Catchment Authority retains a statutory and joint management role in the protection and management of the Special Area. This interest is protected under Section 185 of the *National Parks and Wildlife Act 1974*. This section states that nothing in this Act affects the operation of any of the provisions of the *Sydney Water Catchment Management Act 1998* in relation to lands within a nature reserve or state conservation area in so far as those provisions relate to catchment areas or special areas. The Authority's concurrence is required for the granting of any lease, license, easement, or right of way over lands within the Special Area.

Under the *Sydney Water Catchment Management Act 1998*, the Authority is required to prepare a plan of management for each Special Area. A Special Areas Strategic Plan of Management was prepared in conjunction with the National Parks and Wildlife Service (NPWS), as joint sponsor, and was adopted by the Minister for the Environment in May 2001. The Special Areas Strategic Plan of Management encompasses the O'Hares Creek Special Area, and hence the majority of Dharawal Nature Reserve and Dharawal State Conservation Area. It establishes a joint management agreement between the Authority and the NPWS, providing a formal basis for the joint management of the land.

2. MANAGEMENT CONTEXT

2.1 NATURE RESERVES AND STATE CONSERVATION AREAS IN NEW SOUTH WALES

Reserving areas for nature conservation as a general purpose was introduced into Australia with the establishment of Royal National Park in 1879, some seven years after the world's first national park was created at Yellowstone in the United States of America.

Nature reserves and state conservation areas both constitute 'Protected Areas' as defined by the International Union for the Conservation of Nature (IUCN 1994). A protected area is defined as "An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means."

Dharawal Nature Reserve equates to the IUCN Category 1a Strict Nature Reserve. That is an "Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring." Due to continued mining interests, Dharawal State Conservation Area equates to the IUCN Category VI Managed Resource Protected Area. That is an "Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs."

Under the *National Parks and Wildlife Act 1974*, the purpose of reserving land as a nature reserve is to identify, protect and conserve areas containing outstanding, unique or representative ecosystems, species, communities or natural phenomena so as to enable those areas to be managed in accordance with section 30J(2) of the Act.

Under the Act, the purpose of reserving land as a state conservation area is to identify, protect and conserve areas:

- (a) That contain significant or representative ecosystems, landforms or natural phenomena or places of cultural significance, and
- (b) That are capable of providing opportunities for sustainable visitor use and enjoyment, the sustainable use of buildings and structures or research, and
- (c) That are capable of providing opportunities for uses permitted under other provisions of the Act in such areas, including uses such as mining, permitted under section 47J;

so as to enable those areas to be managed in accordance with section 30G(2) of the Act.

Under the Act, the Minister for the Environment, in consultation with the Minister for Mineral Resources, is to undertake a review of state conservation areas every five years. Subject to the review, the Minister for the Environment has the ability to transfer any identified lands to either category of national park or nature reserve, by

publication of an order in the Gazette, with the concurrence of the Minister for Mineral Resources.

Where an existing mineral interest, such as a mine, is operating in a state conservation area, or a potential future mineral interest is likely to operate in a state conservation area, the area cannot be reclassified until the mining interest expires. Any new mining and mineral and onshore petroleum exploration and extraction within state conservation areas requires the concurrence of the Minister for the Environment.

2.2 DHARAWAL NATURE RESERVE AND STATE CONSERVATION AREA

2.2.1 Location, gazettal and regional setting

The Dharawal Nature Reserve and Dharawal State Conservation Area (then called Dharawal State Recreation Area) were reserved by notification in the Government Gazette on 4 April 1996 in accordance with the *National Parks and Wildlife Act 1974* over an area of some 341 hectares and 5,650 hectares respectively. As a result of amendments in 2001 to the National Parks and Wildlife Act, all state recreation areas became state conservation areas. Since then additions of around 6 hectares have been added to Dharawal Nature Reserve and 616 hectares have been added to Dharawal State Conservation Area, making the combined area of the reserves approximately 6,613 hectares.

The reserves are located approximately 45 km south west of Sydney and straddle the Wollondilly, Wollongong and Campbelltown local government areas (refer Figure 1). The nature reserve comprises the southeastern extent of the two reserves and is situated immediately west of the Illawarra Escarpment at Maddens Plains. The state conservation area forms the bulk of the reserves and extends north-west to Wedderburn, immediately south of Campbelltown.

Figure 1: Location of Dharawal State Conservation Area and Nature Reserve

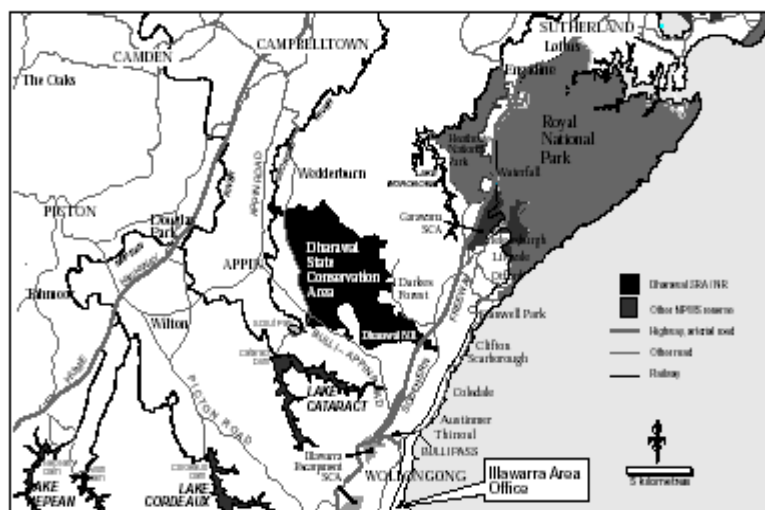


Figure 2: Dharawal State Conservation Area and Dharawal Nature Reserve

The southern and western boundaries of the reserves generally coincide with the Bulli-Appin Road and Lysaghts/Wedderburn Management Trail respectively. The north-eastern boundary is largely defined by management trails separating the reserves from Holsworthy Field Firing Range and Woronora Special Area and the Darkes Forest Road. The northern boundary of the state conservation area consists of a narrow finger of land, bisected by Lysaghts Road and extending to and connecting the state conservation area with the Georges River.

Much of the land adjacent to the western boundary is generally uncleared and is owned by the Tharawal Local Aboriginal Land Council. This boundary includes West Cliff Mine, including pit-top, coal processing and emplacement facilities at its southern extent, and rural residential and rural landuse, primarily orcharding, at its northern extent. Part of this area is set aside under a Special Lease to the NSW Sports Aircraft Club for light aircraft activities.

The bulk of the northern and southern boundaries adjoin large areas of naturally vegetated lands within the Holsworthy Field Firing Range, Woronora Special Area, and Metropolitan Special Area. The eastern boundary includes partly and fully cleared freehold land primarily characterised by rural residential development, and uncleared escarpment lands. The Southern Freeway subdivides the nature reserve.

A number of 'inholdings' are located within the physical boundary of the state conservation area but have been excluded from reservation under the *National Parks and Wildlife Act 1974*. These include some 80 hectares comprising North Cliff Mine, a 4 kilometre corridor encompassing the southern extent of the 10B and the western extent of the 10C management trails between North Cliff Mine and the Bulli-Appin Road, and an area of approximately 500 hectares extending south from the southern boundary of the state conservation area. In addition, several inholdings accommodating active and dormant clay/shale and sand quarries exist on the southern boundary.

These inholdings are residual Crown land, excluded from reservation under the *National Parks and Wildlife Act 1974*, and comprise the Dharawal Reserve (R100247) under the *Crown Lands Act 1989*. This reserve was declared in February 1994 for the purposes of environmental protection, public recreation and rural services and is administered by the Dharawal Recreation Reserve Trust.

The Sydney Water Corporation and its predecessors had statutory responsibility and primary management jurisdiction of the area since 1927 when the O'Hares Creek catchment was declared a Special Area and was proposed to be used for water supply. The Sydney Catchment Authority now retains a statutory jurisdiction and joint management role over the majority of the extent of the reserves that lie within the O'Hares Creek Special Area, under the *Sydney Water Catchment Management Act 1998*. Under this Act, the purposes of a Special Area are:

- (a) Protecting the quality of stored waters, whether intended for use for drinking or other purposes, and
- (b) Maintaining the ecological integrity of an area of land to be declared to be a special area in a manner consistent with the Authority's objectives (s.44(2) *Sydney Water Catchment Management Act 1998*).

A number of coal mining leases and authorisations to prospect currently exist within the state conservation area and will continue to operate. In order to accommodate these existing interests, the majority of the area has been reserved as a state conservation area. This state conservation area category provides for the continuation of existing mineral and petroleum exploration and extraction. The balance of the area has been reserved as nature reserve with the boundary being determined by existing mining and exploration interests rather than any difference in the conservation significance of the area.

The National Parks and Wildlife Service has had a long-standing interest in the area. In 1978, following advice from the then Metropolitan Water Sewage and Drainage Board that the catchment would not be developed for water supply purposes, the NSW Premier announced the Government's intention to establish a state recreation area over the majority of the catchment. However, this proposal did not progress following negotiations involving the National Parks and Wildlife Service, the then Department of Mineral Resources (coal resources), the then Department of Lands (clay and shale extraction leases) and the Australian Army (military training).

In 1986, the then Department of Environment and Planning recommended the area be protected as a nature reserve under the *National Parks and Wildlife Act 1974*. Subsequent to this the National Parks Association further lobbied for the establishment of a nature reserve over the area.

2.2.2 Importance of Dharawal Nature Reserve and State Conservation Area

Together, the reserves encompass almost the entire catchment of the O'Hares and Stokes Creeks. These creeks comprise the head-waters of the Georges River and are the only major watercourses on the Woronora Plateau that have not been impounded for water supply purposes.

Restrictions on development and the active protection by the Sydney Water Corporation and its predecessors of the O'Hares Creek Special Area, including restricted public access, since the late 1920s has contributed to the relatively undisturbed nature of the area. As a result, the significant biodiversity, ecosystems (both terrestrial and aquatic), Aboriginal heritage and aesthetic values have been exceptionally well conserved. This is particularly significant given the area's proximity to the large population centres of Sydney, Wollongong and Campbelltown. The active protection of the area has also contributed to restricted established uses within the area.

The Dharawal reserves are located within and form an integral part of a much larger protected area system that extends from Royal National Park in the north, Budderoo and Morton National Parks in the south and the Nattai and Blue Mountains reserve systems in the west. Together with the Special Areas, these lands combine to form one of the largest contiguous protected areas in the state providing unparalleled opportunities for the maintenance of ecological processes.

The O'Hares Creek catchment has been included on the Register of the National Estate, and the National Trust of Australia (NSW) Register as a Landscape Conservation Area. Both the Macarthur Regional Environmental Study and the

Illawarra Regional Environmental Plan identify the area as having high conservation values.

The reserves conserve exceptional upland swamps, which contain some of the highest species-richness values in the world (Keith and Myerscough, 1993) and are listed on the Directory of Important Wetlands of Australia. Over 500 plant species have been recorded in the reserves including four listed as Vulnerable on Schedule 2 of the *Threatened Species Conservation Act 1995*. Fourteen are on the list of Rare or Threatened Australian Plants (Briggs and Leigh, 1988). A further 24 species are regionally rare or threatened. Major populations of three nationally significant plant species are also conserved within the reserves and eleven species reach their southern limit of distribution in the area. One Endangered Population, the Woronora Plateau population of *Callitris endlicheri* Black Cypress Pine, is conserved within the reserves and one Endangered Ecological Community, the O'Hares Creek Shale Forest Community, is partly conserved within the reserves.

The reserves contain a diverse range of high quality habitats which conserve a significant faunal assemblage including at least twenty animal species listed as Endangered or Vulnerable under the *Threatened Species Conservation Act 1995*, such as the Broad-headed Snake, Koala and Eastern Pygmy Possum. The varied landscape ranges from gorges and waterfalls in the north-west to extensive upland swamps in the south-east.

A high density of Aboriginal sites occurs within the reserves, including exceptionally well preserved examples of drawings, stencils and paintings. The art sites represent a style within a style, differing from the rest of the Sydney Basin in some respects. The significance of the sites is enhanced due to their location in a natural, undisturbed setting, with little human interference since European settlement.

The natural and cultural heritage significance of the reserves coupled with their largely undisturbed condition close to the major population centre in Australia, provide a unique and valuable resource for research and education.

3. OBJECTIVES OF MANAGEMENT

3.1 GENERAL OBJECTIVES FOR NATURE RESERVES AND STATE CONSERVATION AREAS

The general principles of management for nature reserves in New South Wales are as follows:

- (a) The conservation of biodiversity, the maintenance of ecosystem function, the protection of geological and geomorphological features and nature phenomena;
- (b) The conservation of places, objects, features and landscapes of cultural value;
- (c) The promotion of public appreciation, enjoyment and understanding of the nature reserve's natural and cultural values; and
- (d) Provision for appropriate research and monitoring (s.30J(2) *National Parks and Wildlife Act 1974*).

The general principles of management for state conservation areas in New South Wales are:

- (a) The conservation of biodiversity, the maintenance of ecosystem function, the protection of natural phenomena and the maintenance of natural landscapes;
- (b) The conservation of places, objects and features of cultural value;
- (c) Provision for the undertaking of uses permitted under other provisions of this Act in such areas (including uses permitted under section 47J) having regard to the conservation of the natural and cultural values of the state conservation area;
- (d) Provision for sustainable visitor use and enjoyment that is compatible with the conservation of the state conservation area's natural and cultural values and with uses permitted under other provisions of this Act in such areas;
- (e) Provision for the sustainable use (including adaptive reuse) of any buildings or structures or modified natural areas having regard to the conservation of the state conservation area's natural and cultural values and with uses permitted under other provisions of this Act in such areas; and
- (f) Provision for appropriate research and monitoring (s.30G(2) *National Parks and Wildlife Act 1974*).

3.2 SPECIFIC OBJECTIVES FOR DHARAWAL NATURE RESERVE AND STATE CONSERVATION AREA

In addition to the general principles of management applicable to each reserve category, the following specific management principles apply in the management of Dharawal Nature Reserve and Dharawal State Conservation Area:

- protect and maintain the high water quality and yield of catchment streams within the reserves consistent with the established water quality and river flow interim environmental objectives;
- protect and conserve the full range of native species, populations and ecological communities in as natural state as possible;
- foster and encourage Aboriginal community involvement in the conservation and management of the natural and traditional cultural values of the reserves;
- maintain established ecological processes and promote recovery of ecosystems and processes where disturbed;
- avoid new disturbance, and minimise and rectify adverse environmental impact associated with existing interests and visitor use of the reserves;
- safeguard structural landscape features and rock exposures;
- wherever possible, progressively eliminate exploitation or occupation inimical to the purposes of reservation and principles of management; and
- utilise an adaptive approach to management based on periodic monitoring and assessment of ecological integrity and cultural heritage values and emerging scientific data.

3.3 OVERALL STRATEGY

Dharawal Nature Reserve and Dharawal State Conservation Area will be managed primarily to protect and conserve their natural and cultural heritage values in as natural a state as possible, and to protect the quality and yield of catchment streams. The facilitation of scientific research, monitoring and environmental educational use, and a range of self-reliant, environmentally sustainable recreation opportunities will be a secondary role. Intensive visitor use will not be encouraged. As such, minimal visitor facilities will be established within the reserves and general public access will provide for pedestrian and limited bicycle use.

Reflecting the high conservation significance and little disturbed nature of the two reserves, the state conservation area category will be reviewed in consultation with the Department of Primary Industries - Mineral Resources, either every five years or when existing mining interests expire. The option of re-classification to a more appropriate protected area category such as national park or nature reserve will be considered at that time.

4. POLICIES AND FRAMEWORK FOR MANAGEMENT

This chapter contains the policies and framework for the management of Dharawal Nature Reserve and Dharawal State Conservation Area together with relevant background information. Policies are summarised under the following section headings:

- natural heritage;
- cultural heritage; and
- use of the area.

Where not specifically provided for in this plan, management will be in accordance with the *National Parks and Wildlife Act 1974* and with National Parks and Wildlife Service policies.

4.1 NATURAL HERITAGE

4.1.1 Geomorphology, soils and hydrology

The reserves are located on the Woronora Plateau (also known as the Nepean Ramp) which forms part of the southern rim of the Sydney Basin. This dissected plateau dips gently north-west away from the abrupt edge formed by the Illawarra Escarpment to the Cumberland Plain. It is deeply incised by watercourses draining to the Nepean and Georges Rivers.

The plateau is dominated by the Triassic Hawkesbury Sandstone Formation, composed primarily of quartzose sandstone, with outcrops of shale and ironstone in some areas. The Hawkesbury Sandstone is underlain by the Triassic Narrabeen Sandstone Group and the Permian Illawarra Coal Measures respectively. Along the eastern edge, the plateau is characterised by deposits of swamp alluvium which have accumulated in low-relief headwater valleys, forming numerous upland swamps. The treeless swamps contrast sharply with the surrounding forest and woodland and result from the poorly aerated condition of the swamp sediment.

The reserves contain some 26 swamps, including one of the largest on the Woronora Plateau. The upland swamps have been studied by Young (1983) and are of considerable scientific importance. Dates of swamp sediment span at least 17,000 years and, combined with plant fossil evidence, suggest that there has been no significant change in the physical setting of the swamps since at least the late Pleistocene. As such, they provide an excellent record of climatic, geomorphic and biological events of the past 17,000 years after the retreat of the last ice age (Young 1983).

Many upland swamps display linear patterned ground - long furrows, which run roughly parallel to the contour. These contours are thought to be initiated by slow, near-surface flow of saturated sediment and are thought to characterise areas where the climate was formerly periglacial (Young, 1983).

The upland swamps play an important role in capturing, storing and slowly releasing water and consequently contribute to maintaining a more regular flow in the reserves' streams during dry periods. Upland swamps are very susceptible to disturbance and once disturbed can rapidly erode causing downstream sedimentation and greater irregularity of stream flow. Weirs and mining subsidence may adversely affect the continual flow of water supported by the upland swamps, and consequently the health of the aquatic ecosystem, within the reserves.

Average annual precipitation varies from 1550 mm at Maddens Plains in the east to 850 mm at Wedderburn in the west (Australian Bureau of Meteorology, unpublished data in Keith and Myerscough, 1993). The vegetation communities within the reserves reflect this gradient in rainfall with upland swamp development restricted to the east and the replacement of Eastern Gully Forest with Western Gully Forest.

The reserves encompass almost the entire catchment of O'Hares and Stokes Creeks. The catchment is little disturbed and collects water of very high quality. The estimated annual average discharge of the catchment streams is approximately 40,000 megalitres (ML) which represents some eight times that of the Upper Georges River at the confluence of the Georges River and O'Hares Creek at the Woolwash. As such, both the volume and quality of the water discharged from the reserves is significant to the health of the Georges River, a major recreational waterway in southern Sydney.

Water resources are a major feature of the reserves with over 200 km of watercourses. All waters within the O'Hares Creek Special Area, which includes Stokes and O'Hares Creeks and their tributaries, are classified as Class P (Protected Waters), and the waters impounded by O'Hares Weir are classified as Class S (Specially Protected Waters), under the *Protection of the Environment Operations Act 1997 and Regulation*. No effluent may be discharged into Class S waters and discharges of effluent into Class P waters are limited to those with a quality similar to that required as a raw source of potable water.

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Australian Water Resources Council, as part of a national water quality management strategy, have developed the Australian and New Zealand Fresh and Marine Water Quality Guidelines (ANZECC, 2000). The Guidelines provide numerical and narrative criteria to assist in managing water resources in a sustainable manner, and is based on defining the environmental values of particular water resources. Five environmental values have been identified, each requiring a certain level of water quality to be maintained. The most significant environmental value of the water resources within the reserves is the "Protection of Aquatic Ecosystems" (ANZECC, 2000).

Five weirs have been constructed on the major creeks within the state conservation area. Two on each of Stokes Creek and O'Hares Creek, and one on Maddens Creek. The weirs on Stokes and O'Hares Creeks relate to previous water supply investigations and are not currently utilised. The weirs were used to record stream flow volumes from 1943 through to the early 1990s. The Maddens Creek weir is currently used for the extraction of irrigation water for orchards at Darkes Forest.

These weirs and other barriers further downstream on the Georges River would effectively exclude certain native fish species, such as Australian Bass, from the creeks within the reserves. This, and other species likely to occur in the area, move between fresh and marine waters to complete their lifecycle. However, the deep pools created by the weirs may favour Macquarie perch, a species on the list of Australian Threatened Fish.

Soils on the plateau are generally shallow, sandy and infertile. Soil landscapes for the district have been mapped and described by Hazelton and Tille (1990) and are listed in **Appendix 1 - Soil Landscapes**. The reserves are dominated by the Lucas Heights and Hawkesbury soil landscape units. The former characterises the ridges and the latter the water courses and surrounding gorges. The Hawkesbury unit has a very high to extreme erosion hazard. The Bundeena and Maddens Plains units comprise the eastern and south-eastern portions of the reserves. Both these units have a high erosion hazard. The Maddens Plains unit has a very high erosion hazard when subjected to concentrated flows.

Immediately adjoining the reserves, orchards and hobby farms occupy shale capped ridges at Darkes Forest and Wedderburn on the eastern and western watersheds of the catchment respectively. These rural settlements were initially established in the late nineteenth century. A number of licences to extract water from streams within the reserves, which pre-date reservation of the reserves, are associated with the orchards at Darkes Forest. Currently, no volumetric limits are imposed on extractions. It is understood that at least once during drought conditions within the last ten years, extraction was not possible for some time due to a lack of flow.

A number of existing coal mining interests extend over the state conservation area and continue to extract coal from the Bulli Seam of the Permian Illawarra coal measures. Longwall mining of the coal seam occurs at some 450-500 metres underground and can result in ground subsidence of over 1 metre at the surface. This subsidence may alter surface drainage patterns adversely affecting water dependent flora and fauna, and could destabilise steep slopes and rock overhangs threatening public safety and certain Aboriginal sites such as rock shelters (Healthy Rivers Commission 2001).

Searle (1997) found a strong spatial association between abnormal cracking in creek beds and the location of underground mining workings within Dharawal State Conservation Area, suggesting that cracking may be attributable to the subsurface mining. He identified sites along parts of O'Hares, Stokes and Four Mile Creeks displaying evidence of subsidence that correlate with the location of underground workings.

Extensive cracking of the Hawkesbury Sandstone strata allows vertical seepage of water and may disrupt stream flows, particularly during periods of low flow. Upland swamps, dependent on permanent perched water tables, and aquatic habitats and species could be adversely affected by such changes in surface hydrology. A recent study by the Department of Primary Industries - Mineral Resources (DMR 2000) noted that "Cracking of deeply incised river beds due to mining is not uncommon. Loss of water may result in such cases, which may be temporary or permanent."

Policies

- Protect upland swamps from activities and disturbance other than those assessed to be essential for management and non-destructive ecological research and environmental education.
- Protect, and where possible improve, water quality and stream flow consistent with the established environmental objective of the protection of aquatic ecosystems, and with their classification as Class S (Specially Protected) or Class P (Protected) waters.
- In conjunction with the Department of Infrastructure, Planning and Natural Resources, develop a strategy to minimise water extraction that adversely affects natural flows.
- Protect, and where possible improve, the ecological condition of waterbodies and their riparian zones over the long term.
- Avoid, and where necessary minimise, new disturbance and associated soil erosion and sediment movement, particularly areas comprising the Hawkesbury and Maddens Plains Soil Landscape Units
- Stabilise and rehabilitate disturbed areas to permanently avoid, and where necessary minimise, soil erosion and sediment movement, and assist restoration to pre-disturbance condition. Priority will be given to upland swamp communities and areas comprising the Hawkesbury and Maddens Plains Soil Landscape Units.
- The siting, design, construction, maintenance, and management of use of tracks, trails and other facilities are to be in accordance with contemporary best practice soil and water management principles and procedures.
- Foster research examining subsurface mining initiated surface subsidence and the implications for surface drainage and water dependent flora and fauna, and the on-going stability of steep slopes and rock overhangs with particular regard to public safety and certain Aboriginal sites.

Actions

- Plan and implement an initial audit and subsequent periodic monitoring of the ecological integrity and condition of the upland swamp communities.
- Investigate, and where appropriate, nominate the upland swamp communities for listing under the Ramsar convention.
- Plan and implement an initial audit of disturbed areas and prioritise stabilisation and rehabilitation works.
- Periodically monitor the effectiveness of stabilisation and rehabilitation works and initiate rectification or augmentation where necessary.

- In conjunction with Sydney Catchment Authority, initiate establishment of an on-going water quality monitoring program to provide information on the condition and any changes to water quality.
- As necessary, assess and monitor proposed activities by existing interest holders to ensure thorough and complete consideration and application of contemporary best practice environmental and soil and water management principles and procedures.
- Negotiate with and encourage the Department of Infrastructure, Planning and Natural Resources to develop and apply environmental flow rules to temporarily limit, and where necessary cease, licensed water pumping from streams within the reserves during periods of low or no flow.
- Negotiate with and encourage the Department of Primary Industries - Mineral Resources and existing mining interest holders to establish a monitoring and research program examining subsurface mining related subsidence impacts on surface drainage and water dependent flora and fauna, and the stability of steep slopes and rock overhangs with particular regard to public safety and certain Aboriginal sites, and investigate and apply safeguards to avoid, and where necessary minimise, adverse effects.
- Liaise with relevant government departments to monitor any discharge from quarry sites, both active and redundant.
- Jointly, with relevant authorities, including Department of Primary Industries - Fisheries, assess the appropriateness, feasibility, and potential costs and benefits of removing weirs.

4.1.2 Native vegetation and introduced plants

The reserves encompass two of the Sydney sandstone regions defined by Pidgeon (1941), differentiated by physiography, climate and vegetation communities. The majority of the area of the reserves is within the Nepean Ramp sub-region. In the west the reserves contain the only example of the southern outlier of the Macdonald region.

The Nepean Ramp sub-region is represented within a number of existing conservation reserves on the Nepean Ramp, including Royal and Heathcote National Parks in the north and Illawarra Escarpment State Conservation Area and Macquarie Pass National Park in the east and south. Unlike the conservation reserves to the north, the reserves conserve a transition from the Coastal Region to the Macdonald Region.

The vegetation of the reserves has been mapped and described by Keith (1994). Thirteen communities have been defined and are detailed in **Appendix 2 - Vegetation Communities**. The dominant communities, Sandstone Woodland and Eastern Gully Forest, while typical of other areas of Sydney sandstone, display

considerable regional differences in species composition. Levels of species richness in the dry sclerophyll forests, dry sclerophyll woodlands and heathlands are higher than in comparable plant communities in other parts of coastal NSW (Keith and Myerscough, 1993).

Of the thirteen communities identified by Keith, the majority of the area of four of the communities is situated immediately outside the boundaries of the reserves. These are detailed in Appendix 2 and include Shale Forest at Darkes Forest, Western Gully Forest in O'Hares Creek Gorge to the north, Banksia Thicket in the Crown reserve to the south of the SCA, and Sedgeland-Heath Complex (upland swamps) at Maddens Plains.

Shale Forest is very poorly represented in the reserves. It occurs on broad ridges, with the majority, some 165 ha, located on the adjacent Woronora Special Area and freehold land at Darkes Forest. The O'Hares Creek Shale Forest Community is listed as an Endangered Ecological Community on Schedule 1 of the *Threatened Species Conservation Act 1995*. The conservation significance of a large area of the Western Gully Forest outside of the reserves to the north in the O'Hares Creek Gorge has been recognised and is currently in government ownership.

The Woronora Plateau population of *Callitris endlicheri*, Black Cypress Pine, is listed as an Endangered Population on Schedule 1 of the Threatened Species Conservation Act. The Woronora Plateau population is restricted to a single outcrop of sandstone located within the reserves. It represents the coastal limit of this species' range and is disjunct from other known populations of this species. It is also the wettest area (in terms of mean annual rainfall) from which records of this species are known (NSW Scientific Committee 2004).

The reserves contain vegetation communities that are not well sampled in existing conservation reserves on Sydney sandstone. These include the five upland swamp communities, Shale Forest, Western Gully Forest, Ironstone Woodland, Heath Woodland and Rock Pavement Heath (Keith 1994).

Other communities, such as Mallee Heath and Ironstone Heath are significant because they represent the southern distributional limits of these community types. The examples of Riparian Scrub are also important because they are generally unaffected by weed invasion, unlike many comparable stands within conservation reserves where runoff is polluted by urban and industrial development in upper catchments.

Keith (1994) recorded 510 vascular plant species in the area. Two species, *Persoonia hirsuta* and *Acacia bynoeana*, are listed as Endangered on Schedule 1 of the *Threatened Species Conservation Act 1995*, and four species are listed as Vulnerable on Schedule 2 of the Threatened Species Conservation Act, namely: *Acacia baueri* ssp. *aspera*, *Leucopogon exolasius*, *Pultenaea aristata*, and *Melaleuca deanei*. These and a further fourteen species are on the list of Rare or Threatened Australian Plants (Briggs and Leigh, 1988). Some of these species, including *Pultenaea aristata*, *Leucopogon exolasius* and *Grevillea longifolia*, have distributions that are essentially restricted to the Nepean Ramp. Maintenance of the populations of these species is important for their overall conservation.

An additional 24 species are regionally significant, being uncommon either generally or in the Sydney Region. Two of these species are represented by atypical coastal populations. The reserves are also an important biogeographic location for eleven species that reach the southern limit of their known distribution in the area. Significant plant species are detailed in **Appendix 3 - Significant Plant Species**.

The reserves contain numerous and excellent examples of upland swamp communities. Keith and Myerscough (1993) found these communities to have extremely high levels of species richness, among the highest values in the world for shrub/sedge dominated vegetation, especially in the drier soil communities. Over 140 different plant species have been recorded from the swamps. These swamps are considered exceptional because equally high levels of richness have not been encountered in similar communities elsewhere.

The swamps occur only on the Hawkesbury sandstone, which provides a surface of low permeability. Water from groundwater seepage through the joints in the sandstone and from precipitation contributes to the development and maintenance of the swamps. Deep permanent pools in the larger upland swamps are important sources of water during drought periods and at least one animal (the small yabby, *Euastacus kierensis*) is found only in the swamps (Young, 1985).

Keith and Myerscough (1993) classified the swamps into five communities. The communities reflect soil moisture status (and consequently available soil nutrient status), and from the wettest to driest habitat include: Ti-tree Thicket; Cyperoid Heath; Sedgeland; Restioid Heath; and Banksia Thicket. The relative occurrence of the three drier habitat swamp communities (Sedgeland; Restioid Heath; and Banksia Thicket) in particular, may be influenced by recurrent fires. As such, management of fire allows manipulation of the composition, diversity and structure of these swamp communities.

Fifty of the recorded plant species in the reserves are introduced, non-indigenous species. Sixteen of these are native to Australia but are considered unlikely to be indigenous to all or part of the area (Keith 1994).

An introduced species is defined in this plan as any plant or animal species not native to the reserves. Introduced species and environmental weeds within the reserves and on adjoining land are of concern because they have the potential to have detrimental effects on ecological values and can spread to and from neighbouring land. The *Noxious Weeds Act 1993* places an obligation upon public authorities to control noxious weeds on land that they occupy to the extent necessary to prevent such weeds spreading to adjoining lands.

A history of limited disturbance and restricted public access has minimised the introduction and establishment of major weed populations within the reserves. Introduced species are largely confined to disturbed areas, including abandoned quarries, the boundary with creeks draining from adjoining agricultural and urban development, around mining and other structures, and along public roads, easements and access trails. Weeds are most abundant at sites exposed to heavy vehicular traffic (such as along Bulli-Appin Road, 10B North Cliff mine access trail, Darkes Forest Road, and Lysaghts Road), and sites affected by nutrient enriched

runoff such as the boundary with adjoining agricultural and urban land and Darkes Forest and Wedderburn mine pit-top sites and public roads.

Crofton Weed (*Ageratina adenophora*) is particularly abundant along roads, creeks and drains from adjacent agricultural land and localised infestations occur south of Darkes forest mine pit-top, where treated sewage effluent was discharged by spray irrigation. This species favours damp places and is dispersed by wind-blown seed. Pine trees (*Pinus spp.*) are also spreading into bushland along Darkes Forest Road and previously cleared lands adjacent to Lysaghts Road.

Pampas grass (*Cortaderia selloana*) is scattered throughout the reserves, particularly old quarry and spoil emplacement sites, along easements and access trails, and other disturbed areas. This species is an aggressive competitor with native plants and is a prolific seeder. Seeds are often wind dispersed for large distances and can float down drainage lines. It can also develop from discarded root fragments contained in illegal rubbish dumping.

A number of other noxious or environmental weeds are beginning to establish in the vicinity of the reserves and are likely to become problems in the future if not rapidly controlled. These include: Gorse (*Ulex europaeus*); Fireweed, *Cotoneaster glycophylla*, Broad and Narrow-leaf Privet (*Ligustrum spp.*), Scotch thistle (*Cirsium vulgare*) and Cassia (*Senna pendula*).

Policies

- Native vegetation will be managed to:
 - maintain floristic and structural diversity;
 - conserve endangered, vulnerable and uncommon species, populations and ecological communities;
 - encourage regeneration of areas previously cleared or disturbed; and
 - maximise habitat values for native animal species.
- The current diversity of native plant species will be comprehensively surveyed and periodically monitored to assess any significant changes over time.
- Research into the distribution, life history, and threats to, plant species, populations and ecological communities which are endangered, vulnerable or otherwise of special interest will be encouraged.
- Any planting/revegetation within the reserves will be restricted to species appropriate to the habitat and occurring within the reserves, and only from plant material collected from the Woronora Plateau, preferably from within the reserves.
- The Service will liaise with neighbours and relevant government authorities to encourage retention of areas of native vegetation close to the reserves, with priority given to the Shale Forest community in the Darkes Forest area, the Banksia Thicket community within the Crown reserve to the south of the state conservation area, the Western Gully Forest in the Wedderburn area, and the Sedgeland-Heath Mosaic community in the Maddens Plains area.

- Priority will be given to the protection from all avoidable disturbance and rehabilitation of any non-operational disturbed areas of the Sedgeland - Heath Complex, Shale Forest, Western Gully Forest, Ironstone Woodland, Heath Woodland and Rock Pavement Heath.
- Introduced plant species will be controlled and where practicable eradicated. Priority for control will be given to those which:
 - have been declared noxious under the Noxious Weeds Act, 1993;
 - threaten the integrity of native vegetation communities;
 - may affect neighbouring land;
 - are situated along creek-lines;
 - have a high capacity for dispersal;
 - are new, isolated occurrences and where;
 - required by any adopted Threat Abatement Plan under the *Threatened Species Conservation Act 1995*.
- The development and implementation of cooperative introduced species control programs with the reserves' stakeholders (i.e., utilities, mine lease holders, Sydney Catchment Authority, RTA, Council) and neighbours will be encouraged.
- Imported soil/fill material will not be permitted unless it can be demonstrated to be weed-free sandstone geology material.
- The potential to introduce new weeds species or exacerbate existing infestations will be an important consideration in assessing the adverse environmental impacts associated with any proposed activities.
- A high priority will be given to the protection and maintenance of the currently weed-free status of the Riparian Scrub Vegetation Community.

Actions

- Assist with the preparation and implementation of threat abatement plans for key threatening processes, and recovery plans for endangered and vulnerable plant species, populations and ecological communities, in accordance with the *Threatened Species Conservation Act 1995*.
- In accordance with recognised ecological research procedures, establish permanent survey transects in each of the main native vegetation communities and undertake a regular monitoring program.
- Rehabilitate and encourage regeneration of existing disturbed areas within the reserves with priority given to disturbed areas of the Sedgeland - Heath Complex; Heath Woodland; Ironstone Woodland; and Ironstone Heath.
- Survey, map and regularly monitor noxious and environmental weed distribution within the reserves and schedule and implement annual prioritised control programs.

- Initiate liaison with relevant private landowners and government agencies to encourage the examination and progression of possible conservation options such as voluntary conservation agreements for areas of native vegetation adjoining the reserves. Priority to be directed to areas with significant vegetation communities including Shale forest, Western Gully Forest, Banksia Thicket and the Sedgeland-Heath Complex.

4.1.3 Native and introduced animals

The fauna of the reserves and immediate area has not been comprehensively surveyed. Limited studies of mammals have been undertaken by Phillips, Callaghan, Parnaby and Fitzgerald (1986), Close (1993), Cork, Margules and Braithwaite (1988), and Robinson (1985); of birds by Leishman (1993) and Mills (1992); of fish by Bishop (1997); of reptiles and frogs by Harlow and Taylor (1995) and terrestrial and aquatic fauna by the NPWS and Macarthur National Parks Association (1997).

These studies have recorded some 186 bird, 44 reptile, 25 mammal, 24 frog, 5 fish, 2 crayfish, 1 shrimp, 1 freshwater mussel and 273 invertebrate species. Twenty of these vertebrate species are of state significance and listed as endangered or vulnerable on Schedule 1 or 2 of the *Threatened Species Conservation Act 1995*. Eleven significant species were recorded several decades ago and have not been sighted for many years. It is probable that these species may no longer occur in the area. Significant animal species are listed in **Table 1**, below.

TABLE 1 - SIGNIFICANT ANIMAL SPECIES

(E= Endangered, V= Vulnerable in accordance with Schedules 1 & 2 respectively of the Threatened Species Conservation Act)

Species of State significance known to currently exist within the reserves*	Species of State significance previously recorded from the area*
Broad-headed Snake (E)	Spotted-tailed Quoll (V)
Regent Honeyeater (E)	Brush-tailed Rock Wallaby (V)
Eastern Bristlebird (E)	Long-nosed Potoroo (V)
Koala (V)	Squirrel Glider (V)
Eastern Little Mastiff Bat (V)	Parma Wallaby (V)
Large-footed Mouse-eared Bat (V)	Southern Brown Bandicoot (V)
Large Bent-wing Bat (V)	Stuttering Frog (E)
Greater Broad-nosed Bat (V)	Giant Barred Frog (V)
Red-Crowned Toadlet (V)	Turquoise Parrot (V)
Grey-headed Flying Fox (V)	Sooty Owl (V)
Giant Burrowing Frog (V)	Masked Owl (V)
Powerful Owl (V)	Barking Owl (V)
Glossy Black Cockatoo (V)	Large Eared Pied Bat (V)
Heath Monitor (V)	Golden Tipped Bat (V)
Brown Treecreeper (V)	Yellow-bellied Sheath Tail Bat (V)
Ground Parrot (V)	
Littlejohns Tree Frog (V)	
Eastern False Pipistrelle (V)	
Eastern Pygmy-possum (V)	
Yellow-bellied glider (V)	

* *N.B.* The list of significant animal species above is not exhaustive, is only current at the time this plan was prepared, and should therefore not be relied upon as the most up-to-date listing.

Other species considered rare or regionally uncommon but present in the area include the Platypus, Dusky Antechinus, Greater Glider, Wombat, Eastern Grey Kangaroo, Wallaroo, Red-necked Pademelon, Red-necked Wallaby and Peregrine Falcon.

The reserves provide a diverse range of high quality habitats that have been protected for many years and are little disturbed. The faunal conservation significance of the reserves are complemented by the extensive area of adjoining protected natural areas, which facilitate wildlife exchange and movement over an exceptionally large area.

The largest and most significant population of Koalas on the southern outskirts of Sydney occurs at Wedderburn, within and immediately adjoining the state conservation area. The core breeding habitat is located along the creeklines in the O'Hares Creek / Georges River area from the junction of Stokes creek to north of Kentlyn. Preferred Koala feed/habitat trees in the area include *Eucalyptus punctata*, *E. haemastoma* and also *E. oblonga* and *E. agglomerata*. These species are most common within the Western Gully Forest vegetation community, which is restricted to the northern-most section of the state conservation area and land beyond its boundary to the north. According to Close (1993) the colony is capable of expanding into other presently unoccupied but suitable areas within the district provided bushland corridors are retained. Research has indicated that there is a constant supply of new animals into the area and that some are moving considerable distances through the region.

Wildfires pose a significant threat to the colony. Careful fire management and the maintenance of the vegetated connection between the state conservation area and the core breeding habitat immediately adjoining the north of the state conservation area will be essential for the long-term well-being of the population.

The reserves are also significant in the diversity and richness of their frog and reptile populations, including a number of nationally significant species. The Broad-headed snake is restricted to rock-on-rock habitat where thin sheets of exfoliated rock occur in open sandstone ridge country. Extensive, undisturbed areas of this habitat occur on undulating sandstone ridges and plateau tops in the reserves. The Broad-headed snake's major food species, the Velvet Gecko, is also abundant in the reserves.

Areas of exfoliating rock habitat elsewhere in the Sydney region have been significantly reduced due to bush-rock collection for garden use. As such, bushrock collection has been listed as a Key Threatening Process on Schedule 3 of the *Threatened Species Conservation Act 1995*. Conservation of this rock habitat is crucial for the survival of the broad-headed snake.

The Giant Burrowing Frog is usually associated with sandstone ridges that support heath vegetation. This species occurs widely, though in low numbers, throughout the reserves. The Great Barred Frog prefers rainforest and wet sclerophyll forest and

only occurs in remote parts of the area. The Red-crowned Toadlet occurs in small, widely scattered colonies beside temporary creeks, gutters and soaks on Hawkesbury Sandstone throughout the reserves.

The creeks contain a diverse freshwater fish fauna and have been identified as potential habitat for the Macquarie Perch. This species is on the list of Australian Threatened Fish and is protected under the *Fisheries Management (General) Regulation 1995*. Other aquatic species recorded include Cox's gudgeon, Long-finned eel, Climbing galaxia, and the Sydney and Spiny crayfish. The Climbing galaxia is a small nocturnal fish linked back to Gondwana, a time when the continents on the earth divided approximately 60-120 million years ago.

Part of the 10B and 10C management trails have been formed using coal wash waste material. Stockpiles of this material are stored within the state conservation area next to the 10B management trail. The coal wash is readily transported in runoff during rainfall and accumulates in drainage lines, ephemeral pools, and creeks within the reserves and produces an alkaline leachate. The alkaline conditions created by the coal wash may adversely affect both flora and fauna in areas where it has been used, which include good breeding grounds for many frog species, including the Vulnerable Red Crowned Toadlet.

A number of introduced animal species have been recorded within and adjoining the reserves and include: feral dogs and cats; rabbits; foxes; black rat, deer and mosquito fish. The extensive network of existing trails facilitates the easy movement of introduced animals throughout the reserves. Foxes and feral dogs pose a particular threat to a number of native species, especially Koalas moving through the area. Bats entering and leaving roosting sites are susceptible to predation from feral cats.

The plague minnow, otherwise known as the introduced mosquito fish, has previously been recorded in the down-stream tributaries of the Georges River. The distribution and impact of this species upon other fish, invertebrates and frogs in the creeks within the reserves is unknown.

Predation by feral cats, foxes and mosquito fish, and competition, alteration of vegetation structure and composition and land degradation by the feral European rabbit have both been listed under the *Threatened Species Conservation Act 1995* as a key threatening processes.

Policies

- Native animal species and their distribution will be monitored and recorded for use in decision-support systems. Priority will be given to threatened species and other regionally significant species.
- The current diversity and abundance of native animal species will be comprehensively surveyed and monitored to assess any significant changes over time.
- The Service will encourage the complementary management of neighbouring naturally vegetated lands to optimise species conservation and facilitate wildlife movement, especially Holsworthy Field Firing Range, Woronora and Metropolitan Special Areas, and on private freehold land on the western boundary, and in the Darkes Forest and Wedderburn areas.
- The Service will foster and assist research into the distribution, habitat requirements, and threats to animal species, populations and ecological communities which are endangered, vulnerable or otherwise of special interest.
- The habitat of significant species, including hollow-bearing trees and areas of exfoliating rock, will be protected from all avoidable disturbance.
- Non-native animal species of conservation concern will be controlled and where practicable eradicated. Priority for control will be determined by assessment of their existing or potential:
 - threat to biodiversity and/or endangered and vulnerable species, populations and communities;
 - effect on neighbouring land;
 - effect on revegetation/rehabilitation works;
 - threat to soil stability;
 - capacity for dispersal and;
 - by any adopted Threat Abatement Plan under the *Threatened Species Conservation Act 1995*.
- Cooperative non-native animal species control programs with the Rural Lands Protection Board, the reserves' stakeholders (i.e., utilities, mine lease holders, Sydney Catchment Authority, etc) and neighbours will be encouraged.
- Non-native animal control programs will utilise techniques which avoid and minimise adverse environmental impact, particularly effects on non-target species.
- An introduced animal species control plan will be prepared for the reserves setting out techniques and annual programs, including monitoring of effectiveness.
- The use of coal wash waste will not be permitted within the reserves.

Actions

- Assist with the preparation and implementation of threat abatement plans for key threatening processes, and recovery plans for endangered and vulnerable species, populations and ecological communities, in accordance with the *Threatened Species Conservation Act 1995*
- Design and implement periodic biodiversity surveys.
- Liaise with relevant neighbours to foster and assist biodiversity conservation with priority given to areas likely to support threatened species.
- Liaise with the holder of the Northcliff Mine existing interest and the Dharawal Recreation Reserve Trust to discontinue the use of coal wash on the 10B and 10C management trails and to replace it with alternative material less likely to contaminate surrounding water courses and impact on flora and fauna species.
- Prepare and implement annual introduced animal control programs with priority given to fox, feral dog and cat control in the northern section of the state conservation area adjacent to the core koala habitat, and to deer control.

4.1.4 Fire management

Fire is a natural feature of the environment of Dharawal Nature Reserve and Dharawal State Conservation Area and is essential to the survival of some plant species and communities. However, frequent or regular fire can also cause the loss of particular plant and animal species and communities. As such, “high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition” has been listed as a Key Threatening Process on Schedule 3 of the *Threatened Species Conservation Act 1995*. Fire can also damage some types of Aboriginal sites, historic sites, visitor and management facilities and threaten utility and mining assets and neighbouring land.

Management of fire in the reserves is an important and complex issue. Management must aim to achieve both long term conservation of natural communities and on-going protection of life and property within and adjacent to the reserves.

The reserves are located within a region where, based on the on-set and duration of moisture stress, fire activity generally occurs from December through to the end of February (Walker, 1979).

Fire history

The pre-European fire history of the reserves is not known. Traditional fire practices by Aborigines in NSW have not been well researched and are therefore poorly understood. However, Aborigines are likely to have utilised burning regimes which encouraged grazing plants in areas in which they hunted game and kept corridors open in lands they travelled through. From research conducted elsewhere, it appears likely that the frequency and intensity of fire now is different from traditional Aboriginal burning practices.

Fire history records covering the reserves have been maintained by the Sydney Water Corporation and its predecessors since the 1950's, and subsequently to date by the Sydney Catchment Authority and National Parks and Wildlife Service. In this period, four major wildfires in 1965/66, 1968/69, 1990/91 and 2001/02 each burnt the majority of the area of the reserves. At least three of these wildfires were part of larger fires that commenced outside the reserves.

Most other unplanned wildfires in the reserves have been restricted to less than 50 ha of burnt area. The limited area of most wildfires may be due in part to the rapid detection and suppression of fire events made possible by a network of fire towers and the close proximity of the reserves to fire-fighting resources.

The Letter Box fire tower is located on the southern boundary of the reserves, opposite the 10B management trail. This tower is staffed for most of each fire season and provides good visibility over most of the reserves. Observations from this and the Avon and Narrow Neck towers allows the rapid and accurate locating of smoke-sightings in the region.

The fire history records indicate that arson is the primary source of bushfire ignition (almost one third of all recorded fires) followed by the accidental, and in some cases negligent, escape of picnickers and bushwalkers camp fires. A number of fires have also resulted from Army operations both within the area of the reserves and from fires initially started in the adjoining Holsworthy Military Area.

The main location of wildfire ignition is immediately adjacent to roads bounding the reserves, particularly Bulli-Appin, Darkes Forest and Lysaghts Roads. This latter road forms the western boundary of the state conservation area and is a sealed private road established to provide access to West Cliff Mine from the Bulli-Appin Road. The road continues northward beyond the mine, on Crown land, as an unsealed management trail, linking up with a sealed public road at Wedderburn. Prior to access to this trail being controlled, it was subject to moderate public use. Due to its relative remoteness, it has been used extensively for dumping stolen vehicles and waste material. Dumped vehicles were often set alight and caused the majority of wildfires in the area.

The unsealed section of the Lysaghts Road between the southern access road into the NSW Sports Aircraft Club south to the sealed section terminating at West Cliff Mine was closed to general public access by notice in Government Gazette of 26 October 2001. The northward extension of this unsealed road is also closed to general public access and now licensed to and managed by the NSW Sports Aircraft Club. The recent closure of this road is expected to significantly reduce the previously high levels of waste dumping and arson occurring along this boundary of the state conservation area.

The upland swamps are a particularly flammable vegetation community and an important location for fire ignition. High traffic volume public roads bisect or pass close to the major upland swamp communities increasing the likelihood of accidental or intentional bushfire ignition.

Ecological requirements

Fire frequency, intensity and season of occurrence (fire regime) are major factors influencing the distribution and composition of plant and animal communities. A variety of fire regimes is needed in order to conserve floristic diversity and provide diversity of habitats for animals. Fire management aims to maintain this diversity by restricting planned and, if possible, unplanned fires to only a part of the distribution of a vegetation type within the reserves at any one time. This approach will ultimately result in a mosaic of age classes for each of the vegetation types of the reserves.

Bradstock, Keith and Auld (1995) have determined a number of general principles for fire regimes in coastal heaths and associated shrublands and woodlands. These principles would also have relevance to the vegetation communities within the reserves.

A decline in the population of plant species can be expected when:

- there are more than two consecutive fires less than 6-8 years apart (fire sensitive shrubs decline);
- intervals between fires exceed 30 years (heaths and shrubs with short-lived individuals and seed-banks decline);
- three or more consecutive fires occur at intervals of 15-30 years (sub-dominant herbs and shrubs decline); and
- more than two consecutive fires occur which consume less than 8-10 tonnes per hectare of fuel (species with heat-stimulated soil seedbanks decline) (Bradstock, Keith and Auld, 1995).

Keith and Myerscough (1993) found that the species richness of the upland swamp communities in the reserves was inversely related to the resource gradient. They also found that species richness may be enhanced by fire, which for a short time reduces competition for resources, particularly light, promoting the establishment of species that may be competitively excluded in an older community.

According to Stricker and Wall (undated) directional changes in the vegetation of the upland swamps are driven by the fire regime and the maintenance of high species richness is dependent on fire disturbance. However, knowledge of the fire responses of individual species is poor, particularly in the wetter habitats. Keith (1991) proposed a model to provide a framework for fire management as a conservation tool for upland swamps and he emphasised that the scale of fire mosaics is crucial in the survival of particular species, but that mosaic patterns are difficult to maintain due to problems of controlling wildfires. Keith's model predicts that in the short-term, species diversity may be maintained by fires at "intermediate intervals (ca. 12-25 year intervals)". The model also predicts that occasional and short fire intervals are necessary to maintain full diversity in wet and dry habitats respectively and that the replacement of eucalypt woodland by upland swamp vegetation may be hastened by frequent fires across their boundary.

The response to fire of endangered and vulnerable plants in the reserves is not well known. However, many rare plants tend to be fire sensitive and management should

aim, as far as possible, to minimise the known detrimental effects of fire in areas with known or predicted populations of fire-sensitive endangered or vulnerable species.

Auld, Bradstock & Keith (1991) and Bradstock, Auld & Keith (1991) have examined some aspects of the effect of fire on a number of significant plant species in the Sydney Region, some of which occur within the reserves. They found *Darwinia diminuta* was killed by fire and relied on seed germination after a fire to maintain populations. Post fire germination levels were found to be affected by soil heating during a fire, with high temperatures (more intense fires) required to break seed dormancy. Regular, low intensity fires lead to a decline in populations of this species.

For *Eucalyptus luehmanniana* it was found that it takes between 5-10 years for seeds to become available on plants after a fire. Regular burning at intervals less than 5-10 years will potentially inhibit flowering and fruiting. Care is needed to exclude this species from areas subject to high frequency burning.

Whelan (1994) has identified three characteristics of fire regimes of importance to native animals. These are fire frequency, season and extent/patchiness. Frequent fires in most vegetation types will reduce the complexity of the understorey with a corresponding reduction in habitat value for most species, an increase in exposure to the elements and predation, and potential loss of food source. Fires occurring during the breeding season could adversely affect some species through direct mortality, preventing breeding, or change/remove habitat and food, while providing other species with greater numbers of exposed prey. Burns of limited or patchy extent will assist to support a full complement of animals as a range of post-fire age-classes of vegetation is required. As areas regenerate following fires, different species of small mammals find the habitat suitable. Areas not burnt also act as refuges for wildlife to congregate in, providing shelter and food for survivors that are crucial to the re-colonisation of burnt areas over time.

Strategies and cooperative arrangements

The Service is a fire authority under the Rural Fires Act 1997 and is responsible for suppressing wildfires on the reserves and ensuring that they do not escape onto neighbouring lands. An important part of the Service's fire management is participation in district bush fire committees. The reserves straddle the boundaries of the Wollondilly; Campbelltown; and Wollongong bushfire management districts.

A variety of fire management strategies will be developed for the reserves, including perimeter and management trails, fuel reduction, establishment of asset protection zones, bushfire detection and cooperative arrangements. Some, or at times all, of these will be applied where appropriate to best protect life, property, and natural and cultural assets within and adjacent to the reserves. In particular, close to boundary areas, fuel reduction programs will be implemented in cooperation with neighbours. A fire management strategy will be prepared which details fire management strategies and programs in the reserves.

An extensive management trail network of over 70km already exists within the reserves and this is supplemented by perimeter trails or public roads on all boundaries except some areas of Darkes Forest and a small section on the northern boundary adjoining Holsworthy Military Area.

Policies

- Fire will be managed in accordance with a Fire Management Strategy and the principles below to ensure (not in any priority):
 - protection of human life and property within and adjacent to the reserves;
 - conservation of endangered, vulnerable and biogeographically significant native plant and animal species, populations and ecological communities and their habitat;
 - maintenance of native plant and animal species, populations and ecological communities through the provision of fire regimes compatible with their conservation;
 - protection of Aboriginal sites and areas, historic places, scenic landscapes, water quality and visitor destinations and management assets.

- Prescribed fire may be used to achieve a variety of fire regimes in appropriate vegetation types, particularly upland swamps (Sedgeland - Heath Complex community).

- Designated management trails will be classified according to their strategic use and capability and maintained accordingly.

- Prescribed burning may be undertaken to produce habitat suitable for species with specific requirements. Prior to any such burning an assessment of vegetation characteristics and the status of key species in the area will be undertaken to determine the need for fire and its likely ecological effect.

- On-going review will be undertaken of the impact of prescribed burning on vegetation composition and structure. Programs will be modified where appropriate to minimise adverse impacts.

- The use of heavy machinery for fire suppression in the reserves is generally not appropriate. Where such use is unavoidable, machinery will be managed to avoid populations and ecological communities of endangered and vulnerable species, upland swamps, Aboriginal sites and historic places.

- Areas disturbed by fire suppression operations, such as construction of temporary trails, helipads and fire control lines, will be stabilised to prevent soil erosion prior to the removal of heavy equipment from the area, and rehabilitated within twelve months of the fire event. Any uncontrolled access points into the reserves or new trails or control lines constructed for specific fire suppression operations will be effectively controlled to prevent unauthorised vehicle access on cessation of suppression operations and prior to the removal of heavy equipment from area.

- Records and maps including ignition date, ignition source, whether planned or unplanned, extent, and average intensity will be maintained for all fires as they occur.

- The Service will encourage research into the ecological effects of fire in the reserves, particularly the fire response of endangered, vulnerable and biogeographically significant species, populations and ecological communities and the requirements of upland swamp communities.
- The Service will maintain close contact and cooperation with volunteer bush fire brigades and executive officers, neighbouring private property owners and relevant government agencies including the Sydney Catchment Authority and the Australian Army. The Service will actively participate on the Wollondilly, Campbelltown and Wollongong Bush Fire Management Committees.
- As far as possible fuel management will be carried out in cooperation with neighbours for mutual protection.
- Land use planning and development authorities and private developers will be encouraged to incorporate boundary fire breaks and other fuel reduction measures in any development adjacent, or in proximity, to the reserves.
- All prescribed burning proposals will be subject to prior environmental assessment.
- The reserves may be closed to the public and holders of existing interests during and for a period following wildfire events, and during periods of extreme fire danger.

Actions

- A fire management strategy will be prepared for the reserves detailing life, property and natural and cultural resource protection principles, strategies and programs including the location, nature and scale of asset protection zones and strategic management zones, cooperative bushfire management arrangements and management trail network requirements.
- Fuel reduction programs will be prepared and implemented annually and may include prescribed burning, fuel reduced zones, and trail maintenance requirements in accordance with the policies outlined above and in the fire management strategy.
- All existing vehicle trails will be assessed in terms of their strategic benefits, environmental impact and sustainable use capability. Non-designated trails will be rehabilitated. Designated management trails will be categorised into a number of use categories and upgraded and/or maintained consistent with the relevant categorisation.
- Plan and implement regular reserves bushfire management familiarisation exercises with the Wollongong, Wollondilly and Campbelltown Rural Fire Service District personnel.
- Maintain the fence and gates along the western boundary of the state conservation area with Lysaghts Road and, where necessary, construct and

maintain appropriate fencing on other boundaries of the reserves to ensure the continued reduction of previous high levels of arson, environmental degradation and other illegal activities undertaken in the reserves.

- Liaise with relevant local government, the Rural Fire Service and Department of Infrastructure, Planning and Natural Resources with regard to new or intensification of existing developments adjacent, or in close proximity, to the reserves to ensure that bushfire management and other matters relevant to the conservation and management of the reserves are fully addressed.
- A reserve fire management strategy base map detailing water draughting points, trails, helipads and other issues relevant for bushfire management will be prepared and regularly maintained.

4.2 CULTURAL HERITAGE

Cultural heritage includes both indigenous and non-indigenous history. It comprises important components of the environment that may have aesthetic, historic, scientific, and social significance to past, present and future generations.

4.2.1 Aboriginal Heritage

The Dharawal reserves are located within an area that was occupied by the Dharawal Aboriginal people. Their territory covered an area from Botany Bay south to the Shoalhaven River and inland to Camden. Large Aboriginal populations were recorded as occurring in the Georges River - Liverpool area and were called the Cowpastures tribe by Europeans. From archaeological evidence, Aboriginal occupation of the area has been estimated to extend back at least 15,000 years.

Early European contact with local Aborigines in the region is poorly documented. Most tribal living by the local Aborigines in the region probably ceased in the 1840's as European settlement expanded and disease and warfare took its toll. Tribal living within the area of the reserves may have continued for somewhat longer as the sandstone country, which characterises the reserves, was not suitable for agriculture.

A number of important sites of contact between the Aborigines and Europeans occur in the region near the reserves including the Cataract Gorge Massacre site and Bull Cave, near Campbelltown. The former site relates to a punitive expedition by Europeans near Appin in 1816 resulting in the death of 14 Aboriginal people.

The reserves fall within the Tharawal Local Aboriginal Land Council area and the Illawarra Local Aboriginal Land Council area, and are considered to be a culturally significant area to Aboriginal people. The reserves contain symbols of their occupation of land and important evidence of traditional culture. Archaeological sites are important to Aboriginal communities, as they are a testament to their culture's great antiquity and survival. Aboriginal people may also have traditional spiritual links with an area and hold knowledge that is important to nature conservation.

The Tharawal Local Aboriginal Land Council were recently granted freehold title to much of the land adjoining the western boundary and a small portion adjoining the northern boundary of the state conservation area. A claim over an adjoining portion (Portion 10 Parish of Wedderburn) was unsuccessful and this portion is now part of the state conservation area.

The Woronora plateau has been relatively well covered by systematic archaeological survey, primarily by the Illawarra Prehistory Group. These surveys have identified over 1000 Aboriginal sites. Over twenty of these, including three within the state conservation area (Stokes Creek, Cobbong Creek, and O'Sheas Crossing areas), have been assessed as having national significance and are included on the Register of the National Estate. The estimated potential resource of the Woronora Plateau is estimated to be over 15,000 sites.

The geology of the plateau has strongly influenced the distribution and types of Aboriginal sites. The Hawkesbury sandstone has weathered forming numerous rock shelters and large, flat expanses favoured for art, rock engravings, and for stone axe grinding grooves. The art sites on the plateau represent a style within a style, differing from the rest of the Sydney basin in some respects. These art sites display a wide range of motif-type and are technically complex compared to sites to the north of the Georges River.

The reserves contain a high density of archaeological sites. Some 236 sites have been identified to date, primarily shelters (sandstone overhangs) containing art, and axe grinding grooves. Other sites recorded include shelters containing deposits, open camp sites, rock engravings and a water hole/well. Sites are particularly concentrated at the heads of creeks in areas of swamp development and the gullies below the swamps.

Some sandstone overhangs contain exceptionally well-preserved examples of drawings, stencils and paintings in black charcoal, white clay or red, yellow or orange ochre. They contain unique and atypical motifs which are restricted to the Woronora Plateau and represent excellent examples of rock art of the district. Surveys have indicated a transition in sites from predominantly rock engraving art in the east to charcoal and clay drawings in the west.

In many cases the overhangs also contain a considerable depth of deposit which may contain dateable material, providing valuable information on cultural change within the tribes inhabiting the plateau. Important environmental changes on the Plateau may also be recorded from these deposits, making them of geomorphological interest.

The Aboriginal sites in the reserves are particularly significant as they are located in a natural, generally undisturbed setting with little human interference since European settlement. The rugged nature of the reserves coupled with a history of restricted public access has protected most sites from European additions or graffiti. Where graffiti damage has occurred it is generally limited to sites close to vehicle trails. Some of the Cobbong Creek area sites are thought to be subject to accelerated deterioration associated with changed water runoff due to the establishment of a vehicle trail immediately upslope of the sites.

A major rock engraving site exists in the vicinity of the reserve boundary and is known as the "Hunting Scene". It consists of two separate groups of petroglyph figures: a large kangaroo associated with six human figures and six foot prints and close by two similar human figures. The site is one of the largest rock engravings in the district and its composition is unique, and is a very significant Aboriginal site.

The nature and location of many Aboriginal sites make them susceptible to damage associated with certain activities currently or likely be undertaken or to occur in the reserves. Greatest threats are associated with mining subsidence, and surface mining and utility development and maintenance activities, and vandalism associated with increased public access.

While the Service presently has legal responsibility for the protection of Aboriginal sites, it acknowledges the right of Aboriginal people to make decisions about their own heritage. It is a Service policy that Aboriginal communities be consulted about decisions regarding the management of Aboriginal sites and related issues and how the Aboriginal culture and history of an area managed by the Service will be promoted and presented.

Policies

- The Tharawal Local Aboriginal Land Council and other relevant Aboriginal community organisations will be consulted and their active involvement sought in all aspects of management, particularly Aboriginal sites and values in the reserves.
- Aboriginal people will be permitted to carry out activities in the reserves related to maintenance of traditional links to the land. Any such activities must comply with the objectives and policies of this plan of management and have minimal environmental impact.
- Aboriginal sites will be protected from avoidable disturbance or damage by human activities.
- All activities with the potential to impact on Aboriginal sites will be preceded by an archaeological assessment and appropriate controls and safeguards implemented.
- The location of Aboriginal sites will not be publicised except where:
 - the agreement of the Tharawal Local Aboriginal Land Council and other relevant Aboriginal community organisations has been obtained;
 - a conservation study has been prepared and any management works necessary to protect the site from damage have been implemented; and;
 - the site will be interpreted to promote public understanding and appreciation of Aboriginal culture.
- Subject to the above policy, selected sites may be opened to the public to encourage an awareness and understanding of Aboriginal culture and the

prehistory of the reserves. Impacts from such use will be monitored and use restricted if necessary to alleviate adverse impact.

Actions

- Establish and maintain a comprehensive photographic and written data-base of all identified Aboriginal sites and areas, including precise locations.
- Undertake an audit of the condition of each recorded Aboriginal site.
- In conjunction with the Tharawal Local Aboriginal Land Council and other relevant Aboriginal representatives, investigate condition and measures to reduce deterioration of sites, particularly those at Cobbong Creek which may be affected by altered runoff.
- Investigate opportunities for cooperative management arrangements with Tharawal Local Aboriginal land Council and other relevant Aboriginal representatives.

4.2.2 Historic Places

The rugged sandstone of the Woronora Plateau and its poor agricultural soils were avoided by early settlers seeking farming land. This largely remains the case today aside from the establishment of limited agriculture, primarily orchards, along Darkes Forest Road and in the Wedderburn area. Areas more suited to agricultural development, such as around the nearby centres of Appin and Wollongong, were being settled and under cultivation by the early 1820s.

Documented European exploration and settlement in the area commenced with George Caley in 1802 and Dr Charles Throsby in 1815. Until the opening of the Princes Highway in 1920, the main overland route between Sydney and Wollongong was via Appin. Darkes Forest was named after Surveyor Darke who marked out routes in the district in the 1840's.

Coal mining in the district began in 1849 at Mt Keira, near Wollongong. By the 1870s coal mining was a major industry and the primary impetus for construction of a railway line which was completed between Sydney and Wollongong in 1888.

In the same year the Upper Nepean Water Supply Scheme was completed, consisting of the construction of weirs at Broughtons Pass and Pheasants Nest and a canal to convey water to Sydney. This scheme expanded over subsequent years to include the construction of the Cataract, Cordeaux, Avon, Nepean and Woronora Dams. The O'Hares Creek catchment was declared a Special Area in 1927 (amended 1934) with the intention of damming the creek to supplement existing supplies. This proposal was abandoned in 1978 and the area continued to be managed by the then Water Board and subsequently Sydney Water Corporation until 1996, when it was reserved under the *National Parks and Wildlife Act 1974*.

The Australian Army used part of O'Hares Creek catchment from the 1930's till the early 1990s for training as a supplement to the Holsworthy Field Firing Range to the

north. Army use included camping, orienteering and other non-destructive activities. The use of live ammunition and tracked-vehicles was not permitted. Discarded, spent plastic cartridges, 'fox-holes' and cleared bivouac sites are tell-tale signs of the extent of past army activity in the reserves.

Very little, if any, historical physical evidence of past European use of the reserves remains. Several, small concrete "V-notch" gauging weirs for recording stream flow still exist on O'Hares and Stokes Creeks related to past water supply investigations. These weirs and associated facilities, including access trails, were constructed sometime after 1927 and are not recorded on Sydney Catchment Authority's heritage inventory.

Physical evidence of past and current coal mining, and previous sand and shale extraction are widespread in the reserves. These are mainly in the form of cleared or excavated areas and utility infrastructure. Clay/shale and sand quarries continue to operate within the hydrological catchment of the reserves, immediately abutting the southern boundary.

Policies

- The provisions of the Burra Charter for the conservation of places of cultural significance will guide management decisions regarding the reserves' heritage.
- Significant historic places will be recorded, researched and conserved where appropriate.

Actions

- Identify and assess the significance of historic places within the reserves.
- Establish a photographic and textural database of all European structures with precise locations.

4.3 USE OF THE AREA

Public use of the reserves is appropriate provided that it does not conflict with the primary purpose of conservation of natural and cultural heritage and is consistent with the objectives and policies of the plan of management. The major categories of use that may be appropriate are:

- promotion and interpretation of the area and the conservation of natural and cultural heritage resources;
- certain types of recreation undertaken in a sustainable manner;
- environmental education and research; and
- management operations by the Service and other agencies and organisations with statutory jurisdiction in the area, and legal activities undertaken by existing interests holders.

The extent to which these categories of use will be provided for in the reserves is detailed in the following sections.

4.3.1 Promotion and interpretation

Promoting public awareness and understanding of the Service's conservation responsibilities, the natural and cultural heritage values of the reserves, and appropriate recreational opportunities is a major aspect of visitor use management. It assists the protection of the values of the reserves and increases the knowledge and enjoyment of visitors and wider community.

The reserves are not well known to the general public outside of the local area. This primarily relates to the area's status as a Special Area since 1927, which has limited development and restricted public access. The Special Area declaration remains over the reserves and the previous management emphasis on catchment water quality protection will continue in conjunction with conservation of the reserves significant natural and cultural heritage resources.

The significance, little disturbed nature, and restricted existing use of the reserves coupled with their proximity to the population centres of Wollongong and southern Sydney provide an opportunity to promote the reserves for research and education with self-reliant sustainable recreation use. The majority of visitors are likely to come from the Macarthur and Illawarra Regions, particularly Campbelltown and associated centres, and Wollongong. The education and research institutions, and the Local Aboriginal Land Councils within these regions will be target groups towards which promotion will be directed.

The significance and purpose of management programs relating to the protection of the natural and cultural heritage of the reserves will be emphasised within the local community, particularly reserves' stakeholders and neighbours.

Policies

- Widespread public understanding and appreciation of the natural and cultural values of the reserves will be promoted. Themes that will be emphasised in interpretive programs and visitor facilities will include: Aboriginal heritage; significant flora and fauna; and catchments and water quality.
- Limited visitor facilities will be developed within the reserves with preference to locations on the periphery of the state conservation area. The scale and nature of any visitor facility developments will reflect the over-riding emphasis on the conservation of the natural and cultural heritage values of the reserves.

Actions

- Prepare and implement an interpretive strategic plan for the reserves, to encompass walking tracks, interpretive/educational themes, visitor facilities, signage and community programs.
- Prepare interpretive material for public distribution on the natural and cultural heritage significance and recreation opportunities of the reserves.
- Develop and install appropriate track-head and interpretive facilities at major visitor access points.

- Progressively replace existing signs and update existing interpretive material that refers to the old state recreation area with the new reserve category name, state conservation area.

4.3.2 Recreation opportunities

Dharawal Nature Reserve and Dharawal State Conservation Area form part of a much larger regional system of protected and open space lands that cater for a range of outdoor and nature-based recreation in the Macarthur and Illawarra Regions. These lands include the Sydney Catchment Authority picnic areas at Woronora and Cataract Dams, Cataract Scout Camp, Heathcote and Royal National Parks, Garrawarra and Illawarra Escarpment State Conservation Areas; and a number of local government parks and reserves. Together, these areas provide a wide spectrum of outdoor recreation opportunities.

Within this system of recreation opportunities, Dharawal State Conservation Area, and to a lesser extent Dharawal Nature Reserve, caters for a range of self-reliant, nature-based sustainable recreation activities. Appropriate recreation use is governed by the overriding objective of protecting and conserving the significant natural and cultural values of the reserves. In the main, recreation activities revolving around nature appreciation and self-reliant activities are most appropriate. Reflecting this, only minimal visitor facilities, to complement the already extensive trail network, will be provided in the reserves. The spectacular and varying landscape across the reserves and the extensive and high quality water resources, including numerous rocky pools, are major recreational attractions. A walking track, viewing platform, small carpark and information have recently been provided at Maddens Falls, just off Darkes Forest Road.

The reserves provide a new and additional resource for public nature-based recreation in the region. The reserves partly fall within the rapidly expanding Macarthur Region, an area, according to the Macarthur Regional Environmental Study (1986), that is under provided with land managed for passive recreation purposes. The reserves southern boundary generally coincides with the Bulli-Appin Road, a main through route for people travelling between the Macarthur Region, including Campbelltown, and south coast beaches. As such, the reserves have high public exposure to passing traffic and considerable usage by this group can be expected.

Important considerations affecting the management of recreation in the reserves include:

- the relatively small size and convoluted boundary of the reserves created by the existing North Cliff Mine and supporting infrastructure, quarry operations, and the Crown reserve inholdings;
- lack of public transport services to the immediate area;
- the high to extreme soil erosion hazard of most of the reserves;
- the need to conserve and protect the significant values of the reserves;
- the need to avoid and minimise conflict between the reserves' user groups and with the reserves' stakeholders, including mining interests and utility bodies;

- numerous vehicle-based picnic areas within a bushland setting are provided in the local area at Cataract and Woronora Dams and immediately to the west on the escarpment edge; and
- bush and more formal camping opportunities are catered for in the Royal and Heathcote National Parks, Illawarra Escarpment State Conservation Area, as well as the adjacent Cataract Scout Park.

The long-standing Special Area status restricted the establishment of recreation use of the reserves. Prior to gazettal, all public access required authorisation, which was generally limited to research, education, and formal emergency incident or similar training activities. Recreational activities were not normally permitted, with an exception for a single commercial horse riding operation at Darkes Forest.

This commercial operation was authorised by Sydney Water in the 1980s and permitted the operator to conduct supervised horse riding along the 10H management trail from the Darkes Forest Road to its junction with 10C management trail. The operator was restricted to a maximum of twenty riders at any one time and was not permitted to use the area immediately following rain. The authorisation was cancelled shortly after declaration of the area in 1994 as the Dharawal Reserve under the *Crown Lands Act 1989*. The Dharawal Recreation Reserve Trust invited the operator to submit an application to continue the horse riding activity under similar conditions as with Sydney Water until such time as the area was gazetted under the *National Parks and Wildlife Act 1974*. The Trust has advised that this invitation was never formally taken up.

Horse riding appears to be more widespread within the reserves and is evidenced by the resulting development of numerous tracks, particularly in the Darkes Forest area. Horses can cause and exacerbate unacceptable environmental impacts in certain circumstances including erosion of soils, walking tracks and management trails; the possible introduction of weeds and plant species not native to the area and plant pathogens; and conflict with other recreational uses. Armstrong (1997) reports that horses have greater impact on an area than bicycles or walkers in both wet and dry conditions, generally creating deeper and wider tracks, particularly when travelling downhill.

As detailed previously, the reserves are characterised by soils of generally high to extreme erosion hazard, minimal weed infestation, water courses of high water quality, numerous and widespread significant flora and fauna species, populations and ecological communities, and a high density of Aboriginal sites. Widespread and more intensive horse riding poses a significant threat to these values and is considered an inappropriate activity within the nature reserve and the majority of the state conservation area.

The current and potential impact of horse riding on significant flora and fauna species, populations and ecological communities and Aboriginal sites in the reserves has not been formally assessed. Aboriginal rock engravings are particularly vulnerable to damage from metal horse shoes. Horse riding activity in areas rehabilitated following mining exploration and bushfire suppression operations, has also been reported to reduce the effectiveness of the rehabilitation works. Off-trail

horse riding has also resulted in a proliferation of bridle trails and some areas of weed infestation appear to be attributable to horse manure. This is of particular concern in and near water courses where rapid spread and establishment is possible. The importance of the Riparian Scrub vegetation community primarily relates to its current, generally weed-free status, which contrasts with most other examples of this community in other existing conservation reserves (Keith 1994).

A number of alternative sites providing opportunities for horse riding, within a similar bushland setting, exist in the local area. These include substantial areas of freehold land in the Darkes Forest (including an existing commercial horse riding facility) and Wedderburn areas, and land adjoining the western boundary of the state conservation area. In addition, horse riding is permitted within parts of the nearby Garrawarra and Illawarra Escarpment State Conservation Areas.

The Sydney Catchment Authority's Cataract Dam picnic area on the southern side of the Bulli-Appin Road caters for car-based picnics with sophisticated facilities in a generally bushland setting. Similar facilities are provided at Courdeaux Dam and to the north at Woronora Dam. Commercial cafes, picnic facilities and lookouts are available immediately east of the reserves on the edge of the escarpment, such as Sublime Point, and Bulli Lookout.

Public recreation use is excluded from the extensive natural areas adjoining the reserves to the northeast and south comprising the Holsworthy Field Firing Range and Special Areas. Beyond these immediate areas, extensive, nature-based recreation opportunities are provided in Royal and Heathcote National Parks, and Garawarra and Illawarra Escarpment State Conservation Areas.

The reserves contain an extensive network of vehicle trails. This network has developed over a number of decades primarily in response to the access requirements associated with activities of past and current existing interests. In the main these have included coal exploration and extraction, water supply investigations, utility infrastructure, and quarrying. Many of the trails were developed for temporary use only and have evolved into major formed trails due to excessive vehicle use by unauthorised users over the years.

As a result, many of the existing trails are poorly located and constructed in terms of current management needs, public safety, and adverse impact on the local environment. Erosion and scouring of trails is common, particularly on steeply sloping sections, and a number have degraded to the extent that they are no longer trafficable nor feasibly recoverable. These trails, in particular, compromise and detract from the natural and cultural values of the reserves and are often sites for illegal activities such as waste dumping and arson, drug cultivation, and timber and bush rock collection.

Public vehicle use of the reserves management trail network is considered inappropriate because of the risk to public safety, adverse impacts on the natural and cultural heritage values of the reserves, and potential for conflict with, and threat to the safety of, other users of the reserves including existing interests. Public roads delineate the majority of the southern, eastern and western boundaries of the reserves providing many convenient opportunities for recreational access. Numerous

access points exist in the Darkes Forest area, off Darkes Forest Road and in the Wedderburn area off Victoria and Wedderburn Roads.

Research has identified the dominant source of increased runoff and sediment movement in forested areas is associated with the construction and usage of unsealed vehicle trails. Reported increases in sediment yields range from 2 to over 100 times the background levels for undisturbed forest areas (Reid 1993 in Hairsine, Croke, Mathews, Fogarty & Mockler, in prep; Haydon, Jayasuriya & O'Shaughnessy 1991). Sediment generation increases with trail use intensity, particularly use during periods of wet weather. Croke, Wallbrink, Fogarty, Hairsine, Mockler, McCormack & Brophy (1999) have recorded sediment concentrations in runoff between 5 and 8 times higher on well used unsealed trails than abandoned or infrequently used ones.

The designated management trail network provides good access to the reserves for a range of self-reliant recreation opportunities. The substantial width of management trails will minimise the likelihood of conflict between pedestrians and bicycle riders and with the legal activities of existing interests. A number of poorly located and constructed trails have been closed to vehicle use and rehabilitated.

A field archers club previously operated on Lots 15 and 47, adjacent to the northern end of Lysaghts Road at Wedderburn, which now forms part of the Dharawal State Conservation Area. Lot 47 was formerly a Special Lease for grazing which expired in December 1991. Lot 15 comprised a License for grazing and was terminated by the Department of Infrastructure, Planning and Natural Resources in July 1995. Much of Lot 47 has been cleared of woody vegetation and remnants of dumped waste materials remain on the site.

The O'Hares Creek Special Area is part of a contiguous network of Special Areas in the Sydney Region. A coordinated approach between agencies with regard to legal and illegal access is therefore important to ensure threats are minimised to water supply quality and ecological integrity.

Policies

- The use of recreational motor vehicles, e.g. 4WDs and trail bikes, will not be permitted in the reserves.
- Visitors will be required to follow minimal impact bushwalking and cycling techniques within the reserves.
- Cycling will be permitted on designated management trails within the state conservation area and riders will be required to abide by a code of conduct aimed at avoiding possible environmental impact and recreational conflicts. Cycling will not be permitted in the nature reserve.
- Limited visitor facilities will be developed within the reserves with preference to locations on the periphery of the state conservation area. The scale and nature of any visitor facility developments will reflect the over-riding emphasis on the conservation of the natural and cultural heritage values of the reserves. Overnight camping will not be permitted.

- Organised adventure and recreation programs by commercial and community organisations will not be permitted in the nature reserve but may be permitted in the state conservation area subject to the following:
 - prior detailed notice to, and compliance with written consent (which will include a maximum group size) of, the National Parks and Wildlife Service;
 - activities will be excluded from sensitive areas; and
 - only one program will be permitted within the reserves at any one time and a maximum of one program per month only may be permitted.
- Horse riding will not be permitted within Dharawal Nature Reserve and Dharawal State Conservation Area except for regulated use along 10H management trail between Darkes Forest Road and the junction with 10C management trail, subject to a satisfactory annual environmental audit.
- Where possible and feasible, vehicle access points will be physically controlled and maintained.
- Existing vehicle trails will be assessed for their capability and suitability for recreational and management use. Non-strategic and otherwise redundant or inappropriate existing trails will be closed and rehabilitated or, where appropriate, maintained for bushwalking use only.
- Where necessary, the Service will negotiate with neighbouring landholders and local government to maintain access to established or appropriately proposed walking / cycling routes into the reserves.

Actions

- Undertake a regular audit of visitor and management assets, including signage, fences and gates, and program and implement replacement, maintenance or additions as necessary.
- Audit existing trails, including formal assessment of management importance, environmental impact and feasibility of appropriate management, and compliance with appropriate trail design and maintenance standards in conjunction with user groups. Designate trails to be retained and determine and assign use capability and prepare and implement a cyclic trail maintenance program to upgrade &/or maintain to assigned use standard. Non-designated trails to be closed and stabilised, or retained for self-reliant recreation use where appropriate.
- Investigate opportunities for the reconstruction of Seven Creek Way as a formal walking track, subject to the resolution of land tenure issues.
- Identify, and where appropriate, facilitate a range of bushwalking and cycling opportunities in terms of length and degree of difficulty.
- Investigate, and where appropriate plan appropriate visitor facilities on the periphery of the state conservation area with priority given to the Darkes Forest

and Wedderburn areas. Any new facilities, other than the Seven Creek walking track and associated carparking, will require an amendment to this plan.

- Consult with relevant stakeholders and develop a recreational horse riding strategy for regulated use of the 10H management trail between Darkes Forest Road and the junction with the 10C management trail within the state conservation area by the end of 2006. Use will be limited to those with permits and the strategy developed with particular reference to management for conservation.
- Liaise with cycling groups to develop a code of conduct for cycling in the reserves.
- Continue to undertake law enforcement programs targeting unauthorised use of the reserves.
- Carry out coordinated law enforcement activities with the Sydney Catchment Authority to minimise the impacts of illegal access to the reserves and Special Areas.

4.3.3 Research and education

Prior to gazettal, research activities in the reserves were regulated by the then Sydney Water Corporation and its predecessors. Intermittent, though reasonably numerous, research projects have been undertaken within the reserves by tertiary education institutions, particularly by students and staff of the University of Wollongong. The long-standing restricted public access to the reserves ensured minimal disturbance and interference to research sites. Unfortunately, much of this research has been of restricted duration and extent, which has limited its contribution to the better understanding and management of the reserves.

Past research in the reserves has primarily concentrated on flora and Aboriginal heritage. Very limited research has been undertaken of fauna, European heritage and water quality.

Policies

- The Service will foster and assist appropriate research and education opportunities in the reserves, particularly that which contributes to improved understanding of the reserves' natural and cultural heritage and the processes which affect them.
- Priority will be given to research projects that provide information of direct relevance to management of the natural and cultural resources of the reserves as outlined within this plan. Where structures and markers are required for research, they will be placed in locations, which minimise their visual impact and removed immediately upon completion of the project.

Actions

- Identify and establish baseline areas within the reserves for scientific studies, environmental monitoring, and education, from which all avoidable access and disturbance is excluded.
- Prepare a research prospectus identifying high priority research opportunities within the reserves and promulgate with tertiary education and other research organisations.
- Liaise with relevant education institutions, other research bodies and community groups and negotiate a Memorandum of Understanding with each relating to any existing and proposed use of the reserves for research and education.
- Establish and maintain a database of resource material, including research, on the reserves.

4.3.4 Management operations

Dharawal Nature Reserve and Dharawal State Conservation Area are subject to a joint management agreement between the National Parks and Wildlife Service and the Sydney Catchment Authority. This agreement provides a formal basis for the joint management of the reserves consistent with each agency's enabling legislation.

The *National Parks and Wildlife Act 1974* makes provision for the continuation of legal activities by holders of an 'existing interest' in force at the time the land is reserved under the Act. An existing interest is any authority, authorisation, permit, lease, licence or occupancy under a number of statutes.

A number of existing interests continue to prevail in both reserves, particularly the state conservation area. Management operations associated with existing interests will continue and include underground coal mining and mineral exploration, water extraction for irrigation, and public utilities facilities for electricity transmission, drinking water supply, and telecommunications.

Mining, mineral exploration and extractive industry

Existing interests in the reserves include mining interests granted in accordance with the *Mining Act 1992* and the *Petroleum (Onshore) Act 1991*. New mining interests or the renewal or extension of any existing mining interests may be granted in Dharawal State Conservation Area, but not Dharawal Nature Reserve, with the concurrence of the Minister for the Environment. Unlike the state conservation area, which was reserved with no depth restriction, the nature reserve was restricted to a depth of 100 metres.

Both Dharawal Nature Reserve and Dharawal State Conservation Area overlie the extensive Southern Coalfields and have a history of underground mining and associated surface activities. The majority of the area of the two reserves was reserved as a state conservation area to protect conservation values while continuing to accommodate mining and mineral exploration. As such, existing mining interests

encompass almost the entire extent of Dharawal State Conservation Area and mining and surface exploration operations will continue until the interests expire. Mining interests are likely to persist for some time as over 30 years of coal reserves are estimated to remain in the area.

In addition to the mining legislation, mining and exploration may also require approvals from the Minister for the Environment. These include heritage impact permits under section 90 *National Parks and Wildlife Act 1974* to destroy Aboriginal objects or places, determinations under Part 5 of the *Environmental Planning and Assessment Act 1979*, and grants of licences under the *Threatened Species Conservation Act 1995*. Approvals from the Director-General of National Parks and Wildlife or other delegated authority may also be required under the *National Parks and Wildlife Regulation 2002*.

In early 1998, a memorandum of understanding (MoU) initiated by the Department of Primary Industries - Mineral Resources addressing the continuation of exploration and mining in Dharawal State Conservation Area, was endorsed by the National Parks and Wildlife Service, Department of Primary Industries - Mineral Resources, and BHP Steel (AIS) Pty Ltd. At that date, BHP Steel (AIS) Pty Ltd held Consolidated Coal Leases 724 and 767 within the state conservation area. The MoU is to be reviewed five years from the date of its endorsement.

Exploration and mining operations undertaken within the state conservation area may include coal and seam gas exploration, resource assessment and mining or extraction. Coal is currently mined using underground methods from the Bulli seam some 450-500 metres below the ground surface. Existing underground workings connect two main surface facilities located outside the state conservation area.

West Cliff Mine is situated adjacent to the southwest boundary where mined coal from all underground workings within the state conservation area is brought to the surface. The facility comprises coal processing, stockpiling, transportation, waste emplacement, and mine administration facilities. North Cliff Mine forms an inholding of Crown land subject to a surface mining interest within the state conservation area. The mine comprises limited facilities, most of which have been decommissioned and removed in recent years.

An overhead 33kV electricity transmission line connects West Cliff and North Cliff Mines along an approximately 5 km surface mining interest corridor. The sections of the 10B and 10C management trails connecting North Cliff Mine with the Bulli-Appin Road are also corridors of Crown land subject to surface mining interests.

Many of the existing management trails within the state conservation area were initially established as part of mining and exploration activities over the years. Continued routine access by mining interests holders is required on a number of trails to maintain assets and to undertake exploration and subsidence monitoring activities. These currently include management trails 10O, 10N, 10F, 10G and the powerline trail. The primary purpose of these trails is to provide access for maintenance of the mine power line. Future exploration and monitoring activities may require the construction of additional, temporary access trails through currently undisturbed areas, subject to satisfactory environmental assessment. The southern part of 10B and western portion of 10C management trails were excluded from reservation and

remain the responsibility of the Dharawal Recreation Reserve Trust and the existing mining interest holder.

Exploration activities are undertaken as required by mining interest holders. Surface methods used include drilling and seismic activities and these have been employed extensively over most of the state conservation area. Visible evidence of exploration activity is widespread and the adequacy and effectiveness of subsequent rehabilitation is variable.

Some of the areas subject to exploration have significant limitations to development (i.e., slope, erosion hazard, rock outcrops etc.) and have the potential to be significantly degraded by exploration activities. While each proposal is relatively spatially and temporally restricted, the cumulative adverse impact of exploration in the form of access trails, seismic lines and borehole site disturbance and potential subsequent degradation by unauthorised users may become significant and pose ongoing management problems.

Several Crown mineral leases for sand extraction (PO 1975-1) and clay/shale extraction are situated in the headwaters of Stokes Creek and comprise inholdings on the southern boundary of the state conservation area. The Healthy Rivers Commission (2001) states that these clay mining and other extractive industries pose a serious threat to the high environmental values of the remaining natural areas of the upper Georges River catchment. Resource extraction is expected to continue for some time with the exception of mining leases 35, 54 and 74. An application to develop Mining lease 35 was recently rejected and rehabilitation has commenced on the latter two leases. Several redundant quarry sites remain within both the nature reserve and state conservation area. These are generally stabilised but are largely unrehabilitated.

Utilities

Existing interests also relate to existing broadcasting or telecommunications facilities within the meaning of the *Broadcasting Services Act 1992* of the Commonwealth, or *Telecommunications Act 1997* of the Commonwealth. Existing facilities occur in both Dharawal Nature Reserve and Dharawal State Conservation Area associated with electricity transmission, drinking water supply, and telecommunications.

Three electricity transmission lines and an associated vehicle access trail (10Q) bisect Dharawal Nature Reserve. Separate, but closely located 330 kV and 11kV lines parallel the western side of the Southern Freeway and a 132 kV (Homebush - Tallawarra) line crosses the eastern tip of the nature reserve, near the Princes Highway. The 132 kV and 11 kV lines are owned and maintained by Integral Energy and the 330 kV (Dapto - Sydney South) line by TransGrid. An additional 33 kV electricity transmission line and three associated vehicle access trails (10F, 10G, and power line trail), owned and maintained by the mining interest holder, extends through part of Dharawal State Conservation Area, connecting the North Cliff and West Cliff Mines.

Two underground telecommunications lines are located within the state conservation area, servicing neighbouring properties and North Cliff Mine, and two fibre optic cables parallel the western side of Southern Freeway through the nature reserve.

Several hundred metres of underground telephone cable, including two access pits, are located within the western boundary of Dharawal State Conservation Area, on Lots 15 and 47, Wedderburn. Approximately two kilometres of similar cable, connecting North Cliff Mine pit-top and Darkes Forest Mine also exists. Much of the extent of the cable is located along the 10R management trail to its junction with O'Hares Creek where it enters adjoining private freehold. Installation of the cable has resulted in substantial degradation of the management trail to the point where sections are no longer trafficable. This line is now redundant.

Previous water supply investigations by Sydney Water Corporation and its predecessors resulted in the establishment of two concrete V-notch gauging weirs and associated facilities on Stokes Creek and one on O'Hares Creek. The weirs are all located in the state conservation area and are associated with existing vehicle access trails (10B, 10D and 10P) within the state conservation area. The primary purpose of the 10P and 10D management trails is access to the weirs. Another weir is located on O'Hares Creek further downstream in the state conservation area, and is maintained by the Department of Infrastructure, Planning and Natural Resources.

Sydney Catchment Authority also owns and maintains a meteorological station and seismic monitoring station in the north of the state conservation area. The former is located immediately adjacent to 10B management trail, at the northern junction with 10D, and the latter is located in a remote site accessed by foot every six weeks.

A number of management trails generally coincide with the boundary of adjoining Special Areas and Holsworthy Military Area. These jointly used trails include: No.10; 10A; 10Q; 10V; and No.14.

Water extraction

The Department of Infrastructure, Planning and Natural Resources (DIPNR) currently administers three licenses to extract water under the *Water Act 1912* from creeks within the reserves. These include two from Maddens Creek and one from O'Hares Creek. These licenses are issued and renewed for periods of five years. Water extracted under the licenses is used to provide water for domestic purposes and orchards at Darkes Forest.

License number 10SL 038861, renewed in March 2002 provides for an overshot dam on Maddens Creek and a 100mm centrifugal pump, both located within the state conservation area. An underground pipeline conveys the water several hundred metres through the reserve to a neighbouring orchard. A Permissive Occupancy (PO 1960/178 Metropolitan) for the pipeline was terminated in April 1996 by the Department of Infrastructure, Planning and Natural Resources (DIPNR). The pump is accessed by an existing short vehicle trail off Darkes Forest Road (10Z management trail) and is used regularly to operate and maintain the pump.

License number 10SL031775 renewed in March 2000 provides for a 50mm centrifugal pump on Maddens Creek. The pump is situated on immediately adjacent private land and currently extracts water from a series of *ad hoc* small weirs constructed within the creek.

Flows within Maddens Creek, immediately downstream of the two pumping licenses, have been observed to cease periodically during prolonged dry periods. At these times the rate of water extraction can exceed natural inflows and a section of the creek, including Maddens Falls, completely dries out until pumping ceases or sufficient rainfall occurs within the catchment. The impacts of the cessation of flow are outlined in Section 4.1.1. Geomorphology, soils and hydrology.

License number 10SL 028895 renewed in April 1998 provides for a 65mm & 80mm centrifugal pump on O'Hares Creek. A Permissive Occupancy (1968/7 Metropolitan) for the associated pipeline and pumpsite, now within the state conservation area, was terminated in April 1996 by DIPNR. This facility has not operated for some time.

Structures/facilities associated with water extraction are to be assessed and where appropriate regularised/licensed under the NPW Act and conditions included to ensure that environmental values are adequately protected.

Organised events and other activities

Sydney Catchment Authority and its predecessors previously permitted some limited, non-commercial rescue, navigation and similar type training exercises within the reserves. A number of local groups have undertaken various exercises in the reserves over the last few years.

A single bee keeping operation exists with the nature reserve, however, no documented authorisation for it has been identified. Use of the site has been limited with a single hive in place when the reserved was gazetted. Vehicle access is no longer possible to the site and continued use is inconsistent with the conservation values of the nature reserve.

Policies

- In the long term to progressively reduce, and if possible eliminate, existing interests within the reserves with priority given to those located in the nature reserve. Existing interests will be kept under review and where feasible will be relocated or closed and sites rehabilitated. Remaining interests will be licensed.
- Provision for the undertaking of exploration and mining within the state conservation area must have regard to the conservation of the areas' natural and cultural values and must be consistent with other relevant State and Commonwealth legislation.
- Avoid, and where necessary minimise, new disturbance and associated soil erosion and sediment movement, particularly in areas comprising the Hawkesbury and Maddens Plains Soil Landscape Units.
- Stabilise and rehabilitate disturbed areas to permanently avoid, and where necessary minimise, soil erosion and sediment movement, and assist restoration to pre-disturbance condition.

- All stabilisation and rehabilitation works should be inspected on a regular basis following completion and any aspect found faulty or deficient should be rectified until the site is fully restored.
- The siting, design, construction, maintenance, and management of the use of vehicle trails and other facilities is to be appropriate to the planned scale and nature of use, environmental constraints and undertaken in accordance with contemporary best practice soil and water management principles and procedures.
- The end use of any area affected by existing interests is nature conservation and on cessation of use such areas are to be sufficiently rehabilitated to ensure timely restoration to pre-disturbance condition and all foreign materials to be removed from the reserves. Rehabilitation measures are to include on-going protection from soil erosion and control of any noxious and environmental weeds
- All designated and any new temporary vehicle access routes into and within the reserves will be adequately controlled to prevent unauthorised access and use. Temporary access trails will be permanently closed and rehabilitated on cessation of use.
- Existing interest holders are responsible for securing and maintaining and/or closing and rehabilitating those vehicle trails which primarily provide access to existing interest assets or which are primarily required for existing interest activities.
- All designated vehicle access points into the reserves will be secured and sign-posted to prevent unauthorised use.
- Organised commercial training exercises will not be permitted within Dharawal Nature Reserve and State Conservation Area.
- Organised training exercises by non-commercial groups will not be permitted within the nature reserve but may be permitted in the state conservation area subject to the following:
 - prior detailed notice to, and compliance with written consent (which will include a maximum group size) of, the National Parks and Wildlife Service;
 - activities will be excluded from sensitive areas;
 - use will be confined to the designated management trail and walking track network; and
 - only one exercise may be permitted at any one time and a maximum of six exercises in total in any one calendar year.

Actions

- In conjunction with the Department of Primary Industries - Mineral Resources, develop specific conditions and protocols for mining interests necessary for the

management of exploration and mining and protection of natural and cultural heritage in the state conservation area.

- In conjunction with DIPNR, audit compliance with water extraction licences and associated structure/facilities, rectify deficiencies and, where appropriate and feasible, regularise with appropriate conditions under the NPW Act.
- Liaise and negotiate with existing interests holders to develop and apply a standard, formal protocol addressing access into the reserves.
- Liaise with the operator of the beehive to relocate the operation outside of the nature reserve.
- In conjunction with existing interest holders, undertake an initial audit of all sites currently or previously disturbed by existing interests and identify and prioritise stabilisation and rehabilitation requirements.
- Liaise with mining interest holders and the Department of Primary Industries - Mineral Resources to undertake an initial audit of areas disturbed by surface activities and subsidence, and to identify and prioritise rectification of any deficiencies in stabilisation and rehabilitation.
- Undertake an audit of existing interests current and proposed management trail usage to clarify trails used and the scale and nature of use.
- Liaise and negotiate with relevant existing interest holders, Rural Fire Service, Department of Primary Industries - Mineral Resources, and Sydney Catchment Authority to formalise responsibility for the security and maintenance, or closure and rehabilitation of those existing management trails that primarily provide access to existing interest assets or are otherwise required for existing interest activities. These trails currently include:
 - 10P;
 - 10D;
 - 10B (part)
 - 10C (part)
 - No.10 (part)
 - 10A (part)
 - No.14;
 - 10Q;
 - 10O;
 - 10N;
 - 10F; and
 - 10G
- Close and rehabilitate part of existing vehicle trail 10R from O'Hares Creek to top of ridgeline.

5. PLAN IMPLEMENTATION

This plan of management is part of a management system developed by the National Parks and Wildlife Service. The system includes the *National Parks and Wildlife Act 1974*, national parks and Wildlife Service management policies which are based on established conservation and recreation philosophies, and strategic planning at National Parks and Wildlife Service Corporate, Directorate, Regional and Area levels.

Implementation of this plan will be undertaken within the annual programs of the National Parks and Wildlife Service Sydney South Region. Priorities, determined in the context of corporate, directorate and regional strategic planning, will be subject to the availability of necessary staff and funds and to any special requirements of the Director-General National Parks and Wildlife or Minister administering the Act.

Regional programs are subject to ongoing review within which work programs and other activities carried out in the reserves are evaluated in relation to the objectives, policies and actions laid out in this plan.

The environmental impact of all activities undertaken in the reserves will be formally assessed at all stages and any necessary investigations will be undertaken in accordance with the requirements of the *Environmental Planning and Assessment Act 1974* and other relevant statutes. This requirement applies to all activities and works proposed by all existing interests, including mining interests, in addition to those proposed by the National Parks and Wildlife Service and the Sydney Catchment Authority.

Section 81 of the National Parks and Wildlife Act requires that this plan shall be carried out and given effect to, and that no operations shall be undertaken in relation to the nature reserve and the state conservation area unless they are in accordance with the plan. However, if after adequate investigations, operations not included in the plan are found to be justified, the plan may be amended in accordance with Section 73B of the Act.

One of the key performance measures for this plan of management will be the rate of implementation of the actions listed in the plan. In addition, there is a need for broad environmental indicators that can be used to gauge the effectiveness of NPWS management practices in maintaining and improving the environmental values of the reserves. Standard environmental indicators are currently being developed by the NPWS for the recently introduced NPWS 'State of the Park' reporting process. When the measures are available they will be employed in relation to the reserves.

Actions

- A limited internal review of the plan will commence five years after it has been adopted. All subsidiary plans and strategies will be reviewed on a five-yearly basis. The review will principally be confined to possible amendments associated with:
 - Pertinent new research findings and information or the emergence of significant previously unforeseen management issues;
 - The results of monitoring programs, where they indicate that the policies and actions contained in the plan are not achieving stated management objectives.
- A full internal review of this plan will commence approximately ten years after adoption of the plan by the Minister for the Environment. This plan will remain in force until such time that a new plan is adopted.

TABLE 2 - IMPLEMENTATION PRIORITIES

As a guide to the implementation of this plan, relative priorities for identified actions in this plan are summarised in the following table.

Program	Plan Reference
High Priority	
1. Investigate &, where appropriate, nominate the upland swamp communities for listing under the Ramsar convention.	4.1.1
2. Plan & implement an initial audit of disturbed areas & prioritise stabilisation & rehabilitation works.	4.1.1
3. Survey, map & regularly monitor noxious & environmental weed distribution within the reserves & schedule & implement annual prioritised control programs	4.1.2
4. Liaise with relevant neighbours to foster & assist biodiversity conservation with priority given to areas likely to support threatened species.	4.1.3
5. Prepare & implement annual introduced animal control programs with priority given to fox, feral dog and cat control in the northern section of the state conservation area adjacent to the core Koala habitat, and to deer control.	4.1.3
6. A fire management plan will be prepared for the reserves detailing life, property and natural & cultural resource protection principles, strategies & programs including the location, nature & scale of asset protection zones & strategic management zones, cooperative bushfire management arrangements & management trail network requirements.	4.1.4
7. Audit existing trails, including formal assessment of management importance, environmental impact & feasibility of appropriate management, & compliance with appropriate trail design & maintenance standards in conjunction with user groups. Designate trails to be retained & determine & assign use capability & prepare & implement a cyclic trail maintenance program to upgrade &/or maintain to assigned use standard. Non-designated trails to be closed & stabilised, /or retained for self-reliant recreation use where appropriate.	4.1.4 & 43.2
8. Plan and implement regular reserve bushfire management familiarisation exercises with the Wollongong, Wollondilly and Campbelltown Rural Fire Service District personnel.	4.1.4
9. Maintain the fence & gates along the western boundary of the state conservation area with Lysaghts Road &, where necessary, construct and maintain appropriate fencing on other boundaries of the reserves to ensure the continued reduction of previous high levels of arson, environmental degradation & other illegal activities undertaken in the reserves.	4.1.4

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| 10. Undertake a regular audit of visitor & management assets, including signage, fences & gates, & program & implement replacement, maintenance or additions as necessary. | 4.3.2 |
| 11. Consult with relevant stakeholders and develop a recreational horse riding strategy for regulated use of the 10H management trail between Darkes Forest Road and the junction with 10C management trail within the state conservation area by 2006. Use will be limited to those with permits and the strategy developed with particular reference to management for conservation. | 4.3.2 |
| 12. In conjunction with the Department of Primary Industries - Mineral Resources, develop specific conditions & protocols for mining interests necessary for the management of exploration & mining & protection of natural and cultural heritage in the state conservation area. | 4.3.4 |
| 13. Liaise with existing interests holders & develop & apply a standard, formal protocol addressing access into the reserves. | 4.3.4 |
| 14. Undertake an audit of existing interests current and proposed management trail usage to clarify trails used and the scale and nature of use. | 4.3.4 |
| 15. In conjunction with DIPNR, audit compliance with water extraction licences and associated structure/facilities, rectify deficiencies and, where appropriate and feasible, regularise with appropriate conditions under the NPW Act. | 4.3.4 |
| 16. Liaise & negotiate with relevant existing interest holders, user groups, Department of Primary Industries - Mineral Resources, & Sydney Catchment Authority to formalise responsibility for the security & maintenance, or closure & rehabilitation of those existing management trails that primarily provide access to existing interest assets or are otherwise required for existing interest activities. | 4.3.4 |

Moderate Priority

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| 1. Plan & implement an initial audit & subsequent periodic monitoring of the ecological integrity & condition of the upland swamp communities. | 4.1.1 |
| 2. Periodically monitor the effectiveness of stabilisation & rehabilitation works & initiate rectification or augmentation where necessary. | 4.1.1 |
| 3. In conjunction with Sydney Catchment Authority, initiate establishment of an on-going water quality monitoring program to provide information on the condition & any changes to water quality. | 4.1.1 |
| 4. Negotiate with and encourage the Department of Infrastructure, Planning and Natural Resources to develop and apply environmental flow rules to temporarily limit, and where necessary cease, licensed water pumping from streams within the reserves during periods of low or no flow. | 4.1.1 |
| 5. Negotiate with & encourage the Department of Primary Industries - Mineral Resources & existing mining interest holders to establish a monitoring & research program examining subsurface mining related subsidence impacts on surface drainage & water dependent flora and fauna, & the stability of steep slopes & rock overhangs with particular regard to public safety & certain Aboriginal sites, & investigate & apply safeguards to avoid, & where necessary minimise, adverse effects | 4.1.1 |
| 6. As necessary, assess and monitor proposed activities by existing interest holders to ensure thorough and complete consideration and application of contemporary best practice environmental and soil and water management principles and procedures. | 4.1.1 |
| 7. Liaise with relevant government departments to monitor any discharge from quarry sites, both active and redundant | 4.1.1 |
| 8. Identify key threatening processes to endangered & vulnerable plant species, populations & ecological communities & assist with the preparation & implementation of threat abatement plans in accordance with the <i>Threatened Species Conservation Act 1995</i> | 4.1.2 |
| 9. Rehabilitate and encourage regeneration of existing disturbed areas within the reserves with priority given to disturbed areas of the Sedgeland - Heath Complex; Heath Woodland; Ironstone Woodland; and Ironstone Heath. | 4.1.2 |
| 10. Assist with the preparation & implementation of threatened species management plans for each endangered animal species, population & ecological community currently occurring within the reserves. | 4.1.3 |

11. Identify key threatening processes to endangered & vulnerable animal species, populations and ecological communities & schedule and assist in the preparation & implementation of threat abatement plans in accordance with the *Threatened Species Conservation Act 1995* 4.1.3
12. Liaise with the holder of the North Cliff Mine existing interest & the Dharawal Recreation Reserve Trust to discontinue the use of coal wash on 10B and 10C access trails and to replace it with alternative material less likely to contaminate surrounding water courses & impact on flora & fauna species. 4.1.3
13. Fuel reduction programs will be prepared & implemented annually & may include prescribed burning, fuel reduced zones, & trail maintenance requirements in accordance with the policies outlined above & in the fire management plan. 4.1.4
14. A reserves fire advantages map detailing water draughting points, trails, helipads & other issues relevant for bushfire management will be prepared & regularly maintained. 4.1.4
15. Establish & maintain a comprehensive photographic & written data-base of all identified Aboriginal sites & areas, including precise locations 4.2.1
16. Investigate opportunities for cooperative management arrangements with Tharawal Local Aboriginal Land Council and other relevant Aboriginal representatives. 4.2.1
17. Undertake an audit of the condition of each recorded Aboriginal site 4.2.1
18. In conjunction with the Tharawal Local Aboriginal Land Council & other relevant Aboriginal representatives, investigate condition & measures to reduce deterioration of sites, particularly those at Cobbong Creek which may be affected by altered runoff. 4.2.1
19. Prepare and implement an interpretive strategic plan for the reserves, which encompasses walking tracks, interpretive/education themes, visitor facilities, and signage and community programs. 4.3.1
20. Develop and install appropriate track-head and interpretive facilities at major visitor access points. 4.3.1
21. Progressively replace existing signs and update existing interpretive material that refers to state recreation area with the new reserve category name, state conservation area. 4.3.1
22. Investigate opportunities for the reconstruction of Seven Creek Way as a formal walking track, subject to the resolution of land tenure issues. 4.3.2
23. Investigate, & where appropriate plan & develop appropriate visitor facilities on the periphery of the state conservation area with priority given to the Darkes Forest & Wedderburn areas. Any new facilities, other than the Seven way Creek walking track and associated carparking, will require an amendment to this plan. 4.3.2
24. Continue to undertake law enforcement programs targeting unauthorised use of the reserves 4.3.2
25. Carry out coordinated law enforcement activities with Sydney Catchment Authority to minimise the impacts of illegal access to the Reserves and Special Areas 4.3.2
26. Prepare a research prospectus identifying high priority research opportunities within the reserves & promulgate with tertiary education & other research organisations in the region 4.3.3
27. Close and rehabilitate existing vehicle trail 10R from O'Hares Creek to top of ridgeline. 4.3.4
28. Liaise with the operator of the beehive to relocate the operation outside of the nature reserve. 4.3.4
29. In conjunction with existing interest holders, undertake an initial audit of all sites currently or previously disturbed by existing interests & identify & prioritise stabilisation and rehabilitation requirements. 4.3.4
30. Liaise with mining interest holders & the Department of Primary Industries - Mineral Resources to undertake an initial audit of areas disturbed by surface activities & subsidence, & to identify & prioritise rectification of any deficiencies in stabilisation and rehabilitation. 4.3.4

Low Priority

1. Jointly, with relevant authorities, including Department of Primary Industries - Fisheries, assess the appropriateness, feasibility, and potential costs and benefits of removing weirs. 4.1.1
2. In accordance with established ecological research procedures, establish permanent survey transects in each of the main native vegetation communities & undertake a regular monitoring program. 4.1.2
3. Initiate liaison with relevant private landowners & government agencies to encourage the examination & progression of possible conservation options such as voluntary conservation agreements for areas of native vegetation adjoining the reserves. Priority to be directed to areas with significant vegetation communities including Shale forest, Western Gully Forest, Banksia Thicket & the Sedgeland-Heath Complex. 4.1.2
4. Design & implement periodic biodiversity surveys 4.1.3
5. Liaise with relevant local government, the Rural Fire Service & Department of Infrastructure, Planning and Natural Resources with regard to new or intensification of existing developments adjacent, or in close proximity, to the reserves to assist to ensure that bushfire management & other matters relevant to the conservation and management of the reserves are fully addressed. 4.1.4
6. Identify and assess the significance of historic places within the reserves. 4.2.2
7. Establish a photographic and textural database of all European structures with precise locations. 4.2.2
8. Prepare interpretive material for public distribution on the natural and cultural heritage significance and recreation opportunities of the reserves. 4.3.1
9. Identify, and where appropriate, facilitate a range of bushwalking & cycling opportunities in terms of length & degree of difficulty. 4.3.2
10. Liaise with cycling groups to develop a code of conduct for cycling in the reserves 4.3.2
11. Liaise with relevant education institutions, other research bodies and community groups and negotiate a Memorandum of Understanding with each relating to any existing and proposed use of the reserves for research and education. 4.3.3
12. Establish & maintain a database of resource material, including research, on the reserves. 4.3.3
13. Identify & establish baseline areas within the reserves for scientific studies, environmental monitoring, & education, from which all avoidable access & disturbance is excluded. 4.3.3

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APPENDIX 1 - SOIL LANDSCAPES (after Hazelton and Tille 1990)

	Extent	Fertility	Erodibility	Erosion Hazard
Lucas Heights	2105 Ha (34.8%) Ridges	Moderate	Topsoil is moderately erodible and subsoils are highly erodible.	Moderate for both non-concentrated & concentrated flows
Hawkesbury	1928 Ha (31.8%) Gorges	Low	Topsoil has low erodibility. Subsoils have moderate erodibility.	Very high for non-concentrated flows & extreme for concentrated flows.
Bundeena	1541 Ha (25.5%) East	Very low	Moderately erodibility	High to very high for non-concentrated flows & high for concentrated flows.
Maddens Plains	459 Ha (7.6%) South east	Very low	Low erodibility unless coherent fabric disrupted making soils highly erodible.	Slight to very high for non-concentrated flows & very high for concentrated flows.
GyMEA	17 Ha (0.3%) North	Very low	Topsoil has very low erodibility. Subsoils are moderate to highly erodible	High to very high (but can range from moderate to extreme) for non-concentrated flows & high to extreme for concentrated flows.
Blacktown	4 Ha (0.1%) Eastern boundary	Low	Moderate	Moderate (but can range from low to very high) for non-concentrated flows & moderate to high for concentrated flows.

APPENDIX 2 - VEGETATION COMMUNITIES (after Keith 1994)

Vegetation Community	Distribution	Disturbance	Conservation
Shale Forest	11 Ha (0.2%) Restricted to patches on broad ridges in the eastern third of the area. The majority (165 Ha) is situated immediately outside the reserve boundary on Sydney Catchment Authority and private freehold along Darkes Forest Road. Small patches also exist in the quarry site off Bulli-Appin Road.	Most stands have been selectively logged. Patches at Darkes Forest have been partly cleared for agriculture. Three other areas have been partly cleared for clay quarry operations	Important locally as habitat because it differs markedly in composition and structure from surrounding vegetation on sandstone. Forests occur on Hawkesbury Shale further north, but have restricted distribution and differ in floristic composition.
Western Gully Forest	135 Ha (2.2%) Gullies and adjacent ridges in western part of area. The majority (690 Ha) is located outside the reserve in the O'Hares Creek Gorge to the north.	Selective logging in small accessible areas.	Likely to extend along western edge of Woronora Plateau to the Holsworthy Military Area in the north and Sydney Water catchments in the south. Near Wedderburn, Western Gully Forest is habitat for significant population of Koalas.
Eastern Gully Forest	1446 Ha (24%) Gullies in eastern part of area.	No obvious disturbance.	Similar vegetation is represented within Heathcote and Royal National Parks.
Riparian Scrub	171 Ha (2.8%) O'Hares and Stokes Creeks and their major tributaries.	Small weirs on O'Hares, Stokes and Maddens Creeks. Each creek is also crossed by one or two fords. Otherwise no evidence of disturbance.	Similar vegetation represented elsewhere. However, area is significant because of weed-free condition
Ironstone Woodland	205 Ha (3.4%) Restricted to two main patches. Along 10B management trail between Bulli-Appin Road and 10C management trail and from the head of O'Hares Creek to Maddens Plains.	Small gravel borrow pits.	Limited stands represented elsewhere.
Sandstone Woodland	3150 Ha (52.2%) Widespread throughout area.	Localised clearing for mine ventilation shafts.	Similar vegetation represented elsewhere.

Heath woodland	142 Ha (2.4%) Two main patches: along 10B management trail between its junction with 10C and 10K: and along 10H management trail near its junction with Darkes Forest Road.	Localised clearing for army camps.	Limited stands represented elsewhere.
Ironstone Heath	12 Ha (0.2%) Single small patch near 10B trig.	Small area cleared for gravel extraction.	Represented elsewhere.
Mallee Heath	28 Ha (0.3%) Small patches scattered in the eastern part of the area.	No obvious disturbance.	Eucalyptus luehmanniana characteristic of this community. Locally restricted community at southern limit of distribution.
Rock Pavement Heath	11 Ha (0.2%) Restricted to a few very small patches in the eastern and southern part of the area.	No obvious disturbance.	Highly restricted.
Banksia Thicket	45 Ha (0.7%) Restricted to patches in the south. A similar area exists within the Crown land to the south.	No obvious disturbance.	Limited areas represented elsewhere.
Sedgeland - Heath Complex (Restioid Heath, Sedgeland, & Cyperoid Heath)	612 Ha (10.1%) Patches scattered throughout the south and east of the area, especially Maddens Plains. Large area excluded from reserve to north of Nature Reserve, between Freeway and Princess Highway.	Small patches cleared for clay extraction.	Restricted distribution.
Ti-Tree Thicket	43 Ha (0.7%) Scattered in south and east of area.	No obvious disturbance.	Limited representation.

APPENDIX 3 - SIGNIFICANT PLANT SPECIES (after Keith 1994)

Species	Significance	Community
Acacia bynoeana	Vulnerable (TSC Act), 3VC-	Sandstone Woodland & Restioid Heath
Leucopogon exolasius	Vulnerable (TSC Act), 2VC- (southern limit)	Eastern Gully Forest
Pultenaea aristata	Vulnerable (TSC Act), 2VC-	Banksia Thicket, Restioid Heath & Mallee Heath
Blandfordia cunninghamii	3RC-	Western Gully Forest
Darwinia diminuta	3RCi (southern limit)	Mallee Heath
Darwinia grandiflora	2RC-	Woodland Heath & Restioid Heath
Epacris coriacea	3RC-	Eastern Gully Forest
Eucalyptus apiculata	2R	Restioid Heath, Mallee Heath & Rock Pavement Heath
Eucalyptus luehmanniana	2RCa (southern limit)	Mallee Heath
Gonocarpus salsoloides	3RCa (southern limit)	Cyperoid Heath & Sedgeland
Grevillia longifolia	2RC-	Eastern Gully Forest
Hibbertia nitida	2RC-	Eastern Gully Forest
Lomandra fluviatilis	3RC-	Riparian Scrub
Melaleuca deanei	Vulnerable (TSC Act), 3RC-	Sandstone Woodland
Monotoca ledifolia	3RC-	Rock Pavement Heath
Prasophyllum nublingii	2KC- (southern limit)	Sandstone Woodland
Tetraloche neglecta	3RC-	Sandstone Woodland, Ironstone Heath & Mallee Heath
Acacia stricta	uncommon in Sydney region	Shale Forest
Allocasuarina nana	Coastal locality of typical inland species	Mallee Heath
Allocasuarina paludosa	uncommon in Sydney region	Restioid Heath
Angophora hispida	Southern limit	Ironstone Heath & Mallee Heath
Banksia cunninghamii	Coastal locality of typical inland species	Eastern Gully Forest
Blechnum ambiguum	Uncommon	Eastern Gully Forest
Boronia serrulata	Uncommon & southern limit	Sandstone Woodland
Callitris endlicheri	Coastal locality of typical inland species & disjunct population	Rock Pavement Heath
Corybas fordamii	uncommon in Sydney region	Cyperoid Heath, Sedgeland & Restioid Heath
Doryanthes excelsa	Southern limit	Shale Forest & eastern Gully Forest
Eriachne glabrata	Southern limit	Restioid Heath
Eucalyptus ligustrina	Uncommon	Sandstone Woodland
Eucalyptus multicaulis	Uncommon	Sandstone woodland and Western Gully Forest
Eucalyptus squamosa	Uncommon	Western Gully Forest
Grevillia diffusa var. diffusa	Uncommon	Sandstone Woodland & Eastern Gully forest
Leucopogon amplexicaulis	Uncommon	Eastern gully Forest
Melaleuca squamea	uncommon in Sydney region	Cyperoid Heath
Melichrus urceolatus	uncommon in Sydney region	Sandstone woodland
Persoonia mollis subsp. nectans	Uncommon	Eastern Gully Forest
Pseudanthus orientalis	uncommon in Sydney region & southern limit	Banksia Thicket & Mallee Heath
Pultenaea divaricata	uncommon in Sydney region	Ti-Tree Thicket & Cyperoid Heath
Pultenaea hispidula	uncommon in Sydney region	Shale Forest
Tetraloche shiressii	Southern limit	Sandstone Woodland
Thelymitra circumsepta	uncommon in Sydney region	Restioid Heath & Ironstone Woodland

* N.B. The list of significant plant species above is not exhaustive, is only current at the time this plan was prepared, and should therefore not be relied upon as the most up-to-date listing.

Plant Species Significance Coding System

Vulnerable (TSC Act) Listed as Vulnerable in Schedule 2 of the Threatened Species Conservation Act, 1995.

Rare or Threatened Australian Plants (Briggs and Leigh 1988)

2 Species with a very restricted distribution in Australia and with a maximum geographic range of <100 km

3 Species with a range over 100 km but occurring in only small populations which are mainly restricted to highly specific and localised habitats

V Vulnerable species at risk of disappearing from the wild over a long period

R Rare

K Poorly known

C Population reserved

a Adequately reserved

i Inadequately reserved

- Adequacy of reservation unknown.