EIS 1331 Vol 2 Fauna impact

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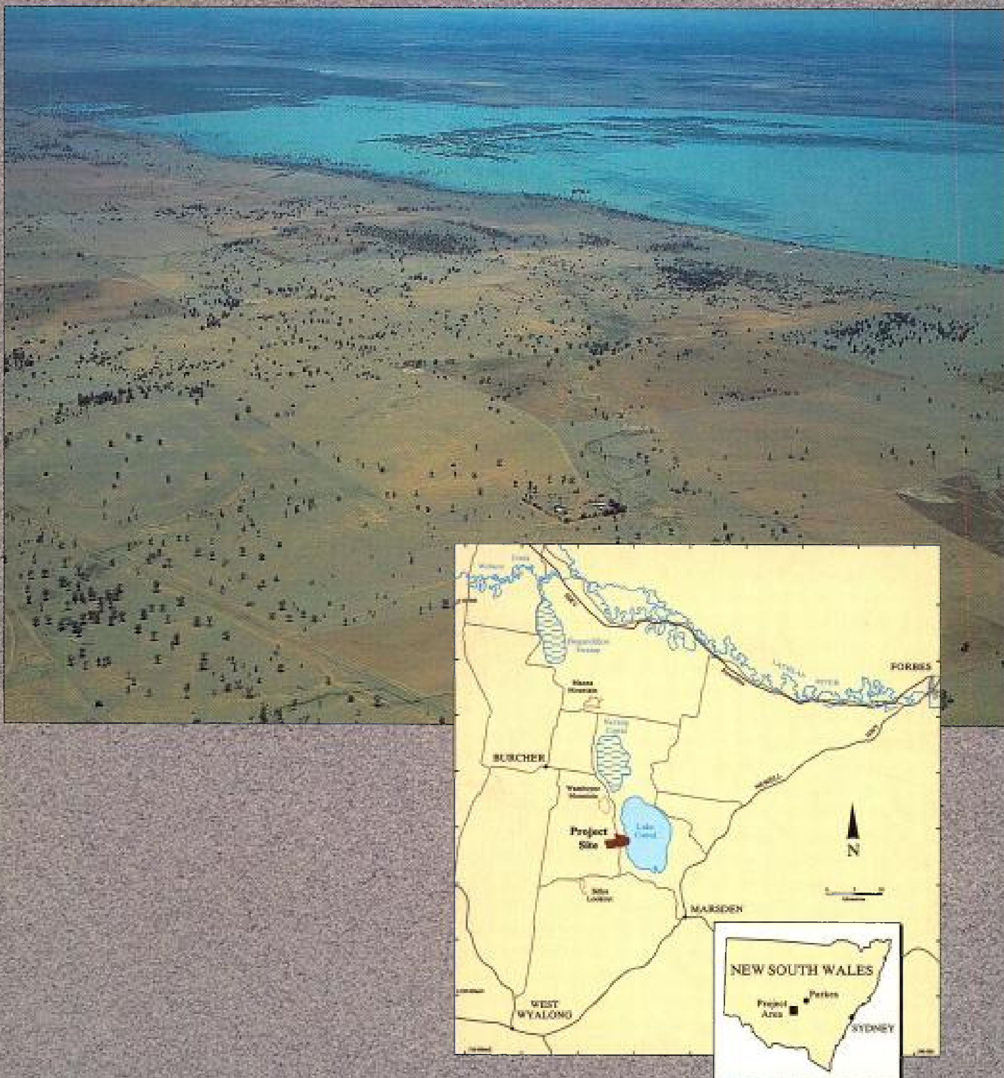
Lake Cowal gold project : environmental impact statement

NORTH

Lake Cowal Gold Project Environmental Impact Statement



Volume 2
Fauna Impact Statement & Fauna and Flora Studies (Appendices A-F)

August 1995

Environmental Consultants

North Mining Limited

Lake Cowal Gold Project

Environmental Impact Statement
Appendices A-F

CR 521/11
August 1995

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Lake Cowal Gold Project
Appendices A-F

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Lake Cowal Gold Project

Appendix A

FAUNA IMPACT STATEMENT

by

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August 1995

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

F Dominic Fanning

August 1995

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LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

F Dominic Fanning

August 1995

This Fauna Impact Statement has been prepared by the undersigned in accordance with Section 92D of the National Parks & Wildlife Act 1974, as amended by the Endangered Fauna (Interim Protection) Act 1991, after consultation with the Director-General of the NSW National Parks & Wildlife Service.

F Dominic Fanning BSc (Hons 1) MEIA MAIBiol MESA
Director and Principal

13th August 1995

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LAKE COWAL GOLD PROJECT
NORTH MINING LTD

FAUNA IMPACT STATEMENT

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LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

EXECUTIVE SUMMARY

F Dominic Fanning

August 1995

A Fauna Impact Statement (FIS) has been prepared to consider the endangered fauna and their habitats in an area proposed by North Mining (WA) Ltd for an open-pit goldmine and processing plant at Lake Cowal, NSW. The proposed mine operation will include an open-pit mine approximately 800m in diameter and 350m deep, located partly within the Lake, with the associated waste rock dump, tailings dam and ore treatment facilities located on the adjacent plains. The pit will be separated from the Lake waters by a bund, to ensure that there is no discharge from the mining operation into the Lake.

When full, Lake Cowal and the adjacent Nerang Cowal waterbodies cover an area of approximately 14600 ha, constituting a significant and substantial wetland. Lake Cowal is shallow and ephemeral, supplied by runoff from within its own catchment, and also by flooding from the Lachlan River to the north. During extended dry periods, the Lake dries out completely, and is used for agricultural purposes by the local landholders.

Detailed field investigations have been conducted in the Lake and around the proposed Project area, to identify the native fauna and habitats present. The areas to be disturbed by the mine operations on land are characterised as disturbed agricultural grasslands with small areas of open woodland and occasional small creeklines through pasture. The small portion of Lake shoreline and Lake shallows which are to be affected are also already disturbed, and support no features or resources of special value for endangered fauna.

Investigation of the terrestrial parts of the Project area and vicinity at Lake Cowal yielded a total of 124 species of native vertebrate fauna, including 96 bird species, 15 mammals, 7 reptiles and 6 amphibians.

No endangered 'terrestrial' fauna species were recorded on the Project area at Lake Cowal, although a number of Schedule 12 species have been recorded in and around the Lake, and several others are known from the region.

Four endangered 'terrestrial' fauna species were tentatively identified in the study area or nearby, including the Little Pied Bat *Chalinolobus picatus* and Troughton's Bat *Vespadelus troughtoni* (around Wamboyne Mountain), and the Greater Long-eared Bat *Nyctophilus timoriensis* approximately 9km to the northeast of the operation (NSW NP&WS Wildlife Atlas). Gilberts Whistler *Pachycephala inornata* was also sighted on Wamboyne Mountain (6km to the north) during the field surveys for this report.

An additional four endangered 'terrestrial' bird species are considered likely to occur in the region from time to time, on the basis of the habitats and resources present. These include the Painted Honeyeater *Grantiella picta*, Regent Honeyeater *Xanthomyza phrygia*, Pink Cockatoo *Cacatua leadbeateri* and the Superb Parrot *Polytelis swainsonii*.

Several additional species of endangered 'terrestrial' fauna could be present in the study area, as individuals have been recorded in the general area (NP&WS Wildlife Atlas, NSW Bird Atlas). However, given the generally depauperate and modified terrestrial habitats present, few species are anticipated to occur on the study area, other than on an occasional and transitory basis. Some species are considered unlikely to occur at all because the habitats available are not suitable (Malleefowl, Brush-tailed Rock-wallaby, Chestnut Quail-thrush), or unlikely to be dependent on the habitats present even if they do occur, given the mobility of the animals concerned (the Brolga, Black-breasted Buzzard, Pink Cockatoo and Yellow-bellied Sheathtail Bat). Several species have been recorded only a considerable distance from the Project area (the Malleefowl, Square-tailed Kite, Brush-tailed Rock-wallaby, Grey Falcon, Bush Stone-curlew, Swift Parrot and Chestnut Quail-thrush).

Waterbirds known from Lake Cowal which are endangered in NSW include the Australasian Bittern, Magpie Goose, Freckled Duck, Blue-billed Duck, Osprey, Painted Snipe and Black-tailed Godwit. Of these, only the Freckled Duck has been recorded on the Project area.

None of the endangered species considered in this FIS have been recorded breeding on the lands to be affected by the proposed mine operation. None of the 'terrestrial' species have been recorded on the project site at all, and of the endangered wetland birds, there have been only occasional sightings of the Freckled Duck in the Lake area which will be directly affected by the project. It is considered unlikely that any adverse impacts will be imposed on endangered native fauna as a result of the mine operation, given the design of the project and the impact amelioration measures proposed.

Features of the Lake Cowal project which are intended to avoid or mitigate impacts on native fauna, and in some instances to enhance the highly degraded habitats in the vicinity, include:

- the prevention of water and contaminant discharge from the mining and processing operations into Lake Cowal;
- careful construction of the bunds into Lake Cowal, to avoid significant impacts from sediment discharge into the Lake;
- extensive use of sediment control measures to limit sediment discharge from all works sites;
- an extensive habitat restoration and enhancement program over the Project site, including revegetation with Lignum and other native plant species on the perimeter bund, re-erection of removed dead River Red Gums to provide shelter and breeding resources for birds, creation of islands in the Lake near the mine to provide safe breeding sites for wetland birds, and other measures;
- appropriate management of all construction sites and subsequently of the tailings empoundments during their operation to minimise or avoid adverse impacts on native fauna. In particular, the tailings storages will be managed to minimise the concentrations of cyanide to relatively low levels, to limit the size of the decant ponds, and to discourage birds from using the tailings ponds;
- a specific habitat creation program for the waste rock dumps and tailings empoundments which will substantially increase the resources and habitats present in the area for endangered fauna;
- establishment of a pre-operations survey program and subsequent monitoring program to provide on-going management options for further enhancement of the local environment for endangered fauna. The potential for re-introduction of endangered species into the area once the operation and habitat re-creation activities have been completed is to be further explored.

Given the design of the proposed mining operations and the highly degraded nature of the existing habitats and features of the site, no adverse impacts on endangered fauna are considered likely to arise from the Lake Cowal mining operation. It appears unlikely that a "*take or kill*" of endangered fauna will arise as a result of the operations, although some minor disturbance to a few endangered species (notably waterbirds which could theoretically use the tailings storage facilities) could possibly occur. Consequently, a General (Section 120) Licence will be sought for these species. The species for which a Licence is being sought are the Freckled and Blue-billed Ducks, the Magpie Goose and the Brolga.

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LAKE COWAL GOLD PROJECT
NORTH MINING LTD

FAUNA IMPACT STATEMENT

F Dominic Fanning

August 1995

1 INTRODUCTION

This Fauna Impact Statement (FIS) considers the nature of the fauna assemblage and fauna habitats present on a proposed mine site at Lake Cowal (Figure 1). It addresses the potential impacts of the proposal on endangered fauna and their habitats, and recommends a range of impact amelioration measures. The FIS also supports an application from the proponent (North Mining Ltd) for a General (Section 120) Licence from the NSW National Parks & Wildlife Service to "*take or kill*" endangered fauna.

The proposed Lake Cowal Gold Project involves the excavation of ore from an open-cut pit, processing of the ore and extraction of gold on-site, and the deposition of wastes (tailings) in storage cells. The pit and plant are to be protected from Lake Cowal by a perimeter bund, constructed from waste rock (Figure 2). The mine plan involves extensive habitat restoration and rehabilitation, with the area ultimately intended to enhance conservation goals in the area. Details of the proposed development are included in Chapter 4 and Appendix 1 of this FIS.

Detailed fauna surveys have been conducted on the Project area for this FIS, and extensive investigations of the waterbirds of Lake Cowal commenced in 1989. The Lake and its fauna have been the subject of a number of studies over the past two decades. Additional information from previous investigations and from wildlife databases has been incorporated into this report, along with supplementary data from the general and scientific literature.

This Fauna Impact Statement has been prepared in accordance with the requirements of Section 92D of the National Parks & Wildlife Act 1974, as amended by the Endangered Fauna (Interim Protection) Act 1991. It has been structured according to Section 92D of the NP&W Act 1974 and by reference to the Director-General's requirements, which were obtained for its preparation (Appendix 2). The following chapters in this document contain the information required under Section 92D(1)(c) of the NP&W Act 1974:

- Chapter 2 addresses the fauna and fauna habitats present on the study area - Section 92D(1)(c)(i);
- Chapter 3 addresses the endangered fauna of the vicinity - Section 92D(1)(c)(ii);
- Chapter 4 addresses the development and its impacts - Section 92D(1)(c)(iii);
- Chapter 5 addresses the impact amelioration measures proposed and species to be licensed-Section 92D(1)(c)(iv); and
- Chapter 6 addresses the qualification of the FIS author and the information on which the report is based - Section 92D(1)(c)(v).

As required under Section 92D(1)(a) of the NP&W Act 1974, this Fauna Impact Statement is in writing. Additionally, as required under Section 92D(1)(b), the Fauna Impact Statement has been signed by the author (F Dominic Fanning of Gunninah Consultants).

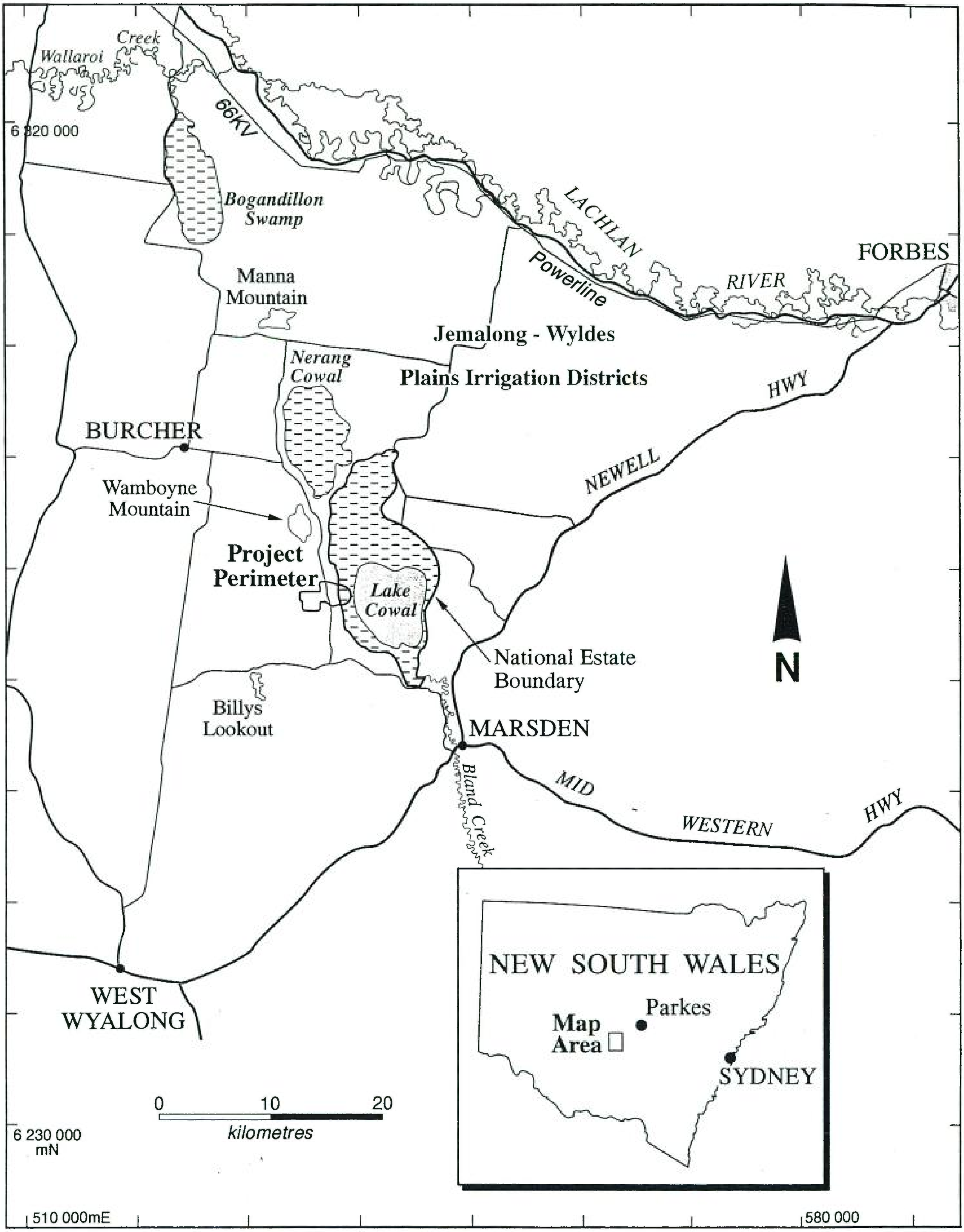

Figure 1: Location of the proposed Lake Cowal Gold Project.

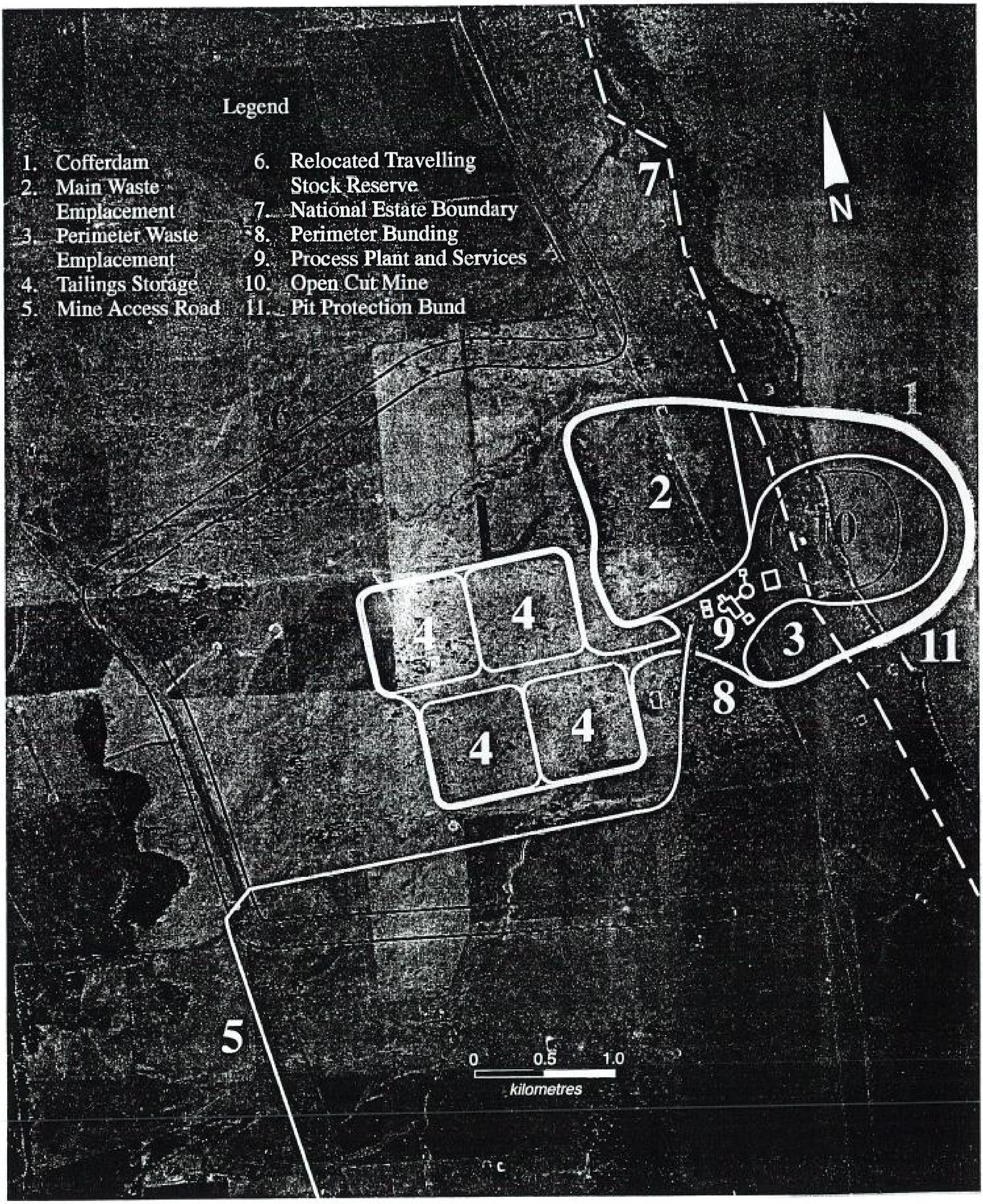

Figure 2: Layout of proposed Lake Cowal Gold Project operations.

2 FAUNA & FAUNA HABITATS

Section 92D(1)(c)(i) of the NP&W Act requires an FIS to provide:

> "*a full description of the fauna to be affected by the actions and the habitat used by the fauna*".

These requirements have been addressed by the conduct of site-specific and detailed field investigations, including 6 years of studies on the waterbirds of Lake Cowal. The FIS also includes information from a number of other studies conducted in the general area, and from databases on native fauna. As indicated in the Director-General's requirements, "*previous fauna studies may be incorporated as part of this work*".

Details of the results of investigations are provided in Sections 2.1 and 2.2 of this FIS, and "*a full description of the fauna to be affected by the actions and the habitat used by the fauna*" on the Project area and in the general vicinity are provided in Sections 2.3 and 2.4.

2.1 FAUNA SURVEY

In addition to the standard Section 92D(1)(c)(i) requirement for an FIS, the NSW NP&WS Director-General's requirements include:

> "*a fauna survey is required to be conducted in the area proposed for the development and surrounding areas likely to contribute to fauna habitat (study area). Sampling methodology should specifically target endangered species known or likely to occur in the study area. This will include but is not restricted to the Black-breasted Buzzard (Hamirostra melanosternon), Square-tailed Kite (Lophoictinia isura), Grey Falcon (Falco hypoleucos), Osprey (Pandion haliaetus), Magpie Goose (Anseranas semipalmata), Freckled Duck (Stictonetta naevosa), Blue-billed Duck (Oxyura australis), Australasian Bittern (Botaurus poiciloptilus), Australian Bustard (Ardeotis australis), Brolga (Grus rubicundus), Bush Thick-knee (Burhinus magnirostris), Black-tailed Godwit (Limosa limosa), Painted Snipe (Rostratula benghalensis), Glossy Black Cockatoo (Calyptorhynchus lathami), Pink Cockatoo (Cacatua leadbeateri), Swift Parrot (Lathamus discolor), Masked Owl (Tyto novaehollandiae), Regent Honeyeater (Xanthomyza phrygia), Pied Honeyeater (Certhionyx variegatus), Painted Honeyeater (Grantiella picta), Chestnut Quail-thrush (Cinclosoma castranotum), Southern Scrub-robin (Drymodes brunneopygia), Shy Hylacola (Sericornis cautus), Gilbert's Whistler (Pachycephala inornata), Greater Long-eared Bat (Nyctophilus timoriensis), Yellow-bellied Sheathtail-bat (Saccolaimus flaviventris), Koala (Phascolarctos cinereus), Bilby (Macrotis lagotis), Giant Burrowing Frog (Heleioporus australiacus). Previous fauna studies may be incorporated as part of this work*".

Throughout this report the Bush Thick-knee *Burhinus magnirostris* is referred to as the Bush Stone-curlew (Christidis & Boles 1994).

Detailed fauna surveys have been conducted on the Project site and through habitats in the general vicinity. Surveys for terrestrial-based fauna were conducted in April 1994 to identify the fauna present on the site and to investigate the extent and condition of habitats in the vicinity. Supplementary surveys have been conducted on several other occasions.

An extensive program of field investigations on Lake Cowal for waterbirds which inhabit, breed in or use the area, has been conducted since 1989 (see Bibliography). These investigations are summarised in the EIS for the Lake Cowal Gold Project (Appendices C & D in NSR 1995) and the results have been incorporated into this FIS. A total of 15 surveys have been conducted over the period from August 1989 to January 1995, and the monitoring of waterbird fauna at Lake Cowal is to continue.

Details of the survey activities and techniques applied during the site surveys are included in Section 2.2 of this FIS, and the results of this and previous fauna surveys in the vicinity are included in Section 2.3.

As required by the NSW NP&WS Director-General, survey methods were applied to "specifically target endangered species known or likely to occur in the study area. Specific survey techniques of relevance to individual endangered fauna species or to particular fauna groups were applied to the Lake Cowal site (Table 1). The species investigated include those listed in the Director-General's requirements for this FIS, although no particular efforts were required for some of the species (eg the Koala and the Bilby), and others recorded on relevant databases (NP&WS, RAOU, NSW Bird Atlassers). Dedicated bird surveys by an expert ornithologist (Mr Chris Chafer) were conducted through the terrestrial field surveys, and the extensive waterbird surveys provide an excellent database of species known from the vicinity.

A number of previous field surveys have been conducted in the Lake Cowal area. As this is a significant waterbird breeding and refuge site, considerable interest is engendered amongst ornithologists and interested naturalists. Previous field surveys within the Lake Cowal area, which were accessed for this FIS, include an investigation of all of the vertebrates at Lake Cowal (Vestjens 1977), a study of waterbird breeding at Lake Cowal (Lawler 1989), and a Draft Water Management Plan for the wetlands of the area (Hatton 1991). Other reports consulted include those of Lane (1990), EES (1994d), Crome (1995), Dent (1990), Schrader (1990) and the NPA (1990).

TABLE 1 Survey methods applied at Lake Cowal for endangered species listed in the NP&WS Director-General's FIS Requirements for the proposed Lake Cowal Gold Project, and for other endangered fauna known from the region.

NAME	SURVEY METHODS
MAMMALS	
Koala	no specific measures beyond spotlighting and diurnal searches (this species is not likely to be present in the general region).
Bilby	no specific measures beyond spotlighting and diurnal searches (this species is not likely to be present in the general region).
Greater Long-eared Bat	ultrasonic recordings, mist nets.
Yellow-bellied Sheathtail-bat	ultrasonic recordings, mist nets.
Little Pied Bat	ultrasonic recordings, mist nets.
Troughton's Bat	ultrasonic recordings, mist nets.
BIRDS	
Black-breasted Buzzard	bird surveys throughout the general area.
Square-tailed Kite	bird surveys throughout the general area.
Grey Falcon	bird surveys throughout the general area.
Osprey	bird surveys throughout the general area.
Magpie Goose	general bird surveys; detailed waterbird surveys 1989-1995.
Freckled Duck	general bird surveys; detailed waterbird surveys 1989-1995.
Blue-billed Duck	general bird surveys; detailed waterbird surveys 1989-1995.
Australasian Bittern	general bird surveys; detailed waterbird surveys 1989-1995.
Australian Bustard	bird surveys throughout the general area.
Brolga	bird surveys throughout the general area.
Bush Stone-curlew	bird surveys throughout the general area.
Black-tailed Godwit	bird surveys throughout the general area.
Painted Snipe	bird surveys throughout the general area.
Glossy Black Cockatoo	bird surveys throughout the general area.
Pink Cockatoo	bird surveys throughout the general area.
Superb Parrot	bird surveys throughout the general area.
Turquoise Parrot	bird surveys throughout the general area.
Swift Parrot	bird surveys throughout the general area.
Masked Owl	bird surveys throughout the general area.
Regent Honeyeater	bird surveys throughout the general area.
Pied Honeyeater	bird surveys throughout the general area.
Painted Honeyeater	bird surveys throughout the general area.
Chestnut Quail-thrush	bird surveys throughout the general area.
Southern Scrub-robin	bird surveys throughout the general area.
Shy Hylacola	bird surveys throughout the general area.
Gilbert's Whistler	bird surveys throughout the general area.
AMPHIBIANS	
Giant Burrowing Frog	amphibian surveys; call taping.

2.2 METHODS

The NSW NP&WS Director-General's requirements for this FIS include:

> *"a full description of the methodology used in the fauna survey (eg. dates of survey, weather conditions, number of traps, configuration of traps, etc.) Identification of reptiles, frogs and bats should be confirmed by a recognised authority (eg. Australian Museum) for species of taxonomic uncertainty".*

The survey methods employed for the preparation of this FIS involved two separate survey programs, one for the 'terrestrial' fauna and one for the lake-dependent waterbirds. The 'terrestrial' fauna survey was conducted in April 1994 by Gunninah Consultants and the waterbird surveys have been conducted over the period from 1989 to the present by several people (including Mr Brett Lane and EES). The results of the waterbird surveys over the six years of investigations at Lake Cowal have been summarised by Crome (Appendix C to the EIS).

The fauna survey methods employed for the 'terrestrial' fauna survey included the use of Elliott traps and pit traps, and habitat searches for 'terrestrial' mammals and reptiles, specific searches for amphibians with recordings of any amphibian calls, the use of an Anabat II ultrasonic recorder and mist nets for microchiropteran bats, and spotlighting surveys for arboreal mammals and forest owls (Figure 3). A specific and detailed bird survey was conducted throughout the study area and habitats in the general vicinity (Figure 4) conducted by a dedicated ornithologist (Mr Chris Chafer). Spotlighting surveys included both walked and driven searches along roads and tracks through the study area and generally through relevant habitats (for example, along the Lake shore and through forest and woodland communities), with records maintained of all species located. Details of the methods employed for the 'terrestrial' fauna surveys are included in Appendix 3.

Waterbird surveys on Lake Cowal involved searches along standard transects at eight locations within the study area (Figure 1). Surveys involved walked searches for specific distances along the Lake shoreline, recording all wetland bird species within the 100 metre wide transect of the Lake itself, as well as surveys conducted by boat within relevant lake habitats. The numbers of birds of each individual species recorded along each transect were recorded, with information including location, habitat being used, and breeding (as indicated by the presence of young). Details of the methods employed for the waterbird surveys are also included in Appendix 3, with analyses and base data included in Crome (1995).

2.3 FAUNA HABITATS

2.3.1 TERRESTRIAL HABITATS

The primary terrestrial fauna habitats/vegetation communities in the general area include patches of remnant Open Woodland, Open Forest and the predominantly cleared Grasslands that dominate the study area and the general region (Figure 5). Details of each habitat type are provided in Appendix 4.

- **Open Woodland**
  Open Woodland communities are patchily distributed throughout the general region and include several distinct types, each dominated by a different suite of tree species. The predominant Open Woodland community on the Project area (which will be subject to disturbance by the proposed mining activities) is dominated by Bimble Box *Eucalyptus populnea* to 10 metres, and Belah *Casuarina cristata*. The trees are generally heavily infested with Mistletoe, which provides a significant food resource for several native fauna species. This community supports very few trees with suitable nesting hollows.

- **Open Forest**
  This habitat is dominated by eucalypt and cypress species, with a groundcover of grasses and introduced weeds. It has been substantially modified and there is a conspicuous lack of understorey and shrub layers, as a consequence of long-term heavy grazing. Numerous scattered rock outcrops and hollow-bearing trees are present, which

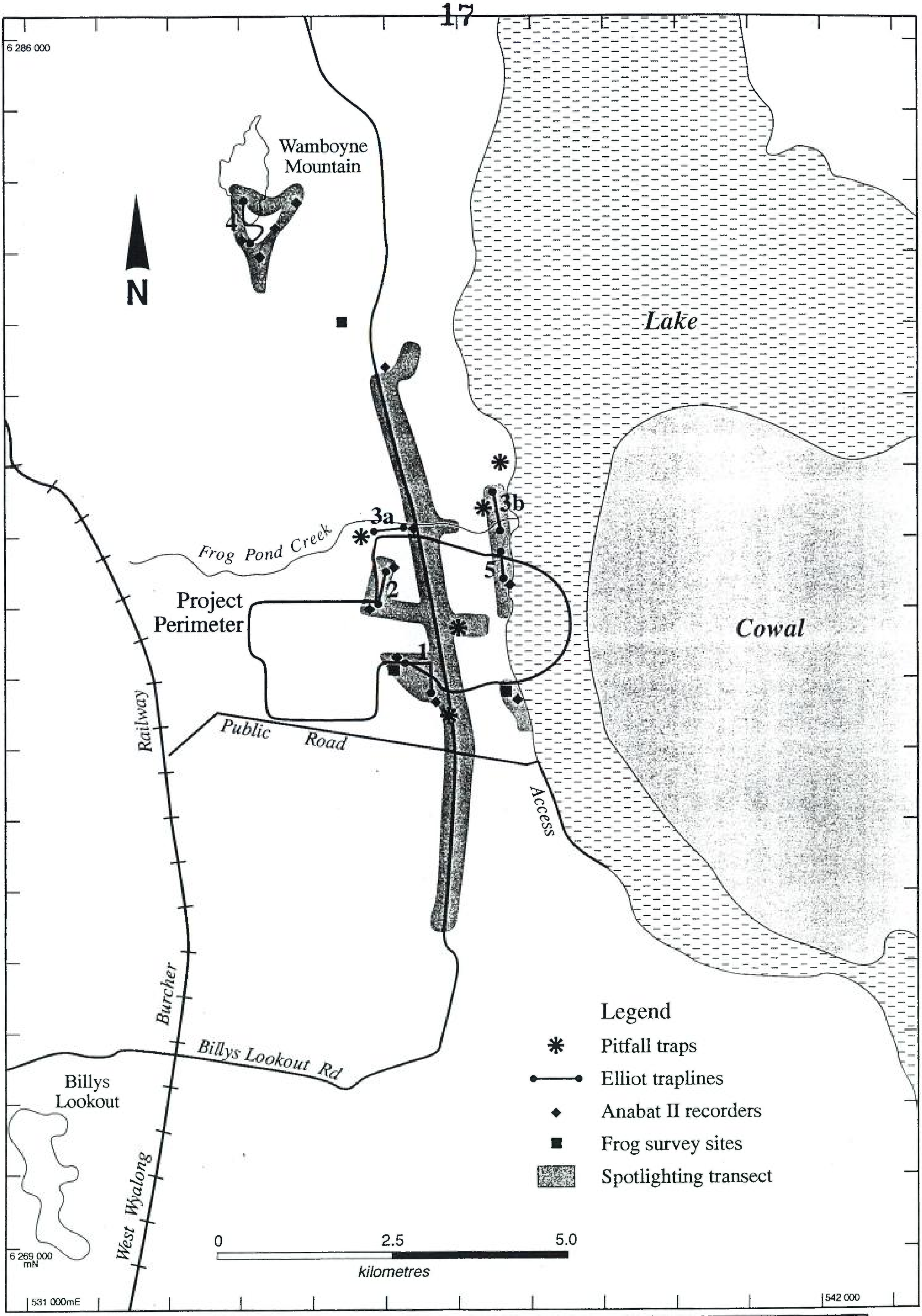

Figure 3: Fauna survey sites and methods applied for the terrestrial studies at Lake Cowal.

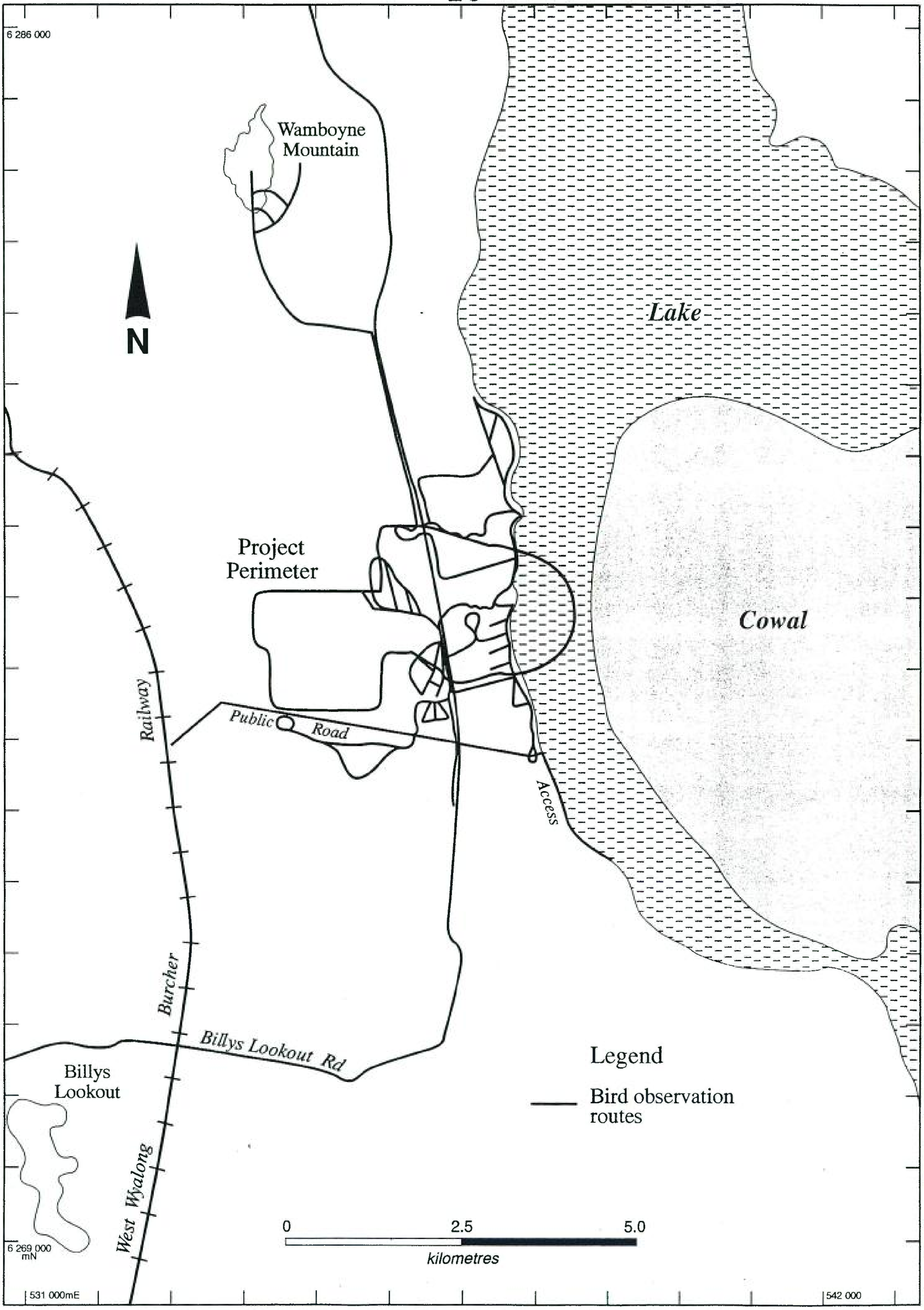

Figure 4: Bird survey transects for 'terrestrial' avifauna at Lake Cowal.

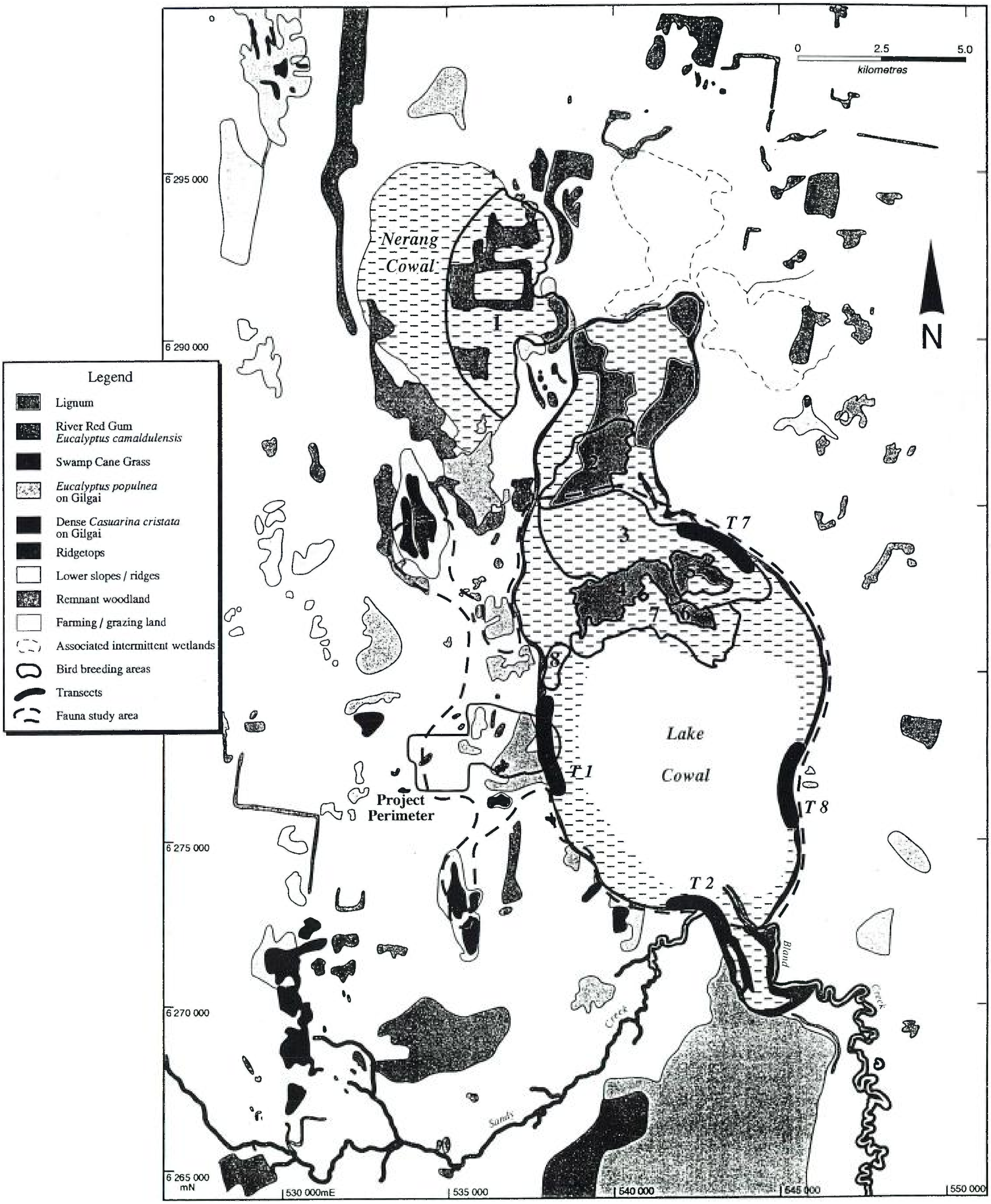

Figure 5: Areas surveyed for fauna at Lake Cowal, areas identified as waterbird breeding habitat, and fauna habitats, as defined by vegetation communities.

provide important potential habitat for many fauna species. This habitat was located only on Wamboyne Mountain, and is not characteristic of the Project site.

- **Lakeside Vegetation**
  The Lakeside habitat occupies a narrow strip along the foreshores of Lake Cowal, and comprises the ecotone between the aquatic environments and the Grasslands of the adjacent grazing lands. This is a mobile ecotone, changing in location as the Lake Water level alters. The major shoreline habitat is that marking the high water level of the Lake, and comprises a narrow band of mostly scattered River Red Gums *Eucalyptus camaldulensis* supporting tree-hollows. The area is also characterised by native and exotic grasses, with few native shrubs, and scattered patches of Lignum.

- **Grassland**
  Most of the proposed Project area consists of introduced pasture and grasslands, with scattered native trees or occasional stands, particularly in moister locations. Bimble Box *Eucalyptus populnea* is the common species in these areas, especially east of the access road and along Frog Pond Creek. Grassland habitats in the vicinity are generally heavily grazed, and most native plants and fauna have been excluded, except for a range of native grasses and small herbs.

  Frog Pond Creek is highly modified, but maintains several pools which provide suitable breeding habitat for amphibians. Additionally, the patches of Bimble Box provide otherwise scarce resources, such as tree-hollows, which are of significance for some elements of the fauna assemblage.

2.3.2 LAKE HABITATS

The Lake provides an important habitat for native waterbirds, and is recognised as of considerable significance in this regard. For this report, 6 separate habitats specifically associated with the Lake are recognised, involving the Lake itself and the immediately adjacent shoreline. Details of each habitat type are provided in Appendix 5.

- **Shoreline Habitat**
  This habitat occupies a narrow strip along the foreshores of Lake Cowal, and comprises the ecotone between the aquatic environment and the Grasslands of the adjacent grazing lands. When the Lake is full, the shoreline is characterised by a River Red Gum *Eucalyptus camaldulensis* community, either as scattered trees or occurring in discrete stands. It provides a substantial feeding resource and habitat for many wetland birds.

- **Lignum/Eucalypts**
  A large proportion of the northern margins of Lake Cowal are dominated by dense Lignum growth. Along the channels which drain into Lake Cowal when it is drier, stands of River Red Gums remain, including both dead and living trees. The combined River Red Gum canopy with a dense Lignum understorey and the intervening channels of open water provide a diverse habitat for a range of wetland birds, and many species nest and breed in these areas.

- **River Red Gum**
  The northern parts of Lake Cowal and portions of the western shore are characterised by broad open stands of River Red Gum woodland standing in shallow water. These areas do not generally include either Cane Grass or Lignum as an understorey and, when the Lake is drier, comprise an open grassy River Red Gum woodland. A combination of scattered dead and living trees are characteristic of this habitat, which provides a range of roosting opportunities for birds, as well as shelters for the Australian Water Rat *Hydromys chrysogaster* and sites of particular relevance for some of the native fish.

- **Shallow Water with Lignum**
  Extensive stands of Lignum shrubland occur in the slightly less frequently flooded areas in the northern part of Lake Cowal (Figure 5). This community covers a large area and consists of very large clumps of Lignum, with intervening shallow channels of water. These habitats provide valuable shelter, breeding and feeding resources for a range of wetland birds, as well as shelter and substrates for a substantial array of macroinvertebrates and fish.

- **Shallow Water with Cane Grass**
  This community is characteristic of a substantial proportion of the western and southern areas of Lake Cowal and occurs in the lowest and most frequently inundated parts of the Lake, up to a maximum depth of about 2 metres. It provides an array of refugia for some macroinvertebrate fauna and fish.

- **Open Water**
  A substantial proportion of Lake Cowal, particularly the deeper, most frequently inundated areas, are characterised by open water without emergent vegetation. This habitat provides some feeding resources and protection for wetland birds.

2.4 FAUNA of the STUDY AREA

2.4.1 TERRESTRIAL FAUNA

During this investigation of the proposed Project area, a total of 124 species of 'terrestrial' native vertebrate fauna have been observed or detected, including 96 bird species, 15 mammals, 7 reptiles and 6 amphibians (Appendix 6). Additional species derived from databases (NP&WS Wildlife Atlas, RAOU Atlas, NSW Bird Atlas) have been included in the fauna inventory, but many of these would not be expected in the immediate vicinity of the proposed Project area, because of the absence of relevant habitats or suitable resources. Data from previous fauna surveys from Lake Cowal and the immediate vicinity (including bird observers clubs and records from a local ornithologist) have also been included in the fauna inventories compiled for the area (Appendix 6).

MAMMALS

Only 3 native 'terrestrial' mammal species (the Echidna *Tachyglossus aculeatus*, Yellow-footed Antechinus *Antechinus flavipes* and Eastern Grey Kangaroo *Macropus giganteus*) were recorded from the Project area or from habitats in the vicinity during this investigation, (Appendix 6). All are common and widespread species, which have also been recorded within the Lake Cowal area in previous fauna studies (Vestjens 1977).

Only 5 of the 10 bat species (Appendix 6) recorded during specific surveys were found over the Project area, of which all are common to abundant over generally extensive distributional ranges. Two of the 10 species, the Little Pied Bat *Chalinolobus picatus* and Troughton's Bat *Vespadelus troughtoni*, recorded from Wamboyne Mountains are listed on Schedule 12 of the NP&W Act as Vulnerable & Rare, and are discussed in Appendix 7. It should be noted, however, that calls have only been tentatively assigned to these two species, and the identifications are not considered definite.

Two additional microchiropteran bat species, the Little Brown Bat *Vespadelus pumilus* (Vestjens 1977) and the Greater Long-eared Bat *Nyctophilus timoriensis* (NP&WS Wildlife Atlas), have been recorded from the general Lake Cowal area. The former is widespread, but the Greater Long-eared Bat is an endangered species in NSW.

BIRDS

Seventy 'terrestrial' birds were recorded on the study area or in the general vicinity during this fauna survey, of which 59 species were recorded from the Project area. An additional 11 species were located in the Wamboyne Mountain/'Coniston' area, most of which are expected to occur occasionally within the Project area. Included amongst these was Gilbert's Whistler, an endangered species.

However, no avian species of conservation significance were observed which could be considered dependent on the environmental resources present within the proposed Project area given their highly modified and degraded condition. Additionally, it should be noted that several bird species were observed foraging adjacent to and perching on the drill rigs, despite the rigs being in operation.

A small patch of Lignum *Muehlenbeckia cunninghamii*, located about 500-600 metres north of the drill site, supported a higher concentration of birds than did the sparser portions of the shoreline habitat. The Rufous Night Heron, Intermediate Egret, Little Egret, Australian White Ibis, Australian Crake and Variegated Fairy-wren were observed only at this location, and Whistling Kites, a pair of Little Falcons and a Peregrine Falcon were also observed over this small area of shoreline.

REPTILES

A range of widely distributed and abundant reptile species, including one gecko, three skinks, one dragon, one agamid and one elapid, were recorded during this investigation. Species detected during habitat searches included the Lace Monitor *Varanus varius*, Eastern Thick-tailed Gecko *Underwoodisaurus milli*, *Cryptoblepharus carnabyi* and the Eastern Brown Snake *Pseudonaja textilis* (Appendix 6).

An additional 24 reptile species have been recorded from around Lake Cowal or from within the general vicinity (Vestjens 1977; NP&WS Wildlife Atlas). However, the habitats present on the Project area are considered unlikely to be particularly suitable for most of these species, or do not provide unique or 'critical' resources.

AMPHIBIANS

Six amphibian species were recorded from pit traps through the study area during this investigation (Appendix 6), including Sloane's Froglet *Crinia sloanei*, the Crucifix Toad *Notaden bennettii*, Smooth Toadlet *Uperoleia rugosa*, Peron's Tree-frog *Litoria peronii*, Marsh Frog *Limnodynastes fletcheri* and the Spotted Grass Frog *L tasmaniensis*.

A further 5 amphibian species have been recorded from around the Lake or the general region (Vestjens 1977; NSW NP&WS Wildlife Atlas), including the Eastern Sign-bearing Froglet *Crinia parinsignifera*, Painted Frog *Neobatrachus pictus*, Green Tree-frog *Litoria caerulea*, Giant Banjo Frog *Limnodynastes interioris* and the Salmon-striped Frog *L salmini*.

No endangered amphibian species were detected in the study area during this investigation, and none are included on the NP&WS Wildlife Atlas for the region. All of the amphibian species recorded are common to abundant and widespread throughout their ranges.

2.4.2 LAKE FAUNA

BIRDS

A total of 79 wading or lake and wetland-dependent bird species have been recorded from Lake Cowal (Appendix 6) during investigations over the last 20 years (Vestjens 1977; EES 1992-1995; Lawler 1989; Lane 1990; Dent 1990; Hatton 1991; this investigation). Fifty six species have been recorded on the waterbird survey transects at Lake Cowal (Crome 1995).

Of the 79 avian species associated with the Lake and wetland habitats at Lake Cowal, 8 endangered bird species (as listed on Schedule 12 of the NP&W Act 1974) have been recorded. Additionally, several of the wetland species are listed on international conservation treaties to which Australia is a signatory (Table 2), including JAMBA (the Japan-Australia Migratory Bird Agreement), CAMBA (the China-Australia Migratory Bird Agreement), and BONN (the Agreement on Wetland Birds).

A number of avifauna species are noted as having geographical or breeding limits in the Lake Cowal region. Of the wading or wetland birds associated with the Lake itself or dependent on it, 10 species apparently either reach their known breeding or distributional limits at Lake Cowal. Amongst these are the endangered Freckled and Blue-billed Ducks, the Australasian Bittern, the Brolga (endangered in NSW), the Magpie Goose (endangered in NSW), and 4 wading species (Table 2).

OTHER LAKE FAUNA

In contrast to the waterbird fauna, few representatives of the other native vertebrate fauna (excluding piscean fauna, which are not considered in this FIS) depend on the habitats present within or immediately adjacent to Lake Cowal. Only 1 mammal (the Australian Water Rat *Hydromys chrysogaster*), 1 reptile (the Eastern Long-necked Tortoise *Chelodina longicollis*) and the amphibian species (Appendix 6) recorded in the vicinity of Lake Cowal are dependent upon aquatic habitats and, whilst reliant on aquatic habitats, are not restricted to the Lake itself.

TABLE 2 Bird species associated with Lake Cowal and included on Schedule 12 of the NP&W Act 1974, and those under International Treaties to which Australia is a signatory.

COMMON NAME	SCIENTIFIC NAME	TREATIES
Ardeidae		
Cattle Egret	*Ardeola ibis*	JAMBA, CAMBA
Great Egret	*Egretta alba*	JAMBA, CAMBA
★ Australasian Bittern	*Botaurus poiciloptilus*	
Threskiornithidae		
Glossy Ibis	*Plegadis falcinellus*	CAMBA
Anseranatidae		
★Magpie Goose	*Anseranas semipalmata*	
Anatidae		
★Freckled Duck	*Stictonetta naevosa*	
★Blue-billed Duck	*Oxyura australis*	
Accipitridae		
★Osprey	*Pandion haliaetus*	BONN
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	CAMBA
Gruidae		
★ Brolga	*Grus rubicundus*	
Rostratulidae		
★ Painted Snipe	*Rostratula benghalensis*	CAMBA
Charadriidae		
Lesser Golden Plover	*Pluvialis dominica*	JAMBA, CAMBA
Scolopacidae		
Ruddy Turnstone	*Arenaria interpres*	JAMBA, CAMBA
Greenshank	*Tringa nebularia*	JAMBA, CAMBA
Marsh Sandpiper	*Tringa stagnatilis*	JAMBA, CAMBA
Latham's Snipe	*Gallinago hardwickii*	JAMBA, CAMBA
★ Black-tailed Godwit	*Limosa limosa*	JAMBA, CAMBA
Bar-tailed Godwit	*Limosa lapponica*	JAMBA, CAMBA
Sharp-tailed Sandpiper	*Calidris acuminata*	JAMBA, CAMBA
Pectoral Sandpiper	*Calidris melanotos*	JAMBA, CAMBA
Red-necked Stint	*Calidris ruficollis*	JAMBA, CAMBA
Laridae		
Franklin's Gull	*Larus pipixcan*	
Caspian Tern	*Hydroprogne caspia*	JAMBA, CAMBA

★ Schedule 12 species (NP&W Act 1974, as amended 1992).

JAMBA Japan - Australia Migratory Bird Agreement.

CAMBA China - Australia Migratory Bird Agreement.

BONN Convention on the conservation of migratory species of wild animals.

3 ENDANGERED FAUNA and their HABITATS

Section 92D(1)(c)(ii) of the NP&W Act 1974 requires:

> "*an assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them*".

A detailed species profile for each of those endangered fauna considered relevant to the Lake Cowal Gold Project is provided in Appendix 7, including information on distribution, abundance, habitat requirements and reasons for the species decline. Endangered fauna are those species included on Schedule 12 of the NSW National Parks & Wildlife Act 1974, as amended in 1992.

3.1 RELEVANT ENDANGERED FAUNA

Only 1 endangered fauna species (the Freckled Duck) has been specifically recorded on the Project area at Lake Cowal, although a number of other Schedule 12 species have been recorded in and around the Lake, and several others are known from the region. Of those endangered species known from the vicinity, many are waterbirds associated with Lake Cowal and other regional wetlands (including the Australasian Bittern, Magpie Goose, Blue-billed Duck, Osprey, Painted Snipe and Black-tailed Godwit).

A total of 4 endangered fauna species were recorded or tentatively identified during 'terrestrial' fauna investigations in the vicinity of the Project area at Lake Cowal, or are included on other databases from the immediate vicinity. Ultrasonic calls, which could possibly be ascribed to two endangered microchiropteran bat species (Troughton's Bat and the Little Pied Bat), were obtained around Wamboyne Mountain, and the Greater Long-eared Bat has been recorded from the northeastern side of the Lake, approximately 9km to the northeast of the proposed pit (NSW NP&WS Wildlife Atlas). One other endangered fauna species, Gilbert's Whistler, was recorded on Wamboyne Mountain (6km to the north) during the field surveys for this report.

Several additional species of endangered 'terrestrial' fauna could be present in the vicinity of the proposed mine and its ancillary operations (Table 3), as individuals have been recorded in the general area (NP&WS Wildlife Atlas, NSW Bird Atlas). However, there are no data currently available to indicate the presence of any of these species on the Project area, either from this or previous investigations, despite the intensity of studies at Lake Cowal over an extended period. Furthermore, given the generally depauperate and modified terrestrial habitats present, few species are anticipated to occur specifically on the study area, other than on an occasional and transitory basis. Several are considered unlikely to be present in the vicinity of the Project area at all because the habitats available are not suitable (eg the Malleefowl, Brush-tailed Rock-wallaby and Chestnut Quail-thrush), or are considered unlikely to be dependent on the habitats present even if they do occur given the mobility of the animals concerned and the nature of the habitats present. Species in this latter category (known from the region but considered not particularly relevant to the mine proposal) include the Brolga, Black-breasted Buzzard, Pink Cockatoo, and several species that have been recorded only a considerable distance from the Project area (the Square-tailed Kite, Grey Falcon and Bush Stone-curlew).

The fauna habitats and vegetation communities of the Project area at Lake Cowal, including areas to be disturbed for waste emplacements, tailings storages and plant operations, are widely distributed through the landscape in the general region. The disturbed or modified Grassland and Open Woodland communities, and Lake habitats, present on the Project area are characteristic of southwestern NSW. Those areas which are to be disturbed are not considered 'critical' to the local survival of any endangered fauna species (they support no unique or special characteristics), although some individuals may irregularly use them. Habitat requirements of the endangered species listed in the NP&WS Director-General's FIS requirements, for the Lake Cowal Gold Project and others known from the vicinity are described in Table 4.

Only an insignificant area of any habitat, relative to their distributions through the general region, will be affected by the proposed development. Furthermore, the habitat restoration

TABLE 3 Endangered fauna (Schedule 12 species) known to occur on the Project area or in the general region, or which may theoretically be present on occasions. Likelihood of occurrence is based on the suitability of habitats on the Project site, and on previous records. Endangered species included in the Director-General's requirements which are considered unlikely to ever occur on the site are not included.

COMMON NAME	SCIENTIFIC NAME	REC'D	POSS	OCC
MAMMALS				
Little Pied Bat	*Chalinolobus picatus*			●
Greater Long-eared Bat	*Nyctophilus timoriensis*		●	
Troughton's Bat	*Vespadelus troughtoni*			●
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*			●
BIRDS				
Black-breasted Buzzard	*Hamirostra melanosternon*			●
Square-tailed Kite	*Lophoictinia isura*			●
Grey Falcon	*Falco hypoleucos*			●
Pink Cockatoo	*Cacatua leadbeateri*		●	
Superb Parrot	*Polytelis swainsonii*		●	
Turquoise Parrot	*Neophema pulchella*			●
Swift Parrot	*Lathamus discolor*			●
Regent Honeyeater	*Xanthomyza phrygia*		●	
Painted Honeyeater	*Grantiella picta*		●	
Pied Honeyeater	*Certhionyx variegatus*			●
Australasian Bittern	*Botaurus poiciloptilus*			●
Magpie Goose	*Anseranas semipalmata*			●
Freckled Duck	*Stictonetta naevosa*	●		
Blue-billed Duck	*Oxyura australis*		●	
Osprey	*Pandion haliaetus*			●
Brolga	*Grus rubicundus*			●
Painted Snipe	*Rostratula benghalensis*			●
Black-tailed Godwit	*Limosa limosa*			●
Bush Stone-curlew	*Burhinus magnirostris*			●
AMPHIBIANS				
Giant Burrowing Frog	*Heleioporus australiacus*			●

REC'D Recorded on the Project area or in the immediate vicinity.

POSS Possibly occurs on rare occasions (if present in the region) or may rarely use the resources present. No evidence for presence on the site or in the immediate vicinity.

OCC Could theoretically be present on occasions, although very rarely or briefly, if at all.

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and rehabilitation protocols recommended for the site are intended to enhance fauna habitats in the medium to long term (converse to expectations for fauna habitat under normal agricultural pursuits). Both the gilgai community (Open Woodland) and the Open Woodland on the small knoll on the project area are to be retained, and supplemented with extensive habitat restoration programs on the site.

As noted, only 1 endangered 'terrestrial' bird species and 3 microchiropteran bats have been (or may have been) recorded in the general locality of the Project area, although none of these were recorded on the Project site. These include Gilbert's Whistler *Pachycephala inornata* (considered unlikely to occur on the Project area because of a lack of suitable habitat), Little Pied Bat *Chalinolobus picatus*, Troughton's Bat *Vespadelus troughtoni* and Greater Long-eared Bat *Nyctophilus timoriensis*. An additional 7 bird species are considered likely to occur from time to time, on the basis of the habitats and resources present. These include the Pied Honeyeater *Certhionyx variegatus*, Painted Honeyeater *Grantiella picta*, Regent Honeyeater *Xanthomyza phrygia*, Turquoise Parrot *Neophema pulchella*, Superb Parrot *Polytelis swainsonii*, Swift Parrot *Lathamus discolor* and Pink Cockatoo *Cacatua* *leadbeateri* (Tables 3 and 4). However, none of these have been recorded on the Project site, and there are no records for several of these species in the general area (table 5). In addition, the Black-breasted Buzzard, as well as the Grey Falcon, Bush Stone-curlew and Square-tailed Kite could potentially occur on the Project area on occasions, although there are no unique or 'critical' resources present for these species.

Waterbirds associated with Lake Cowal include several endangered species which are known to use or could use the Project area. The only endangered species actually recorded on the Project site is the Freckled Duck, although several others (the Blue-billed Duck, Osprey and Black-tailed Godwit) could theoretically occur on occasions. Other endangered avifauna which could potentially be affected by the proposed operations (specifically in relation to the powerline from Forbes or the operation of the tailings storages) include the Magpie Goose and Brolga, both of which are extremely uncommon at Lake Cowal.

TABLE 4 Habitat requirements of the endangered species listed in the NP&WS Director-General's FIS requirements for the Lake Cowal Gold Project, and others known from the region.

NAME	HABITATS
MAMMALS	
Koala *Phascolarctos cinereus*	Open eucalypt forest and woodland, containing a variety of preferred food tree species, depending on locality and seasonal conditions (Hindell & Lee 1990). Theoretically suitable habitat, but no recent records for the area.
Bilby *Macrotis lagotis*	Arid to semi-arid woodland, shrubland and hummock grassland, particularly areas that are regenerating after fire (Strahan 1992); open areas and watercourses with suitable soil (Southgate 1990). No suitable habitat.
Greater Long-eared Bat *Nyctophilus timoriensis*	Dry open woodland of southern Australia and around River Red Gums lining watercourses and lakes on the open inland plains (Richards 1991a); thought to roost in tree-holes and under bark (Strahan 1992). Potential foraging habitat present on the Project site; limited roosting resources available.
Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*	Roosts in tree-hollows (Richards 1991b) and has been found in abandoned nests of the Sugar Glider (Hall & Richards 1979); thought to forage above the canopy of woodland (Parnaby 1992). Potential foraging habitat present on the Project site; limited roosting resources available.
Little Pied Bat *Chalinolobus picatus*	Roosts in caves, tree-holes and old mines of warm-temperate to tropical semi-arid to arid woodland (Richards 1991c; Strahan 1992). Potential foraging habitat present on the Project site; limited roosting resources available.
Troughton's Bat *Vespadelus troughtoni*	Warm-temperate to tropical woodland and sclerophyll forest (Strahan 1992); dwells in caves (Parnaby 1992). Potential foraging habitat present on the Project site; limited roosting resources available.
BIRDS	
Black-breasted Buzzard *Hamirostra melanosternon*	Tree-lined watercourses and ephemeral lakes and open woodlands of associated floodplains; nests in dead or partially dead trees usually near a watercourse (Marchant & Higgins 1993). Suitable habitat present, although significantly degraded.
Square-tailed Kite *Lophoictinia isura*	Coastal and subcoastal forests and woodland, and sometimes inland along wooded watercourses; usually nests in tall trees within 100m of a watercourse (Marchant & Higgins 1993). Suitable habitat present, although significantly degraded.

TABLE 3 contd Habitat requirements of the endangered species listed in the NP&WS Director-General's FIS requirements for the Lake Cowal Gold Project, and others known from the region.

NAME	HABITATS
BIRDS contd	
Grey Falcon *Falco hypoleucos*	Timbered lowland plains, acacia scrub, spinifex and tussock grassland; often nests in abandoned nests of crows and ravens within the canopy of mature dense forests (Marchant & Higgins 1993). Suitable habitat present, although significantly degraded.
Osprey *Pandion haliaetus*	Littoral habitats, terrestrial wetlands and coastal lands, ranging inland along large rivers (Marchant & Higgins 1993); nests near open water for fishing, the nest site requires an open position for access and visibility, and height or surrounding water for protection from predators; nest often constructed in tall dead trees or on cliffs or artificial structures (Marchant & Higgins 1993). Suitable habitat present, although predominantly a coastal species.
Magpie Goose *Anseranas semipalmata*	Tropical permanent lagoons in the dry season and flooded black soil plains during the wet; nests in dense vegetation in deep water, such as Lignum (Lindsey 1992; Marchant & Higgins 1990). Suitable habitat present at Lake Cowal, but not on the Project site.
Freckled Duck *Stictonetta naevosa*	Open lake and wetland sites, surrounded by thick vegetation such as Lignum, paperbarks and Cumbungi (Blakers *et al* 1984); its nest consists of a platform of finely woven twigs, usually surrounded by vegetation (Marchant & Higgins 1990). Suitable feeding habitat present on the Project site; no nesting resources.
Blue-billed Duck *Oxyura australis*	Cool to warm temperate deep, permanent freshwater lakes, lagoons and swamps, preferably with extensive reed beds (Lindsey 1992). Suitable feeding habitat present on the Project site; no nesting resources.
Australasian Bittern *Botaurus poiciloptilus*	Terrestrial wetlands and occasionally, estuarine habitats (Marchant & Higgins 1990); nest consists of trampled reeds in dense cover (Lindsey 1992). Suitable habitat present at Lake Cowal, but not on the subject site.
Australian Bustard *Ardeotis australis*	Grasslands, low shrublands and lightly timbered open woodlands, with a preference for tussock and hummock grasses (Marchant & Higgins 1993); nests on bare ground. Theoretically suitable habitat present, but no evidence of this species has been obtained from the immediate area.
Brolga *Grus rubicundus*	Swamps, shallow lagoons, grassland, saltmarsh, croplands (Lindsey 1992); terrestrial wetlands, grasslands and woodlands (Marchant & Higgins 1993). Suitable habitat present, although the eastern shore supports more appropriate habitats.
Bush Stone-curlew *Burhinus magnirostris*	"*Lightly timbered open forest and woodland, or partly cleared farmland with remnants of woodland, with a groundcover of short sparse grass and afew or no shrubs*" (Marchant & Higgins 1993). Potentially suitable habitat present on the Project site.
Black-tailed Godwit *Limosa limosa*	Variety of habitats including coral islets, coastal spits, marshes and bogs, estuarine mudflats and inland freshwater (Lindsey 1992). Potentially suitable habitat present on the Project site.
Painted Snipe *Rostratula benghalensis*	Dense swampy vegetation bordering shallow freshwater wetlands (Lindsey 1992); ephemeral or permanent lakes and swamps (Marchant & Higgins 1993). Very limited potentially suitable habitat present on the Project site; more appropriate habitat to the north.
Glossy Black Cockatoo *Calyptorhynchus lathami*	Inhabits forest and woodland, feeding on the cones of *Allocasuarina torulosa* and *A littoralis* (Garnett 1992b). No suitable habitat present on the Project site.
Pink Cockatoo *Cacatua leadbeateri*	Inhabits desert scrubs, open woodland, mallee, mulga, callitris woodlands and adjacent agricultural areas (Lindsey 1992). Potentially suitable habitat in the general area, although significantly degraded; very limited potential habitat on the Project site.

TABLE 3 contd Habitat requirements of the endangered species listed in the NP&WS Director-General's FIS requirements for the Lake Cowal Gold Project, and others known from the region.

NAME	**HABITATS**
BIRDS contd	
Superb Parrot *Polytelis swainsonii*	Inhabits woodlands dominated by River Red Gums (Blakers *et al* 1984); usually nests in a deep tree-cavity near water (Lindsey 1992). Potentially suitable habitat in the general area, although significantly degraded; very limited potential habitat on the Project site.
Turquoise Parrot *Neophema pulchella*	Woodland, open forests and timbered grasslands on mountain slopes, ridges or along watercourses, favouring the edges of woodlands adjoining grassland, or timbered ridges and tree-lined creeks that traverse farmlands (Forshaw & Cooper 1981); nests in small tree-hollows and holes in tree stumps and logs. Potentially suitable habitat in the general area, although significantly degraded; very limited potential habitat on the Project site.
Swift Parrot *Lathamus discolor*	Migrates from Tasmania to over-winter on the Australian mainland; inhabits woodland and open forest where it feeds on winter-flowering eucalypts such as Red Ironbark, White Box, Yellow Gum and Swamp Oak (Garnett 1992a). Potentially suitable habitat in the general area, although significantly degraded; very limited potential habitat on the Project site.
Masked Owl *Tyto novaehollandiae*	Tall open forest, open forest, riparian woodland, forest/farmland interface, wooded farmland, urban area with scattered trees, Hoop Pine plantations and sugar cane (Debus & Rose 1994); nests in large hollows in living or dead trees, usually in the trunk (Hollands 1991). Marginal habitat on the Project site; not recorded in the area.
Regent Honeyeater *Xanthomyza phrygia*	Woodland and open forest with a tall shrub layer where eucalypt species, in particular Red Ironbark, White Box and Yellow Gum, are flowering (Garnett 1992a; Franklin *et al* 1989). Potentially suitable habitat in the general area, although significantly degraded; very limited potential habitat on the Project site.
Pied Honeyeater *Certhionyx variegatus*	Inhabits acacia scrub, mallee, spinifex and eucalypt woodland, usually were shrubs are flowering, and requires mistletoe and a variety of tubular flowers for food (Blakers *et al* 1984). Potentially suitable habitat in the general Project area, although significantly degraded; limited potential habitat on the Project site.
Painted Honeyeater *Grantiella picta*	Requires heavy infestations of mistletoe of the *Amyema* genus (Lindsey 1992; Garnett 1992a). Potentially suitable habitat in the general Project area, although significantly degraded; limited potential habitat on the Project site.
Chestnut Quail-thrush *Cinclosoma castanotus*	Inhabits acacia scrub and mallee, including that where the understorey is dominated by spinifex (Blakers *et al* 1984). No suitable habitat on the Project site.
Southern Scrub-robin *Drymodes brunneopygia*	Inhabits acacia scrub and mallee, specially where Broombush is common (Blakers *et al* 1984). Potentially suitable habitat in the general area, although significantly degraded; no suitable habitat on the Project site.
Shy Hylacola *Sericornis cautus*	Dense whipstick mallee; coastal dune scrub; sandplain heath (Lindsey 1992). No suitable habitat on the Project site.
Gilbert's Whistler *Pachycephala inornata*	Temperate mallee; mulga and other drier woodlands; Lignum and melaleuca thickets (Lindsey 1992). Suitable habitat in the region (eg Wamboyne Mountain); no suitable habitat on the Project site.
AMPHIBIANS	
Giant Burrowing Frog *Heleioporus australiacus*	Inhabits creeklines in woodland and open forest (Tyler 1992), and is believed to live in burrows in the banks of small creeks; breeds along small creeklines in flat terrain (Cogger 1992). Potentially suitable habitat on the Project site, although no evidence for presence.

3.2 STATE and REGIONAL CONSIDERATIONS

Section 92D(1)(c)(ii) of the NP&W Act 1974 requires:

> *"an assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them".*

3.2.1 DISTRIBUTIONS

FAUNA

The statewide and regional distributions of those endangered species considered likely "*to be affected by the actions*", as well as species included on the Director-General's requirements for this FIS, and other species known from or likely to occur in the general vicinity are included in Table 5. These data have been collated from a variety of sources, including standard reference books (Strahan 1991, 1992; Lindsey 1992; Tyler 1992; Cogger 1991; Marchant & Higgins 1990, 1993; Garnett 1992a,b; Swan 1990; Parnaby 1992; Wilson & Knowles 1992; Morris *et al* 1981), as well as from available databases, published works and the scientific literature (see Bibliography).

The regional distribution of records from the NP&WS Wildlife Atlas are defined as records of species on the four 1:10000 map sheets which surround Lake Cowal (Bogan Gate #8431; Marsden #8430, Condobolin #8331; Wyalong #8330). These four maps cover an area around Lake Cowal 93km wide (east-west) and 110km long (north-south) or 10230 square kilometres.

Of the 6 endangered mammals considered in Table 5, only the Greater Long-eared Bat and Yellow-bellied Sheathtail Bat have state and regional distributions which include the Lake Cowal area. The Yellow-bellied Sheathtail Bat has a very widespread distribution throughout NSW, and whilst there are no records on the NP&WS Wildlife Atlas, this species is regarded as likely to occur in the region. The Greater Long-eared Bat has been recorded within 5km of the Lake Cowal site (Table 5). The two microchiropteran bat species which have been tentatively identified from calls in the Wamboyne Mountain area (the Little Pied Bat and Troughton's Bat) do not have statewide or regional distributions which would normally include the Lake Cowal area. It is possible, therefore, that these tentative identifications are incorrect and that the species present are the Chocolate Wattled Bat *Chalinolobus morio* or Gould's Wattled Bat *Chalinolobus gouldii* and the Pale Bat *Vespadelus vulturnus*.

The Koala was probably historically present in this general region but has long disappeared from the western portions of its original distribution. Similarly, the Bilby may have originally occurred in this general region (200 years ago), but there are no known sightings of this species within NSW in recent times.

Most of the 26 endangered birds listed in Table 5 have statewide and regional distributions which include the Lake Cowal area. The majority of these species have been recorded either frequently or infrequently in the region (according to the RAOU Atlas - Blakers *et al* 1984) and the majority are also included on the regional NP&WS Wildlife Atlas.

The relevance of any of these species to the proposed Lake Cowal Gold Project is related principally to the presence or otherwise of suitable habitat on the Project site and to the proposed habitat restoration program, which is intended to re-create vegetation communities and habitats typical of the area prior to the commencement of agricultural activities. Determination of the relevance of these species to the proposed gold mine Project is considered in more detail in Section 3.3 of this FIS.

Only 1 amphibian is included in the Director-General's requirements for this FIS. The statewide distribution of the Giant Burrowing Frog does not include the Lake Cowal region, and there are no regional or local records for this species on the NP&WS Wildlife Atlas (Table 5).

TABLE 5 The state, regional and local distributions of the endangered species listed in the NP&WS Director-General's FIS requirements for the Lake Cowal Gold Project, and others known from the region.

NAME	DISTRIBUTION
MAMMALS	
Koala	STATE: Eastern NSW, particularly east of the Great Dividing Range and through northeastern NSW (Lunney *et al* 1990; Phillips 1990). REGION: No records for the region (NP&WS Wildlife Atlas); not included in any recent regional studies. LOCAL: Not recorded on the Project area or in the vicinity.
Bilby	STATE: Not currently extant in NSW. REGION: No records for the region (NP&WS Wildlife Atlas); not included in any recent regional studies. LOCAL: Not recorded on the Project area or in the vicinity.
Greater Long-eared Bat	STATE: On the slopes and plains west of the Great Dividing Range (Hall & Richards 1979); all of western NSW (Parnaby 1992). REGION: 2 records at Lake Cowal (NP&WS Wildlife Atlas); 1 to the southwest near Billys Lookout Creek; 1 near the northern perimeter of the Lake. LOCAL: Not recorded during this investigation.
Yellow-bellied Sheathtail Bat	STATE: Widespread, except perhaps for the very arid inland (Hall & Richards 1979); all of NSW (Parnaby 1992). REGION: No records (NP&WS Wildlife Atlas), although likely to occur. LOCAL: Not recorded on the Project area.
Little Pied Bat	STATE: Northwestern NSW (Hall & Richards 1979; Parnaby 1992). REGION: No records from the region (NP&WS Wildlife Atlas). LOCAL: Tentatively recorded in the study area during this investigation, although restricted to the Wamboyne Mountain-'Coniston' area; high probability of a mis-identification.
Troughton's Bat	STATE: Eastern NSW, east and west of Great Dividing Range (Strahan 1992), south to Wadbilliga Swamp, South Coast (Parnaby 1992). REGION: No records for the region (NP&WS Wildlife Atlas). LOCAL: Tentatively recorded in the study area during this investigation, although restricted to the Wamboyne Mountain-'Coniston' area.
BIRDS	
Black-breasted Buzzard	STATE: Recorded on the Western Plains, Central-west Slopes and east to Moree; most numerous in upper Western region (Morris *et al* 1981). REGION: Recorded infrequently in region (Blakers *et al* 1984); 1 record for the region, at Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 4 other sources at Lake Cowal (Appendix 6).
Square-tailed Kite	STATE: Recorded in all regions, but more numerous in the east than the west, frequently recorded on the coast (Debus *et al* 1993). REGION: Recorded infrequently in region (Blakers *et al* 1984); 2 records for the region, 2 locations; 1 record at Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded on the Project area or in the vicinity.
Grey Falcon	STATE: Most numerous, but sparse in the Murray-Darling Basin and northwest; vagrant east of the Great Dividing Range (Marchant & Higgins 1993). REGION: Recorded infrequently in region (Blakers *et al* 1984); 39 records in the region, 1 location >50km northeast of Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded on the Project area or in the vicinity.
Osprey	STATE: Coastal NSW, with occasional occurrences along waterways inland (Marchant & Higgins 1990; Clancy 1989, 1991, 1993). REGION: 1 record within 5km of Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 4 other sources at Lake Cowal (Appendix 6).
Magpie Goose	STATE: Disappeared by 1920, but has increased in numbers of records in central and northeast (Marchant & Higgins 1990). REGION: 6 records for the region; 3 locations; 3 records at 1 location, at Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 6 other sources at Lake Cowal (Appendix 6).

TABLE 5 contd The state, regional and local distributions of the endangered species listed in the NP&WS Director-General's FIS requirements for the Lake Cowal Gold Project, and others known from the region.

NAME	**DISTRIBUTION**
BIRDS contd	
Freckled Duck	STATE: All regions of NSW, except for the South Coast; most numerous in the Riverina and Western regions and seldom recorded on the coast (Morris *et al* 1981). REGION: Frequently recorded in region (Blakers *et al* 1984); 15 records in region; 3 locations; 6 records at 1 location, at Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 10 other sources at Lake Cowal (Appendix 6); recorded on the actual mine site during Waterbird Monitoring Surveys (EES 1995).
Blue-billed Duck	STATE: Widespread with most records in northwest and Murray-Darling Basin (Marchant & Higgins 1990). REGION: Recorded infrequently in region (Blakers *et al* 1984); 7 records for region; 3 locations; 3 records at 1 location, at Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 9 other sources at Lake Cowal (Appendix 6).
Australasian Bittern	STATE: Widespread; most numerous in the Murray-Darling Basin, including a large influx of breeding birds in the southwest (Marchant & Higgins 1990; Morris *et al* 1981). REGION: 1 record in the region at the Lachlan River >50km from Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 2 other sources at Lake Cowal (Appendix 6).
Australian Bustard	STATE: Most abundant in Upper Western region, and east to Barwon River, Cobar, Narrandera and Barham (Morris *et al* 1981). REGION: 1 record for the region 28.5km to the southeast (NP&WS Wildlife Atlas). LOCAL: Not recorded on the Project area.
Brolga	STATE: Mainly northwest, and less often in lower western and central-western plain (Morris *et al* 1981). REGION: 5 records for the region; 4 locations; 2 records at 1 location, at Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 6 other sources at Lake Cowal (Appendix 6).
Bush Stone-curlew	STATE: Recorded in all regions, but most numerous in the western slopes and plains, and Riverina near the Murray-Darling basin; generally absent east of the Great Diving Range (Marchant & Higgins 1993; Morris *et al* 1981). REGION: Recorded infrequently in region (Blakers *et al* 1984); 8 records for the region, 2 locations; >30km southwest and >50km northeast of Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded on the Project area.
Black-tailed Godwit	STATE: Scattered throughout coastal and inland NSW (Blakers *et al* 1984). REGION: No records for the region (NP&WS Wildlife Atlas; Blakers *et al* 1984). LOCAL: Not recorded during this investigation, but recorded by 2 other sources at Lake Cowal (Appendix 6).
Painted Snipe	STATE: Most records from the Murray-Darling region (Garnett 1992b). REGION: Frequently recorded (Blakers *et al* 1984); 1 record for the region, >50km northeast of Lake Cowal on the Lachlan River (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by 4 other sources at Lake Cowal (Appendix 6).
Glossy Black Cockatoo	STATE: East coast, Great Dividing Range and westward to Cobar and Griffith (Lindsey 1992). REGION: Frequently recorded in region (Blakers *et al* 1984); no records contained in the NP&WS Wildlife Atlas. LOCAL: Not recorded on the Project area or in the vicinity.
Pink Cockatoo	STATE: West of the Great Dividing Range (Morris *et al* 1981). REGION: Infrequently recorded breeding in region (Blakers *et al* 1984); 2 records for the region, 2 locations; 1 record at Lake Cowal (NP&WS Wildlife Atlas). LOCAL: Not recorded during this investigation, but recorded by the NSW Bird Atlas for the area.

TABLE 5 contd The state, regional and local distributions of the endangered species listed in the NP&WS Director-General's FIS requirements for the Lake Cowal Gold Project, and others known from the region.

NAME	DISTRIBUTION	
BIRDS contd		
Superb Parrot	STATE:	Interior NSW; northern and western slopes of the Great Dividing Range (Morris *et al* 1981).
	REGION:	Infrequently recorded breeding in region (Blakers *et al* 1984); 92 records for the region, 6 locations; 85 records at 1 location >50km northeast of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded during this investigation, but recorded by 3 other sources at Lake Cowal (Appendix 6).
Turquoise Parrot	STATE:	This species is generally located in all regions of NSW, except for the upper western region (Morris *et al* 1981).
	REGION:	Recorded infrequently (Blakers *et al* 1984); 18 records for the region; 4 locations; 16 records within Webbin Mountains National Park 50km to the southeast of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded during this investigation; no records for the vicinity.
Swift Parrot	STATE:	Winter (March to September) nomadic visitor to central and eastern coastal NSW (Garnett 1992a).
	REGION:	Recorded infrequently (Blakers *et al* 1984); 1 record for the region >30km southwest of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded on the Project area; no records for the vicinity.
Masked Owl	STATE:	Thinly distributed over much of NSW (Debus & Rose 1994).
	REGION:	No records for the region (NP&WS Wildlife Atlas; Blakers *et al* 1984).
	LOCAL:	Not recorded on the Project area.
Regent Honeyeater	STATE:	Eastern NSW, lands west of the Great Dividing Range, on the western slopes and adjacent tablelands (Garnett 1992a).
	REGION:	Recorded infrequently (Blakers *et al* 1984); 2 records in the region >30km southwest of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded on the Project area; no records for the vicinity.
Pied Honeyeater	STATE:	Occurs inland, encompassing western regions of NSW; extends east to about Warrego River, Cobar, Ivanhoe and Wentworth (Morris *et al* 1981).
	REGION:	No records for the region (NP&WS Wildlife Atlas; Blakers *et al* 1984).
	LOCAL:	Not recorded on the Project area; no records for the vicinity.
Painted Honeyeater	STATE:	Greatest concentrations and all breeding occurs on the inland slopes of the Great Dividing Range (Garnett 1992a).
	REGION:	7 records in the region; 5 locations; 1 record at Lake Cowal; 1 record within Webbin Mountains National Park 50km to the southeast of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded during this investigation, but recorded by 5 other sources at Lake Cowal (Appendix 6).
Chestnut Quail-thrush	STATE:	West of the Great Dividing Range (Morris *et al* 1981).
	REGION:	Frequently recorded (Blakers *et al* 1984); 1 record for the region southwest of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded on the Project area; no records for the vicinity.
Southern Scrub-robin	STATE:	Central NSW and the southwest corner (Morris *et al* 1981).
	REGION:	Frequently recorded in region (Blakers *et al* 1984); 9 records in the region; 1 location >30km southwest of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded on the Project area; no records for the vicinity.
Shy Hylacola	STATE:	Central NSW, southwest corner (Morris *et al* 1981).
	REGION:	Frequently recorded breeding (Blakers *et al* 1984); 21 records for the region; 1 location >40km southwest of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded on the Project area; no records for the vicinity.
Gilbert's Whistler	STATE:	Predominantly west of the Great Dividing Range (Morris *et al* 1981).
	REGION:	Frequently recorded (Blakers *et al* 1984); 37 records in the region; 3 locations; 6 records within Webbin Mountains National Park 50km to the southeast of Lake Cowal (NP&WS Wildlife Atlas).
	LOCAL:	Recorded during this investigation in the general area Project area, but restricted to the Wamboyne Mountain-'Coniston' area.
AMPHIBIANS		
Giant Burrowing Frog	STATE:	Ranges and coast from central coast of NSW to eastern Victoria (Cogger 1992).
	REGION:	No records for the region (NP&WS Wildlife Atlas).
	LOCAL:	Not recorded on the Project area, or recorded in the vicinity.

HABITATS

The terrestrial habitats which are characteristic of the Lake Cowal Gold Project area comprise disturbed and modified agricultural lands characterised by grasses, pasture, scattered trees and small copses of regenerating or regrowth Open Woodland vegetation. These terrestrial habitats are typical of the dry western slopes and plains of NSW and are extremely extensive throughout this portion of the state.

The Lake habitats associated with the areas to be disturbed by the proposed mining operation are less widely distributed. Lake Cowal is recognised as a significant wetland in western NSW, and in regional terms is one of the most important wetlands in this part of NSW. Ephemeral lakes occur sporadically throughout the general region, and include sites such as Nerang Cowal, Bogandillon Swamp and a number of smaller lakes and wetlands associated with the Lachlan and Murrumbidgee River systems. Thus, these habitats are widely distributed throughout the state and the region, although are patchy and localised in occurrence.

3.2.2 ENVIRONMENTAL PRESSURES

In general terms, the clearing, degradation or destruction of habitat is regarded as the most significant adverse environmental pressure on endangered fauna and their habitats. Habitat fragmentation or destruction appears to have been responsible for most of the vertebrate fauna extinctions in Australia and for the decline in populations that are responsible for many of these native species being considered endangered.

The NP&WS lists a range of specific criteria describing the environmental pressures on endangered fauna. Population declines are generally related to habitat destruction or fragmentation and are often the result of a relatively high degree of ecological specialisation by those species. The environmental pressures designated by the NP&WS (1992) as relevant to the individual endangered fauna species considered in this FIS are included in Table 6.

In statewide and regional terms, the effects of large scale habitat clearing for agricultural purposes has imposed considerable environmental pressures on the native fauna of the Lake Cowal region. This situation is particularly so for endangered species which generally are either dependent upon a narrow range of specific habitat components or features (ie are "*ecological specialists*") or are now dependent upon a widely scattered and thinly distributed resource base.

For the relevant 'terrestrial' mammals known from the study area or expected to occur (the microchiropteran bats), the specific statewide and regional environmental pressures which pertain to these species are unknown. However, they probably relate to the substantial clearing of forest and woodland communities and the consequent reduction in available roosting resources and suitable foraging habitat (although for most microchiropteran bats there is no evidence of population or range declines).

For the 'terrestrial' birds known from the general region and considered relevant to this proposal, the major environmental pressure relates to the degradation or destruction of habitat. The removal of native woodland communities over large tracts of the surrounding landscape has involved a significant reduction in suitable resources for these species, particularly nesting hollows in trees and feeding resources in the woodland trees through the region. For species such as the Bush Stone-curlew, the Brolga and Australian Bustard, which prefer open woodland and grassland communities, the continuing pastoral activities and agricultural pursuits in the area are likely to present environmental pressures as a result of the grazing of stock, ploughing of fields and general disturbance. These environmental pressures apply on a statewide and regional basis.

For the wetland birds associated with Lake Cowal and which may be present on or in the vicinity of the proposed Project area, the statewide and regional environmental pressures which pertain are also those principally associated with habitat degradation or destruction. In addition, many of these species may be threatened on a statewide or regional basis as a result of the annual duck shooting season, during which a considerable number of endangered birds are shot at Lake Cowal.

TABLE 6 Reasons for species inclusion on Schedule 12 of the NP&W Act (1974), from the NSW National Parks & Wildlife Service (1992).

NAME	REASONS
MAMMALS	
Koala *Phascolarctos cinereus*	population and distribution severely reduced; poor recovery potential; threatening processes severe; ecological specialist.
Bilby *Macrotis lagotis*	extinct.
Greater Long-eared Bat *Nyctophilus timoriensis*	population and distribution suspected to be reduced; threatening processes severe; ecological specialist.
Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*	population suspected to be reduced; ecological specialist.
Little Pied Bat *Chalinolobus picatus*	population suspected to be reduced; concentrates; poor recovery potential; threatening processes severe; ecological specialist.
Troughton's Bat *Vespadelus troughtoni*	population and distribution suspected to be reduced; concentrates; threatening processes severe; ecological specialist.
BIRDS	
Black-breasted Buzzard *Hamirostra melanosternon*	population and distribution reduced to a critical level; poor recovery potential; threatening processes severe.
Square-tailed Kite *Lophoictinia isura*	population reduced to critical level; poor recovery potential; threatening processes severe; ecological specialist.
Grey Falcon *Falco hypoleucos*	population reduced to a critical level; poor recovery potential; threatening processes severe; ecological specialist.
Osprey *Pandion haliaetus*	population critical, but suspected to be stable; poor recovery potential; threatening processes severe; ecological specialist.
Magpie Goose *Anseranas semipalmata*	population critical, but suspected to be stable; distribution severely reduced; concentrates.
Freckled Duck *Stictonetta naevosa*	population severely reduced; concentrates.
Blue-billed Duck *Oxyura australis*	population severely reduced; concentrates.
Australasian Bittern *Botaurus poiciloptilus*	population reduced to a critical level; threatening processes severe; ecological specialist.
Australian Bustard *Ardeotis australis*	population and distribution reduced to a critical level; poor recovery potential; threatening processes severe.
Brolga *Grus rubicundus*	population reduced to a critical level; distribution reduced; poor recovery potential;threatening processes severe; ecological specialist.
Bush Stone-curlew *Burhinus magnirostris*	distribution reduced to a critical level; poor recovery potential; threatening processes severe.
Black-tailed Godwit *Limosa limosa*	concentrates; recovery potential moderate; ecological specialist.
Painted Snipe *Rostratula benghalensis*	population severely reduced; threatening processes severe; ecological specialist.

TABLE 6 contd Reasons for species inclusion on Schedule 12 of the NP&W Act (1974), from the NSW National Parks & Wildlife Service (1992).

NAME	REASONS
BIRDS contd	
Glossy Black Cockatoo *Calyptorhynchus lathami*	population severely reduced; poor recovery potential; ecological specialist.
Pink Cockatoo *Cacatua leadbeateri*	population suspected to be reduced; poor recovery potential; threatening processes severe; ecological specialist.
Superb Parrot *Polytelis swainsonii*	population and distribution severely reduced; threatening processes severe; ecological specialist.
Turquoise Parrot *Neophema pulchella*	population and distribution severely reduced; ecological specialist.
Swift Parrot *Lathamus discolor*	population and distribution severely reduced; threatening processes severe; ecological specialist.
Masked Owl *Tyto novaehollandiae*	population suspected to be reduced; distribution reduced; poor recovery potential; threatening processes moderate; ecological specialist.
Regent Honeyeater *Xanthomyza phrygia*	population and distribution reduced to a critical level; concentrates; threatening processes severe.
Pied Honeyeater *Certhionyx variegatus*	population small; ecological specialist.
Painted Honeyeater *Grantiella picta*	population and distribution severely reduced; threatening processes severe; ecological specialist.
Chestnut Quail-thrush *Cinclosoma castanotus*	population rapidly declining in specific regions; distribution declined; threatening processes severe; ecological specialist.
Southern Scrub-robin *Drymodes brunneopygia*	population and distribution severely reduced; threatening processes severe; ecological specialist.
Shy Hylacola *Sericornis cautus*	population and distribution severely reduced; threatening processes severe; ecological specialist.
Gilbert's Whistler *Pachycephala inornata*	population reduced; distribution severely reduced; ecological specialist.
AMPHIBIANS	
Giant Burrowing Frog *Heleioporus australiacus*	population and distribution suspected to be reduced; threatening processes moderate; ecological specialist.

The major threat to many of the species present in the Lake Cowal area is associated with declines in habitat area or quality and a subsequent reduction in suitable breeding, roosting and feeding sites. On a statewide and regional basis, many of these environmental pressures arise from modifications to the hydrology of the area, associated with flood mitigation works, agricultural and irrigation pursuits and changes in the salinity of ground and surface water. Other environmental pressures which are relevant at the statewide and regional levels for the endangered wetland birds of Lake Cowal, include the effects of introduced predators, particularly feral cats and foxes.

Several of the endangered birds known from Lake Cowal require dense vegetation along the Lake shore for protection and feeding (eg the Painted Snipe and Australasian Bittern) or dense vegetation within water bodies for breeding (eg the Freckled and Blue-billed Ducks and Magpie Goose). Any clearing of appropriate vegetation, such as Lignum, would reduce the potential breeding sites for these species, and may impose an adverse environmental pressure upon them.

3.3 LOCAL CONSIDERATIONS

The NSW NP&WS Director-General's requirements under Section 92D(1)c(ii) of the NP&W Act include:

> "*a description of the local distribution and abundance of endangered fauna known or likely to occur in the study area and any environmental pressures on them or their habitat*".

3.3.1 DISTRIBUTION & ABUNDANCE of FAUNA

DISTRIBUTION

The local distribution and abundance of endangered fauna species relevant to this project have been determined by reference to existing databases (in particular the NP&WS Wildlife Atlas) and to information from the field surveys for this FIS and previous studies in the vicinity.

The local distribution of native fauna is defined as the occurrence of species within 5km of the Project site. This provides a reasonable indication of species which may be considered likely to occur on the site from time to time.

Of the 6 endangered mammal species regarded as potentially present in the region or included on the Director-General's requirements for this FIS, only one (the Greater Long-eared Bat) has been recorded within 5km of the Project site. This species is listed on the NP&WS Wildlife Atlas with one record to the southwest of the site (near Billys Lookout Creek) and one record near the northern perimeter of Lake Cowal. The two species of microchiropteran bats which were tentatively identified from the Anabat recordings during the study (the Little Pied Bat and Troughton's Bat), were both recorded in the Wamboyne Mountain area. Furthermore, given the distance of these records from the known distributions of these species, and the presence of congenerics in the region (Parnaby 1992), it is considered likely that these records are not of the endangered species. No endangered mammals have been recorded from the immediate vicinity of the proposed Lake Cowal Gold Project.

Of the 26 endangered avian species included in Table 5, either as known or likely to occur at Lake Cowal or listed on the NP&WS Director-General's requirements, 14 have been recorded in the general vicinity or within 5km of the Lake Cowal Gold Project site. However, only 1 species (the Freckled Duck) has been recorded in any surveys within the Lake Cowal Gold Project area, ie within the area which is to be disturbed by the mine and its associated operations.

None of the 'terrestrial' avifauna which could potentially occur in the vicinity have been recorded on the mine area or immediately adjacent to it. However, several species (the Black-breasted Buzzard, Brolga, Superb Parrot, Painted Honeyeater and Gilbert's Whistler) have been recorded in the Lake Cowal area (see Bibliography), and given their mobility could theoretically occur on the site. Conversely, the nature of the habitats present within the Project area are not unique and do not support restricted or special resources, and provide no particular incentive for any of these species to visit the site. It is considered unlikely that these species would occur on the site on other than a rare and infrequent occasion, if at all. The proposed habitat restoration program for the Project will enhance the distribution and abundance of suitable habitat and resources for several of these species at this locality. The available data suggests that whilst a few of these avifauna may include the Lake Cowal Gold Project site within their local distribution ranges, the frequency of their occurrence at this site is extremely low.

The endangered wetland birds known from Lake Cowal (the Osprey, Magpie Goose, Freckled and Blue-billed Ducks, Australasian Bittern, Black-tailed Godwit and Painted Snipe) have been recorded by a number of sources, although few give precise location details. Only one, the Freckled Duck, has been recorded on the Project site. The other species could potentially be present, although none has been sighted on the site despite the intensive bird surveys conducted on the Lake and there are no special resources present for any of these species. For the Painted Snipe and Australasian Bittern, the open nature of the shoreline is unsuitable, and the lack of Lignum beds and appropriate foraging habitats indicate that the Magpie Goose and Blue-billed Duck are also unlikely to be present. The Osprey and Black-tailed Godwit could theoretically occur on occasions.

There is no evidence for the presence of the Giant Burrowing Frog in this locality and it does not consequently appear to have a local distribution. If the species was present in the study area, it would be likely to occur along Frog Pond Creek, located immediately to the north of the proposed Project area.

ABUNDANCE

There are no local measures of abundance for any of the endangered species listed in the Director-General's requirements for this FIS, except for the ducks. Given the extremely low frequency of reporting of the listed species, local abundances would appear to be extremely low.

For the endangered mammals discussed in Table 6, it is considered that the local abundance of the Koala and Bilby is zero. For the microchiropteran bats, there are no measure of abundance, but the extremely limited value of the site for these species suggests that their abundance in the immediate locality will be low. The 2 endangered species which have tentatively been described during this investigation were located on Wamboyne Mountain, not at the Project site.

For the endangered avifauna being considered in the FIS, there are abundance data at the locality for only 1 species (the Freckled Duck). This is the only species recorded from the Project area (the Lake Cowal Gold Project area) and 2 individuals were recorded on one occasion over the 15 transect surveys conducted at the site. It would appear, therefore, that the abundance of Freckled Ducks at the Project site is extremely low. With respect to Lake Cowal generally, Freckled Ducks are regularly sighted in small numbers, and Blue-billed Ducks are also present in small numbers.

For the other 25 species of endangered birds under consideration, there are no records of any individuals from the specific locality of the proposed Project area. In most instances, give the high mobility of the birds, their habitat requirements and the condition of the Project area, it is considered likely that the abundance of these species at this locality will be zero except on other than extremely rare occasions. Additionally, most of these species are either nomadic or wide ranging and are unlikely to be present on the proposed Project area (which does not support any unique or species resources) other than rarely.

Thus, the local abundance of most of the endangered avifauna, within the study area may reasonably be considered extremely low to non-existent. For most of these species, abundances at Lake Cowal in general are also extremely low.

The Giant Burrowing Frog has not been recorded from the study area, nor from the specific Lake Cowal Gold Project area, and the apparent abundance of this species at the locality is zero.

3.3.2 ENVIRONMENTAL PRESSURES

The local environmental pressures which may be imposed on endangered fauna in the vicinity of the proposed mining operations at Lake Cowal are essentially those which pertain across the species' ranges. As discussed above, these are principally associated with the removal or degradation of habitats and specific resources which are necessary for the survival of each species. The threatening processes which apply to the native endangered species on a regional or state-wide basis are also relevant at the local level.

With respect to the endangered avifauna of the area, particularly the waterbirds (the Blue-billed and Freckled Ducks, Magpie Goose, Australasian Bittern, Black-tailed Godwit and Painted Snipe) and other possible or occasional visitors (such as the Brolga, Bush Stone-curlew and Australian Bustard), the most significant local environmental pressure for the animals themselves is likely to be associated with the annual duck shooting season. During this period, thousands of waterfowl are shot at Lake Cowal, including a number of individuals of endangered species.

Given the highly disturbed condition of the area which is to be disturbed by the proposed Lake Cowal Gold Project, it is considered unlikely that activities at the site will impose any significant increase in environmental pressures in a local or regional sense. The lack of evidence for individuals of the relevant species and the lack of critical resources on the Project site indicate that the mine Project is unlikely to impose additional environmental pressures at the locality.

There are, however, two activities associated with the Lake Cowal Gold Project which may potentially impose additional local environmental pressures upon endangered fauna. The first of these involves tailings storages, which will be characterised by cyanide-laden water and 'boggy beaches' of fine sediment. Endangered species entering the tailings storages or attempting to use them for feeding or drinking could potentially be adversely affected. Under certain circumstances, it is possible that the tailings storages could impose a localised environmental pressure on or threat to individuals of these species (if any are present).

The second potential for an additional environmental pressure on endangered species arising from the proposed Lake Cowal Gold Project is associated with the powerline from Forbes. This is to be located between Lake Cowal and Nerang Cowal, and involves the possibility for 'bird-strike' on the lines, particularly for the larger wetland species.

The potential impacts of both tailings storage operations and the proposed powerline from Forbes are discussed in detail in Chapter 4 of this FIS, and a range of impact amelioration measures are proposed in Chapter 5.

In the longer term, the habitat restoration program which is proposed for the Lake Cowal Gold Project is intended to restore habitats which have been removed by agricultural activities, and to enhance the habitats and specific resources which are of value to endangered fauna species that either do or may occur in the area. This process involves the re-establishment of woodlands and the creation of small hills at the site with appropriate vegetation communities. Also, the construction of an enhanced lake shore environment with protected islands and vegetation for bird breeding is intended not only to avoid imposing additional environmental pressures on these species, but to improve the local situation and to reduce environmental pressures in the general area.

Elements of the program intended to enhance the environment and reduced environmental pressures include the regeneration of Open Woodland communities which are currently sparse on the site, the creation of a new larger area of shoreline habitat around the perimeter bund, the re-erection of old River Red Gums as stags and hollow-bearing trees for nesting, supplementary planting of the Lake shoreline to provide additional refuge for birds and amphibians which use these habitats, the creation of islands with trees and native vegetation to provide safe nesting environments for birds, and the creation of rocky habitats with crevices to provide habitat for a number of avifauna, reptiles and microchiropteran bats.

3.4 HABITATS of ENDANGERED FAUNA

The NSW NP&WS Director-General's requirements under Section 92D(1)C(ii) of the NP&W Act for this FIS include:

> "*a description of the habitats and potential habitats of endangered fauna in the study area, describing habitat distribution in the study area and local distribution of these habitats. Habitat critical to essential behavioural patterns of the endangered species should be identified*".

3.4.1 LOCAL HABITAT DISTRIBUTION

The "*habitats and potential habitats of endangered fauna in the study area*" have been described in some detail above (Chapter 2; Table 3). The subject site (that is the area to be disturbed by the proposed Lake Cowal Gold Project) does not support any specific or unique habitat features or resources. Those present on the subject site are widespread throughout the general locality and through the regional landscape. Furthermore, the subject site is generally highly disturbed and contains few or no resources of particular value for endangered species.

The only endangered species recorded from the site (the Freckled Duck) was noted feeding in the shallows in the area which will be occupied by the proposed pit. Thus, the project site itself provides a small portion of the potential feeding resources for this species. Conversely, this site does not contain unique or unusual features, and Freckled Ducks are likely to feed essentially anywhere within Lake Cowal and Nerang Cowal.

Whilst the Lake Cowal Gold Project area contains habitats and resources which may be utilised by endangered fauna, the site itself supports a seriously degraded environment and does not support any unique features or resources of particular value for endangered species. In terms of the "*habitats and potential habitats of endangered fauna in the study area*", the area which will be disturbed by the proposed Project is of relatively low value. The features and resources present are widely distributed throughout the general locality and no individuals of any endangered species are considered likely to depend upon those resources or elements present within the Lake Cowal Gold Project site.

The Grassland habitats which could be of value to the Bush Stone-curlew and for food for the Turquoise Parrot are extremely widespread throughout the general locality and through the region. Similarly, the Open Woodland environments which are of value for the parrots, honeyeaters and several of the other avifauna species, and possibly for the microchiropteran bats (at least as foraging habitat), are widespread although patchy throughout the region. The portions of these habitats which are present on the subject site are disturbed and of relatively low value, and the Lake Cowal Gold Project intends to substantially supplement these habitats as a result of the habitat restoration program.

In terms of local distribution, patches of degraded Open Woodland environments such as occur within the Lake Cowal Gold Project site are widespread through the general vicinity. The shoreline of Lake Cowal in the vicinity of the Project is sparsely vegetated, containing little of value for endangered species. Those endangered birds which utilise shoreline habitats (such as the Australasian Bittern, Painted Snipe and Black-tailed Godwit) require dense vegetation for shelter which is not present within the study area. The shoreline also supports a sparse stand of River Red Gums which provide some resources for native fauna, particularly hollows for nesting and limbs for perching Those resources present on the Lake Cowal Gold Project site comprise a small proportion of those present around Lake Cowal, and the proposed habitat restoration program will involve the re-erection of large trees on the new perimeter bund.

3.4.2 CRITICAL HABITAT

As noted in earlier discussions in this FIS, the subject site does not support "*habitat critical to essential behavioural patterns of the endangered species*". The habitats and resources present on the subject site are widely distributed and the site itself is relatively highly degraded. It is therefore considered highly unlikely that any endangered species or individuals of endangered species would be dependent upon the resources present specifically on the Lake Cowal Gold Project site.

The site and the features present on it are not regarded as "*critical to essential behavioural patterns*" of any endangered species, nor indeed of any fauna species at all. Furthermore, the proposed habitat restoration program for the Lake Cowal Gold Project site is intended to generate a number of elements which are of "*critical*" value to some endangered species, and which presently are lacking.

3.5 DISPERSAL and MOVEMENT

The Director-General of NP&WS, under Section 92D(1)(c)(ii) of the NP&W Act, also requires:

> "*an assessment of dispersal or movement areas or routes of endangered fauna species known or likely to occur in the study area and any existing or future barriers to interbreeding opportunities between populations of endangered fauna within the local area*".

For the majority of the avifauna known from the general region around Lake Cowal and those species being considered in this FIS, specific well-defined dispersal or movement corridors are not known, either from within the Lake Cowal area or throughout their ranges in Australia. However, many of these species are nomadic or migratory, moving generally in response to the availability and seasonality of food. Most of the 'terrestrial' bird species will either range widely over the landscape searching for suitable food or move in response to temporary abundances of food resources (such as flowering eucalypts). For these species, no discernible movement corridors or routes are available and the Project is unlikely to impose any "*barriers to interbreeding opportunities between populations*". Indeed, given the proposed habitat restoration program, it is likely that the completed mine site will improve the ability for fauna to move around the local environment.

For many of the waterbirds, similar large scale migratory or nomadic movements arise as a result of changes in water quality and water availability. Wetland birds will move into and out of Lake Cowal depending on local conditions and on the existence of rain and wetlands elsewhere in NSW. In many instances, such migratory or nomadic movements will be generally distributed throughout the landscape, and specific "*dispersal or movement ... routes*" are unlikely to be able to be discerned.

However, Lake Cowal is one of three major wetlands which form a 'corridor' between the Lake itself and the Lachlan River. Nerang Cowal is located immediately to the north and northwest of Lake Cowal, and the Bogandillon Swamp is located midway between Nerang Cowal and the Lachlan River. Wetland birds are likely to move between these waterbodies under some climatic circumstances.

The proposed Lake Cowal Gold Project is not considered likely to impose any "*future barriers to interbreeding opportunities between populations of endangered fauna*". The mine and associated structures will impact on only a very small portion of the local area and will not prevent native fauna from moving generally throughout the landscape. However, there is some potential for the powerline from Forbes to the mine site, which passes between Lake Cowal and Nerang Cowal to impose a hazard for some species of native birds attempting to move between these two wetlands. A detailed discussion of the impacts of powerlines and 'bird-strike' on native birds is provided in Chapter 4 of this FIS. Whilst there is the potential for some mortalities of native birds to arise as a result of 'bird-strike' on the powerline (possibly include endangered species), it is considered unlikely that the powerline or the effects of 'bird-strike' would impose a "*barrier to interbreeding opportunities*", as only a relatively few individuals of any species would likely be involved.

4 IMPACTS of the PROPOSED DEVELOPMENT

4.1 ENVIRONMENTAL EFFECTS

Section 92D(1)(c)(iii) of the NP&W Act 1974 requires:

> *"a description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term where long term encompasses the time required to regenerate essential habitat components".*

4.1.1 THE PROPOSED DEVELOPMENT

This segment of the FIS provides "*a description of the actions*", as required under Section 92D(1)(c)(iii) of the NP&W Act 1974.

The proposed operation by North Mining Limited involves the development of a large low-grade gold deposit on the western side of Lake Cowal in the central west of NSW (Figure 1). The deposit will be mined by an open pit method, with the pit straddling the shoreline and extending approximately 600m into the Lake and 350m across the adjoining plain.

To separate the open pit from Lake Cowal, a permanent pit protection bund will be constructed. This will be a compacted earth and rock structure created from waste rock generated from the pit, covered with topsoil and vegetated with local native plant species. The bund wall will be approximately 2.96km long (extending approximately 1.1 km into the lake) and will replace an existing 1.84km of shoreline. The bund is to be constructed in a manner which will prevent significant erosion and will re-create the existing habitats along the Lake Cowal shoreline. If the Lake is full or nearly full during construction of the bund, a cofferdam will be created first and the bund subsequently constructed within the de-watered area behind the cofferdam. In this instance, once the pit protection bund has been constructed, the cofferdam will be breached and converted into a series of low islands, modified for native fauna.

The main waste rock emplacement will be located immediately to the northwest of the pit and will be enclosed within the perimeter bund for the operational facilities. The waste emplacement will ultimately form a low constructed hill at this location, and will abut an existing small knoll on its western side. Waste material will also be placed between the perimeter bund and the pit.

The ore processing plant is to be located between the perimeter bund and the waste emplacement southwest of the pit. There will be no discharge from any of the mine operations from within the perimeter bund, and all discharge water generated on the site from runoff or from operations is to be collected for use in the processing operation.

Four tailings storage cells of approximately 750m by 750m each will be located to the west of the main mining operations. The tailings cells are to be used individually on a rotational basis, with only one cell being used for discharge at any one time. The 3 remaining cells will be de-watering, and will generally only contain self generated rainfall run-off. The tailings will be enclosed within the perimeter bund, and there will be no discharge from the tailings storages into Lake Cowal.

Power is to be supplied to the Project by a 132kv transmission line from Forbes which will pass between Lake Cowal and Nerang Cowal, then down the western side of the Lake (Figure 6). Supplementary water supplies are to be derived from a borefield to the east of the Lake, with water transferred to the operations by pipeline. The pipe will be trenched and buried between the borefield and the Project site.

The placement and relationship of the various facilities associated with the Lake Cowal Gold Project are illustrated in Figure 2 and in Appendix 1.

The proposed gold mine also entails a substantial habitat restoration program at this locality, as outlined in Section 5.1 of this FIS and in Appendix 10. In general terms, the program will involve the creation of natural habitats over the areas to be affected by the

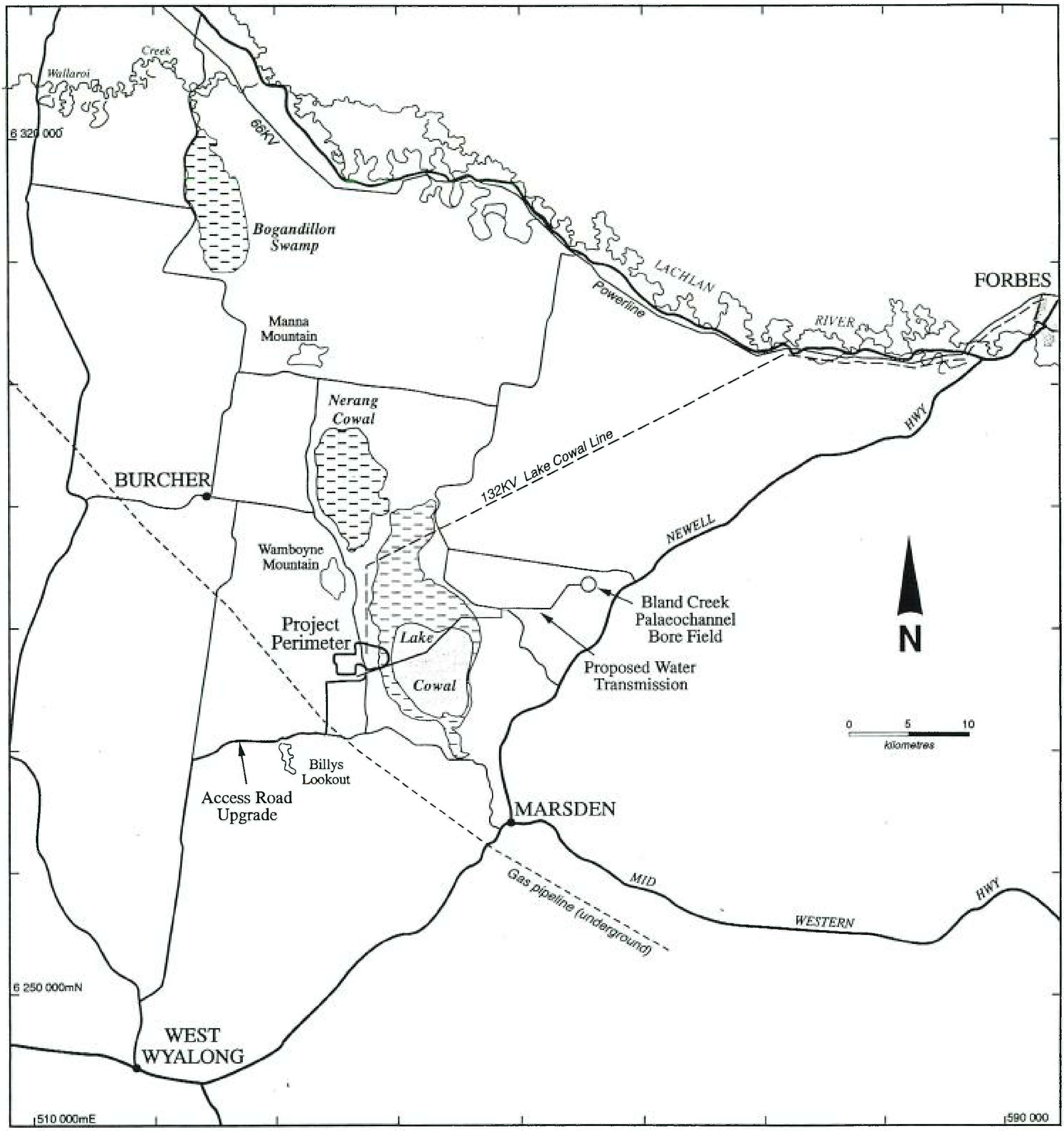

Figure 6: Infrastructure for Lake Cowal Gold Project.

proposed Project. This will enhance the local environment for native fauna by replacing the current disturbed agricultural lands with a more natural environment. Particular elements will involve:

- the breaching of the cofferdam to create small islands in Lake Cowal adjacent to the perimeter bund, with these being vegetated using Lignum, Cane Grass, River Red Gums and other appropriate plants;
- the planting along the perimeter bund of River Red Gums and Lignum and the re-erection of large River Red Gums which have been felled during the mine installation process;
- the generation of Open Woodland environments on the pit protection bund, the waste rock emplacement areas, and rehabilitated areas covered by the ore processing facility;
- the waste rock emplacement will be established as a rocky habitat similar to that naturally occurring on hills in the area (such as Wamboyne Mountain). A varied Open Woodland community relating to topographic location will be encouraged over the waste rock emplacement, with White Cyprus-Pine, Bimble Box, Dwyers Red Gum and Spearwood at appropriate locations; and
- the tailings cells will be revegetated, with three of the cells supporting an Open Woodland community and the fourth providing an ephemeral wetland. This latter feature will collect all of the run-off water from the other three tailings cells.

4.1.2 ENVIRONMENTAL MODIFICATION

This segment of the FIS considers how the actions "*will modify the environment*" of endangered fauna, as required under Section 92D(1)(c)(iii) of the NP&W Act 1974.

The proposed Lake Cowal Gold Project will involve substantial physical modification of a small portion of the Lake Cowal shoreline and a relatively small area of the adjacent plains, as detailed above. However, the areas to be affected are highly degraded and modified, and do not provide special or 'critical' resources or habitats for endangered fauna.

In the Project area, the Lake shoreline is characterised by grassland and a scattered tree cover of large River Red Gums, with occasional patches of River Red Gum woodland and Lignum. The Lake Cowal Gold Project involves the removal of the existing shoreline and associated features, re-erection of the large River Red Gums as stags along the new Lake shoreline, creation of an extensive riparian community along the shoreline and the generation of more extensive suitable habitat for the lake-dependent fauna. Thus, for those species which utilise the shoreline habitats, the environmental modification which will arise from the proposed gold mine will ultimately increase the area of suitable habitat and resources.

With respect to the Lake environment, the Project will only involve a reduction in area when the Lake is more than 40% full (by volume). The open pit and bund will occupy approximately 1.4% of the surface area of Lake Cowal (when the Lake is full), thus removing a small portion of this environment for native fauna. The lake habitat at the pit site is described as Open Water with Cane Grass (dependent on water depth). There are no Lignum stands in the water at this location, and only a few scattered trees are situated within the water of the Lake when it is full. This contrasts significantly with the areas of important bird breeding habitat in the northern part of Lake Cowal, some 2.5km or more to the north of the Project area, which are characterised by dense and extensive Lignum stands, and stands of River Red Gums within the Lake.

The area of Lake Cowal occupied by the open pit and protective bund will obviously decline as the Lake dries out. Once the Lake is approximately 60% empty, the Project will not occupy any of the inundated area. Although the Lake area which will be removed doubtless provides some feeding resources for native waterbirds, detailed investigations of waterbird activity on Lake Cowal over the last 6 years (Crome 1995) indicate that the habitats present on the Project site are not of critical importance to any endangered wetland or wading birds that occur or are likely to occur in the area.

The proposed Lake Cowal Gold Project will involve the construction of waste emplacements, tailings storages and infrastructure, as well as the ore processing plant on the plain adjacent to Lake Cowal and the open pit. These activities will involve some environmental modification and will replace the existing flat plain in this vicinity with a series of low, flat-topped hills and the pit. The area to be disturbed and the majority of the surrounding landscape have long been highly modified as a result of clearing for agricultural practices. Consequently, the majority of the adjacent landscape consists of open paddocks with scattered individual trees or small copses of remnant Open Woodland. A small stand of native Open Woodland located on a small knoll west of the pit ('Cowal West Hill') will be substantially preserved by an alteration in the waste rock emplacement configuration (Figure 2). A second small stand of Open Woodland near the southern end of the perimeter waste emplacement will be retained by placement of the stockpile and bund to avoid the total removal of this community (Figure 2).

The remainder of the area which is to be disturbed by the proposed activities comprises open, cleared grazing lands. Most of the area to be covered by the waste rock emplacements, processing facility and tailings storages consists of grassland with scattered remnant trees. Whilst this landscape and environment provide some limited resources for native fauna, the habitats available are widespread and in a considerably modified condition. Given the intention of the rehabilitation program for the project, which is to supplement the native vegetation communities in the area and to provide a substantially more natural environment, the extent of environmental modification in this locality will be limited. Indeed, at the conclusion of mining, the intention is to enhance the habitats and resources of endangered species in the locality, and to thus provide a nett environmental benefit.

In terms of the resource requirements of endangered native fauna known from or expected to occur in the study area, the proposed Lake Cowal Gold Project does not appear likely to involve modification of the local environment in a significant or adverse manner. None of the endangered wetland and wading birds are known to breed in the vicinity of the Project area, although some non-endangered native birds do breed in this location. The Project area does not involve suitable habitat for the Australasian Bittern, the Painted Snipe or the Magpie Goose, and whilst species such as the Freckled and Blue-billed Ducks may possibly feed in the vicinity, there will be no significant modification to their resource requirements. There are no special or restricted resources for other endangered native wetland birds in the vicinity of the Project area, and the completed rehabilitation program will increase resources for species which may potentially occur in the vicinity.

Similarly, for the 'terrestrial' fauna, the resources of relevance to species such as the Painted and Regent Honeyeaters and the Turquoise, Swift and Superb Parrots are extremely limited on the Project area. There is no evidence for these species being present and the proposed development will not remove significant resources for these animals. Furthermore, the rehabilitation program is intended to increase the resources present in the area and to enhance the suitability of the environment for these species.

4.1.3 EFFECTS on "ESSENTIAL BEHAVIOURAL PATTERNS"

This segment of the FIS considers how the actions will "*affect the essential behavioural patterns of the fauna in the short and long term*", as required under Section 92D(1)(c)(iii) of the NP&W Act 1974.

Whilst the clearing of trees and the modifications to the environment which will occur as a result of a gold mine may usually be considered likely to "*affect the essential behavioural patterns of the fauna*", the highly modified nature of the environment which is to be disturbed by the Lake Cowal Gold Project limits the potential for such effects to occur. Although there are endangered species present on Lake Cowal and in the general vicinity, the highly modified nature of the environment in the Project area precludes the presence of most of these species on other than an extremely transient basis. It is considered that none of the endangered species discussed in this FIS will occur on the Project area other than irregularly and for short periods, and many are considered unlikely to occur at all. The Project area does not support resources or habitat "*critical*" to the survival of any of the endangered species known from the area, and the proposed development is considered unlikely to "*affect the essential behavioural patterns*" of any of the species discussed.

By comparison to the annual duck shooting season, the likely impacts of the proposed Lake Cowal Gold Project (including the effects of construction and the potential for animal use of the tailings storages), are considered likely to insignificant and negligible, particularly with respect to the waterbirds. Indeed, on the basis of the impact amelioration measures and the habitat restoration program to be implemented, it is considered likely that no individuals of any endangered species will perish, and that the nett short and long term effect of the mine Project on the local environment and on the conservation of endangered fauna in the region, will be positive. The same situation does not apply to the annual shooting activities.

The potential for noise arising from the proposed Lake Cowal Gold Project to "*affect the essential behavioural patterns*" of fauna in the area is considered in detail in Section 4.5. It appears unlikely that noise from the operations, either continuous noise or episodic blasting events, will have any adverse effect on the wetland birds or other species. There is no indication that breeding of wetland species will be affected, but a monitoring program is proposed to assess the significance of any responses to noise.

Similar considerations apply to the potential for impacts on "*the essential behavioural patterns*" of endangered fauna arising from the lighting of the Lake Cowal Gold Project and from the creation of dust. There are no known cases from other mine sites throughout NSW, including the nearby Northparkes Project, that the lighting associated with evening activities in the mine area imposes any adverse impacts on native fauna in the vicinity. Indeed, it is possible that microchiropteran bats (including endangered species) will utilise the abundance of flying insects around the lights as a supplementary food resource. This situation has been observed (*pers obs*) in the Hunter Valley.

Additionally, most of the operations at Lake Cowal will be conducted below the perimeter bund which is intended to shield the Lake environs from the effects of noise, light and dust from the operation. With regard to dust creation, the operation at Lake Cowal involves a range of measures to minimise the creation and dispersal of dust. The high bund around the mining operation and the use of water sprays to limit dust creation are considered adequate to avoid any potential for adverse impacts on native fauna or their habitats in the vicinity.

The tailings storages at the Lake Cowal Gold Project have the potential to "*affect the essential behavioural patterns*" of endangered fauna which occur in the vicinity (detailed in Section 4.3). The tailings storages will contain cyanide-laden water, and wetland birds could possibly use the decant ponds for roosting or as sources of drinking water. There is the possibility that endangered species may perish as a result of the ingestion of toxic levels of cyanide or may become bogged in the tailings slurry prior to its drying out. Conversely, the tailings storages at Lake Cowal are to be managed in a manner which will limit the levels of cyanide and will also limit the size of tailings storage beaches. These and a range of monitoring and supplementary (contingency) ameliorative measures will be implemented as required at the Lake Cowal Gold Project site to avoid any adverse impacts upon endangered wetland birds.

Whilst there is clearly some potential for an impact upon individuals of some endangered species (see Section 4.3), it is considered unlikely that the tailings storages at Lake Cowal would impose a significant effect on the "*essential behavioural patterns*" of populations of endangered birds.

The proposed powerline from Forbes to the Lake Cowal Gold Project is to be located between Lake Cowal and Nerang Cowal. This powerline also has the potential to impose impacts upon the endangered native fauna of the area, particularly on large wetland birds. It is possible that 'bird-strike' on the powerline will involve the mortality of endangered species, particularly those large less mobile wetland birds known occasionally from the area (such as the Magpie Goose and Brolga). The potential for these effects on individual birds and on populations is considered in Section 4.3.

In terms of "*essential behavioural patterns*" of wetland birds, the powerline is considered unlikely to alter the behaviour of species at Lake Cowal. Additionally, as discussed in Section 4.3 and in Chapter 5, a series of mitigatory measures are proposed to limit or avoid the potential for adverse effects of the powerline on endangered bird species or populations in this locality.

the potential for adverse effects of the powerline on endangered bird species or populations in this locality.

For the 'terrestrial' fauna known from the general area or which may potentially occur on the Project site, it is considered unlikely that the modifications to the environment or the operation of the proposed gold mine will "*affect the essential behavioural patterns*" of any species. The area is already highly degraded and the proposed habitat restoration program involves the generation of a substantially improved environment and enhanced resources for endangered species.

None of those 'terrestrial' species known to occur in the vicinity or potentially present (the Painted, Pied and Regent Honeyeaters, the Superb and Turquoise Parrots or the microchiropteran bats), are likely to be dependent upon the resources and features present in the existing environment on the Project site. Conversely, several of these species are considered likely to benefit from the proposed rehabilitation program in the area, and there may be an increase in populations of some of these species or an increase in their use of the general locality following mine rehabilitation. The proposed gold mine at Lake Cowal is considered likely to improve local conditions for several endangered species, and may "*affect the essential behavioural patterns*" of species by enhancing their survivability in the region.

4.1.4 REGENERATION of "ESSENTIAL HABITAT COMPONENTS"

This Section of the FIS considers "*the time required to regenerate essential habitat components*", as required under Section 92D(1)(c)(iii) of the NP&W Act 1974.

The proposed Lake Cowal Gold Project will involve the removal of very few resources of any significance to native fauna and almost none of relevance to endangered species. Only a very small area of remnant or regrowth Open Woodland is to be removed and a few large River Red Gums along the Lake Cowal shoreline will need to be removed. The remainder of the project area involves either grasslands with sparse scattered trees on the adjacent plain or a small portion of open water and Cane Grass in the Lake itself.

In terms of "*the essential behavioural patterns*" of native fauna in the area, it is highly unlikely that the degraded habitats and areas to be disturbed by the proposed Lake Cowal Gold Project constitute "*essential habitat components*" for any species, endangered or otherwise. Whilst various elements of the site doubtless provide resources for native fauna (large hollow-bearing River Red Gums, Open Water, Cane Grass, the few patches of Lignum, Dry Open Woodland, Grassland), none are restricted to the site, and endangered fauna would not be reliant on those resources present. There is no evidence for the presence of any endangered species on the site, with the exception of a single sighting of the Freckled Duck.

Furthermore, as detailed in Chapter 5 of this FIS, a substantial program of habitat restoration is an integral part of the mine proposal, and the final landform will support a significantly greater array and density of "*essential habitat components*" than are currently present. Some of these (eg rock crevices and shelters, sediment ponds, re-erected River Red Gum stags with tree-hollows, islands in the Lake) will be created within the first 2 years of mine activity, whilst others (Open Woodland patches, the abandoned pit walls) will either become available at the conclusion of mining or will gradually develop over the ensuing decades. Generation of mature Open Woodland habitats will require several decades, although they may provide suitable resources for some species early in the regeneration phase.

The area of fauna habitat to be disturbed by the proposed mine is limited and the extent of "*essential habitat components*" for endangered species to be removed is negligible. Conversely, the rehabilitation program for the mine site is intended to substantially enhance resources for endangered fauna species.

4.2 HABITAT DEGRADATION

Under Section 92D(1)(c)(iii) of the NP&W Act, the Director-General of the NP&WS requires:

The "*location, nature and extent of habitat degradation*" which will occur as a result of the proposed development has been described in Section 4.1.

The environment in the vicinity of the proposed mine is highly modified and disturbed, and little "*habitat degradation*" is anticipated as a result of the Project. In addition, the habitat restoration program for the Project is intended to enhance the local environment and will provide an increased array and extent of habitat features of value for endangered fauna in the area.

The final landscape design for the Lake Cowal Gold Project in intended to involve a decrease in the "*extent of habitat degradation*" at this locality. The "*likely effect* [of "*habitat degradation*"] *on endangered fauna known or likely to occur in the study area*" is discussed in detail in Sections 4.1 and 4.3, and generally is regarded as likely to be negligible.

4.3 EFFECTS on ENDANGERED FAUNA

Under Section 92D(1)(c)(iii) of the NP&W Act 1994, the NP&WS Director-General requires:

> "*a description of the possible effects of the development on species of endangered fauna known or considered likely to occur in the study area*".

The "*possible effects of the development on species of endangered fauna*" have been discussed in Section 4.1 of this FIS, and are generally considered to be of little significance. Considerable efforts have been dedicated to the design of an environmentally-sensitive mining operation and to the creation of a substantial habitat restoration and enhancement program to benefit the local environment and native fauna. The "*issues of noise and its impacts on endangered fauna*" are considered in detail in Section 4.5 of the FIS, and it is considered that the impacts of noise from the Project on native fauna in the vicinity, including endangered species, will be negligible.

Generally, the proposed Lake Cowal Gold Project is considered unlikely to impose adverse effects on endangered species. There are two elements of the Project, however, which could affect some species, principally the wetland birds. The construction of a powerline to the north of Lake Cowal and the operation of the tailings storages could involve "*possible effects .... on species of endangered fauna*".

The tailings storages designed for the Lake Cowal Gold Project have the potential to impose impacts on the native fauna of the area, although this has been addressed by a series of protocols and actions to limit "*the possible effects of the development on species of endangered fauna*". Details of the potential impacts are provided below, and the measures for preventing adverse impacts on native fauna are provided in Chapter 5 of this FIS.

If not carefully managed, impacts from the tailings storages may arise if animals use the storages, either as a result of the toxic effects of cyanide in the tailings decant pond or by animals becoming bogged in the muddy discharge beaches.

The first possibility for the tailings storages to affect endangered species relates to the toxicity of the discharge water, associated with the levels of cyanide contained in the discharge. Cyanide is the agent used to collect the gold during the processing of ores extracted by the mining operations (McGill & Comba 1990). When cyanide concentrations are high (>50mg CNWAD/L), there is the potential for adverse effects on native fauna if they attempt to drink the water.

Evidence from gold mine operations in the United States of America includes high levels of mortality amongst migratory waders in Nevada, associated with cyanide poisoning on tailings storages (Hallock 1990; Kay 1990; Allen 1990; Schroeder 1990; Klepfer 1990). Between 1984 and 1989, the total number of reported bird mortalities at cyanide-using mining operations in Nevada, California and Arizona was about 9000, or 1500 per year (Smith & Mudder 1995). In most instances, concentrations below 50mg CNWAD/L cyanide do not appear to adversely affect animals (Hallock 1990), although mortalities have occurred at levels as low as 10mg CNWAD/L (Schroeder 1990).

do not appear to adversely affect animals (Hallock 1990), although mortalities have occurred at levels as low as 10mg CNWAD/L (Schroeder 1990).

The potential for cyanide poisoning of waterbirds and other fauna at Lake Cowal is considered relatively low because of the nature of the site and as a function of the proposed management regime for the storages. In the first instance, a low concentration of cyanide will be maintained in the tailings storages most of the time. Cyanide levels in the decant ponds will be less than 50mg CNWAD/L more than 80% of the time, as a result of the operational protocols for the Project and cyanide retrieval. The water discharged to the ponds is required for re-use in the processing operation, and the prior retrieval of cyanide and the maintenance of a small tailings decant pond are intended to optimise the return of both water and cyanide to the system. This approach will minimise the risk for many native fauna which may be attracted to the tailings storage.

The experience of many gold mines in Australia is that waterbirds are rarely attracted to tailings decant ponds (Appendix 8). Conversely, a recent event at the Northparkes Mine indicates that there is a potential for bird mortalities associated with tailings storages. In this instance, over a thousand bird deaths were recorded, involving 19 species (no endangered species were included amongst the mortalities). The mortalities appear to have been associated with high cyanide levels in the decant pond. The levels of cyanide in the tailings were derived from the processing of high copper-gold ore, and substantially exceeded 50mg CNWAD/L (apparently as high as 300mg CNWAD/L.

The incident at North Parkes is currently being investigated in detail and is likely to have arisen as a result of high levels of cyanide, the presence of a large decant pond, and the absence of alternative large wetlands in the vicinity. Conversely, at Lake Cowal, cyanide concentrations will be relatively low, the decant pond will be maintained at a small size, and Lake Cowal provides a substantial and far more attractive resource (with respect to water quality and habitat features) immediately adjacent to the tailings storage.

At Lake Cowal, the greatest likelihood of waterbirds attempting the use the decant ponds would occur if and when Lake Cowal is dry and the ponds constitute the most substantial local source of water. Conversely, in these situations, most of the wetland avifauna are likely to leave the area. Most of the time, however, the Lake, which is both substantially larger than the tailings decant ponds and is characterised by much better quality water, is likely to constitute the preferred roosting site. At Northparkes, no such alternative exists.

Furthermore, a range of monitoring and impact amelioration measures are proposed for the Lake Cowal Gold Project. If monitoring of the tailings storages indicates that native fauna are being affected by the operation, several protocols will be implemented to avoid mortalities. Details of the techniques to be applied are provided in Chapter 5 of this FIS.

The second potential effect on the behaviour of fauna species associated with the tailings storages is related to the nature of the depositional beaches created. Immediately after discharge, these are of a muddy consistency, and wetland birds could become bogged in this material. This phenomenon has rarely been observed, however, and is addressed by the proposed amelioration techniques discussed in Chapter 5.

In addition to designing the management and operation of tailings storages at the Lake Cowal Gold Project to limit the potential for adverse effects on wetland birds (by maintaining low concentrations of cyanide and a small decant pond), a series of supplementary measures are proposed for implementation, if necessary. Details of approaches intended to discourage birds from using the tailings storage areas are included in Chapter 5 of this FIS, and broadly involve reducing the attraction of birds to the tailings storages or discouraging them from remaining. These approaches are all intended to ensure that there will be no significant adverse effect on native avifauna in the vicinity.

There is some limited potential that endangered species which may be encouraged into the area by the habitat restoration program may use the tailings decant ponds as a water source. Should there be an increase in numbers of endangered 'terrestrial' birds or microchiropteran bats in the locality, there is the potential for these animals to use the tailings storages for drinking water. This situation is considered of low likelihood, given the availability of water in the area, but it will be monitored. If endangered 'terrestrial' birds or

The proposed powerline between Forbes and the Lake Cowal mine has the potential to impact on some species of endangered wetland birds. The current proposal is for the powerline to pass between Lake Cowal and Nerang Cowal (Figure 6), crossing a likely bird movement corridor between these 2 wetlands. The process of installing the powerline is unlikely to be of any relevance, as it is intended to locate the line away from known bird breeding locations and the area to be affected by support structures is small. However, there is some potential for 'bird-strike' on powerlines, particularly involving wetland birds moving between Lake Cowal and Nerang Cowal.

For most aerial fauna, the striking of powerlines is unknown or is uncommon. This phenomenon is considered unlikely to impose any adverse impact on the vast majority of native fauna present throughout the general area. However, for a few species there is some potential for adverse impact.

Large birds, particularly large wading or aquatic species, are known to be susceptible to 'powerline strike'. Species for which mortalities associated with 'bird-strike' on powerlines have been recorded include the Grey Teal, Black-necked Stork, Australian Pelican, Black Swan and egrets (ELCOM 1988; G Clancy *pers comm*). Magpie Geese have also been recorded striking transmission lines in the wetlands north of Newcastle (SWC 1993). The susceptibility of these species to 'powerline strike' appears to be related largely to their size and relative inability to quickly avoid obstacles while flying. Other factors considered of importance (Mayer 1978 in SWC 1993) include the location of the powerline between wetlands, the intensity of low-level flight activity, and the characteristics of the transmission line.

The significance of 'bird-strike' on transmission lines is partly related to their proximity to important bird habitats, particularly wetlands. In this regard, it was recommended that the Coffs Harbour/Grafton transmission line be located as far as possible from important wetlands along its route (ELCOM 1988). Similarly, the Waratah West transmission line was considered likely to adversely affect large avifauna, especially the Magpie Goose, and re-routing of the line was suggested (SWC 1993). However, that report also noted that the impacts of the line "*on the Magpie Goose, and other waterbird species, is considered likely to be minor* ..". The Gibbs Inquiry (1991) concluded that, whilst some potential existed for 'bird-strike' as a result of the proposed Coffs Harbour/Grafton transmission line, this impact would not be "*ecologically significant*".

Some of the waterbirds associated with Lake Cowal could potentially be adversely affected by collisions with powerlines, as they are likely to move between Lake Cowal and Nerang Cowal under certain circumstances or will migrate into and out of the area along the Lake Cowal-Nerang Cowal-Bogandillon Swamp corridor, depending on regional climatic and rainfall conditions. The most significant species in this respect are the Freckled and Blue-billed Ducks and the Magpie Goose.

In considering the potential for adverse effects on wetland birds, the Shortland Wetlands Centre (SWC 1993) note that powerlines are not generally considered to "*present an obstacle to smaller waterbirds such as ducks, as they appear to have few problems negotiating transmission lines and seldom record flight avoidance reactions to transmission lines (Murray & Winning 1992)*". The Freckled and Blue-billed Ducks are small and highly manoeuverable, and are considered likely to be able to avoid the powerline under most circumstances. Conversely, the Magpie Goose is less manoeuvrable, and is considered at greater risk (theoretically). However, the numbers of this species at Lake Cowal are extremely low, and the likelihood of the powerline imposing significant adverse impacts on the Magpie Goose is considered limited. The construction of a far larger powerline (330KV) at Waratah West, in an area which supports a substantial population of the Magpie Goose (>100 birds), is considered "*unlikely to affect the Magpie Goose population*" in that area, given the low level of use of wetlands on one side of the transmission line, and "*the low collision rate of waterbirds with existing transmission lines*" in the vicinity (SWC 1993).

Other endangered wetland or grassland species which occasionally occur in the area and which could also be affected include the Brolga and Australian Bustard. However, the rarity of these species in the region suggests that any such incidents would be negligible. The raptors (Grey Falcon, Black-breasted Buzzard and Square-tailed Kite) and the Masked Owl could also theoretically be affected by 'bird-strike' on powerlines, although there are no known incidences of these species being affected. Furthermore, these species are highly manoeuverable and are active during the day, and the Owl is not known from the region. The location of the line between Lake Cowal and Nerang Cowal is not likely to be of particular relevance for these species.

There is the potential for collisions of wetland birds on the powerline between Lake Cowal and Nerang Cowal, and there is doubtless some potential for endangered species to be involved. Conversely, the flight characteristics of the species and their abundances at Lake Cowal suggest that the likelihood of significant impacts is low. A detailed monitoring program will be implemented following construction of the powerline (see Section 5.4), and a series of impact amelioration measures which may be applied if necessary along the powerline corridor is provided in Section 5.1.

4.4 SIGNIFICANCE of LAKE COWAL

Under Section 92D(1)(c)(iii) of the NP&W Act, the Director-General of the NP&WS requires:

> *"a discussion of the importance of Lake Cowal as a waterbird breeding habitat, including migratory birds listed in the Japan Australia Migratory Birds Agreement 1981 and the China Australia Migratory Birds Agreement 1988. Consideration of possible impacts on that habitat during mine development, operation and closure is required. Consideration should be made to the values and significance identified by the Australian Heritage Commission when the listing of Lake Cowal on the Register of the National Estate".*

Lake Cowal is universally regarded as a wetland of major significance for avian fauna, in particular for wading and wetland birds (Vestjens 1977; DWR 1990; Lane 1990; AHC 1992; Rankine & Hill 1980). The high numbers of waterbirds and the intensity of breeding activities qualify Lake Cowal as a 'wetland of international significance', according to the criteria implemented by the IUCN. "*Its natural condition, size and waterbird populations, make it one of the most important wetlands in South Eastern Australia*" (Lane 1990).

The significance of Lake Cowal for waterbirds and as a conservation feature is related to its size and essentially natural flooding regime, and to the variety of habitats and features present. "*Because of its size and unregulated water levels, Lake Cowal provides opportunities for a number of waterbird breeding events involving very large numbers of birds, yet it dries out frequently enough to produce high biological diversity next time it fills*" (Lane 1990). Lake Cowal is not subject to artificial regulatory systems and essentially follows a natural cycle of drying and refilling. The hydrological regime creates variation in vegetation communities present and in the macroinvertebrate and fish fauna over time, contributing to the value of Lake Cowal for breeding waterbirds.

In an investigation of waterbird breeding at Lake Cowal, relatively high breeding densities have been recorded for some species of wading birds (Lawler 1989). In particular, the intensive breeding activities of the night-herons, grebes, Hardheads, ibis and the Eurasian Coot are characteristic of the Lake Cowal wetland bird community. Similarly, Lane (1990) notes substantial numbers of some colonial breeding waterbirds at Lake Cowal. In 1989 and January 1990, the Straw-necked Ibis was the most abundant colonial breeding waterbird, with 4000 and 1500 nests respectively. Other species with significant numbers of nests at Lake Cowal include the Little Black and Little Pied Cormorants, the Rufous Night-heron (with approximately 200 nests in January 1990) and the Whiskered Tern. Vestjens (1977) also recorded a substantial number of birds in breeding colonies at Lake Cowal between 1969 and 1976, with up to 60000 Straw-necked Ibis, 9000 Rufous Night-herons and 7000 Whiskered Terns, along with considerable numbers of Sacred Ibis, Little Black and Little Pied Cormorants, Australian Pelicans and Silver Gulls.

Several of the wetland species are listed on international conservation treaties to which Australia is a signatory (Table 2), including JAMBA (the Japan-Australia Migratory Bird Agreement), CAMBA (the China-Australia Migratory Bird Agreement), and BONN (the Convention on the Conservation of Migratory Species of Wild Animals). Whilst a number of those species listed on JAMBA and CAMBA breed on Lake Cowal, none have been recorded as breeding in the vicinity of the proposed mining operation (Crome 1995; Lawler 1989). As discussed elsewhere in this FIS, the site of the proposed mine operation is not characterised as of particular value for breeding waterfowl. The only species which has been recorded breeding in the vicinity of the mining operation is the widespread and abundant Grey Teal.

The proposed mining operation has been specifically designed in order to avoid imposing adverse impacts upon the environment, and the proposed habitat restoration program is intended to enhance the potential for the survival and breeding of native fauna in the vicinity. There is no measurable likelihood of impacts on the breeding potential for endangered waterbirds, species listed on JAMBA and CAMBA or on any other waterbirds or other species in the locality, and the Project is considered compatible with the conservation of these species.

Previous sections of this FIS and the following Sections 4.5 and 4.6 provide detailed "*consideration of possible impacts on that habitat ["waterbird breeding habitat"] during mine development, operation and closure*". As detailed elsewhere, the proposed mining operation is predicated on the minimisation of potential impacts on the environment (by affecting only already disturbed lands, by avoiding or minimising the discharge of water or contaminants into Lake Cowal and by appropriate management techniques to control sediment discharge and to prevent or limit wildlife use of potential contaminant sources such as the tailings storages) and also on the approach of maximising the potential for habitat enhancement in the vicinity. The habitat restoration program for the Lake Cowal Gold Project will involve the re-creation of native vegetation communities, habitats and resources over a substantial proportion of the Project area and will at its conclusion provide a substantially improved fauna habitat over that which currently occurs. This may be particularly relevant for a number of endangered species which will either be enticed into the area or will be provided with a substantially improved resource base.

The listing of Lake Cowal on the register of the National Estate by the Australian Heritage Commission (AHC 1992; Appendix 9) notes that "*Lake Cowal is one of the most significant waterbird concentration areas in nsw* [sic]. *It is an important site for migratory birds, and supports a high diversity of bird species with 172 species recorded in the area, including a breeding population of 82 species, of which 38 are waterfowl,*" (Appendix 9). The AHC listing is based on existing reference material (Goldney & Bowie 1987; Schwinghamnier 1987; Vestjens 1975, 1976, 1977), and the substantial database prepared for the Lake Cowal Gold Project (see Appendix 9). Nonetheless, the register of Lake Cowal as an important waterbird breeding environment appears warranted and has been recognised in the EIS for the Lake Cowal Gold Project (NSR 1995) and in this FIS.

In recognition of the high conservation value of Lake Cowal, the proposed Gold Project has been specifically designed to enhance and restore native habitats on the mine site and in the immediate vicinity. It is intended that the Project area provide enhanced resources for endangered species, including waterbirds, after completion of mining and rehabilitation operations.

4.5 IMPACTS of NOISE on FAUNA

Under Section 92D(1)(c)(iii) of the NP&W Act, the Director-General of the NP&WS requires:

"*a discussion of the issue of noise and its impacts on endangered fauna*".

The literature regarding "*the issue of noise and its impacts on endangered fauna*" within Australia appears relatively sparse, but a substantial body of information is available from the United States of America. Investigations have principally been related to the impacts of aircraft overflights on fauna (especially birds), and to the use of sound to discourage birds from using facilities ('hazing').

In general terms, the impacts of helicopter and aircraft overflights appear to be of little concern to native wildlife. Hockin *et al* (1992) report that Red-tailed Hawks in Britain readily habituated to helicopter overflights, and that "*least terns were found to nest on take-off pads of harrier jets despite their frequent use (Altmann and Gano, 1984). It is also relevant to note that in the United Kingdom many of the Sites of Special Scientific Interest controlled by the Ministry of Defence and used as training areas and artillery ranges support diverse breeding bird populations (Fuller, 1982)*". Ellis *et al* (1991) reported that the responses of birds to "*real and simulated mid- to high-altitude sonic booms were often* *minimal and never appeared productivity limiting*", and Andersen *et al* (1989) concluded that "*aircraft overflights are often initially startling, but animals generally adapt to them very well under most circumstances*".

The use of noise to discourage birds from using certain facilities or sites appears to have been generally unsuccessful. Jeffress (1990) reviewed the use 'hazing' techniques as on avian deterrent on cyanide ponds at gold mines in the USA, and concluded that "*sound devices have had a very limited overall effectiveness as deterrents to waterfowl*". The use of radio-controlled boats and planes, pyrotechnics, cannons, rock music, avian distress and predator calls, sirens, whistler bombs and a range of other devices have failed to have other than a very short-term effect on waterfowl (Allen 1990; Jeffress 1990). In one instance, the use of 10 automatic acetylene-based bird scarers along an airport runway "*proved effective for 1 week, after which birds even started perching on them*" (Hockin *et al* 1992).

At the Temora Gold Mine (Gidginbung NSW), a pair of Peregrine Falcons have been reported nesting in the open pit (C Doon *pers comm*). This pair apparently bred successfully and the nest site was subsequently destroyed by a 'pit pushback', which had been delayed until the young Peregrine Falcons had been fledged. This pair of Falcons subsequently built a new nest elsewhere in the open pit and there are presently three nesting pairs of Peregrine Falcons within the active Temora Gold Mine pit. Blasting occurs 2-3 times per week and these species appear essentially undeterred by blasting and mining operations in line of sight from their nest locations (C Doon *pers comm*). By comparison, the main waterbird breeding habitats at Lake Cowal are some considerable distance from the mine site (>2km) and will also be shielded from mining operations and blasting activities by the depth of the pit and by the perimeter bund.

The adverse impacts of noise on wildlife appear, therefore, to be minimal. The waterbirds and other fauna in the vicinity of the proposed mine at Lake Cowal are certain to rapidly become habituated to the general noise associated with the mine operations, including blasting activities, and the distance of the main breeding sites for waterbirds at the Lake, as well as the protection provided by the perimeter bund, will render the noise impacts insignificant.

4.6 POTENTIAL IMPACTS

Under Section 92D(1)(c)(iii) of the NP&W Act, the NP&WS Director-General requires:

> "*a discussion of the potential impacts of mining operations on water quality, endangered fauna and habitat within Lake Cowal. This should include discussion of the potential impacts of draining water out of Lake Cowal for use in the mine, discharge of water into the Lake, and the possible effects of leakage of saline water through the bund wall after mining is completed*".

The proposed "*mining operations*" at Lake Cowal have been specifically designed to avoid the discharge of water or contaminants into the Lake from the active mining and processing areas. All run-off and drainage water from the operational area of the mine and the tailings storages is to be collected and used within the operation. The project "*will be a net consumer of water, even under extreme rainfall years*", requiring additional water to that generated on-site for processing and maintenance requirements (NSR 1995).

The first stage of the mine operation will be the construction of a cofferdam into the Lake, followed by the pit protection bund. Once the perimeter bund and water management structures have been constructed, the only discharge from the mine will be of rainwater which falls on the outside of the bund. Rainfall runoff from the external faces of embankments will be released to Lake Cowal after treatment in settling ponds to capture sediment, except for that portion within the Lake which will discharge directly. During construction, stringent erosion control measures are to be adopted, to minimise the discharge of sediment or contaminants into the Lake or adjacent watercourses.

Specific measures will be applied to the borefield pipeline across Lake Cowal, if excessive sediment disturbance and turbidity arise during the pipeline installation (see Chapter 5). It is intended to trench and bury the pipeline across the Lake, using a barge. However, if excessive sediment discharge is generated by trenching when the Lake is full, the pipeline will simply be laid on the Lake bed, and subsequently trenched and filled when the Lake dries out.

The perimeter bund is to be vegetated as rapidly as possible, to limit erosion or sediment discharge. Any sediment derived from the bund during the early stages of stabilisation (prior to establishment of the protective vegetation cover) will be contained within the cofferdam. The intention, therefore, is to avoid sediment discharge into the Lake, and consequently to limit or avoid impacts on water quality from increases in turbidity.

The design of the project as a 'zero-discharge' operation is specifically intended to avoid "*the potential impacts of mining operations on water quality*". As noted in the EIS (NSR 1995), "*all water on active mine areas will be contained and recycled under all foreseeable conditions*" (Appendix 1). No significant adverse impacts on water quality are anticipated as a result of the proposed "*mining operations*" at Lake Cowal.

Similarly, the Lake Cowal Gold project has been designed to avoid "*potential impacts*" on "*endangered fauna and habitat within Lake Cowal*". The project is located in an area of little significance for endangered fauna, the surrounding landscape is already highly modified, and an array of rehabilitation and habitat enhancement measures will be implemented to improve the value of the site for endangered fauna in the medium to long term. The "*potential impacts*" of noise, dust, lighting and the tailings storages (due to cyanide or 'boggy beaches') have been addressed in other sections of this FIS, and a range of monitoring and impact amelioration measures are proposed to minimise or prevent adverse impacts being imposed on native fauna.

The Lake Cowal Gold Project does not propose "*draining water out of Lake Cowal for use in the mine*".

As discussed above and as detailed in the EIS, the Lake Cowal Gold Project will not involve the "*discharge of water into the Lake*" from the "*mining operations*". A small amount of rainfall run-off will be generated from the external surfaces of the bunds around the mine site, and this will be released into the Lake via natural drainage lines, after treatment in settling ponds. These waters will not contain contaminants derived from the "*mining operations*", and no adverse impacts on the natural environment are anticipated.

Consideration of "*the possible effects of leakage of saline water through the bund wall after mining is completed*" has been documented in the EIS (NSR 1995), and the likelihood of this circumstance arising is regarded as negligible. The bund is to be constructed to high standards, and will be topsoiled and vegetated early in the mining operation process. The rates of inundation into the pit compared to rates of evaporation and the source of the pit water (being primarily groundwater) indicate that the water level in the pit will always be below that of the Lake bed, with a maximum level approximately 20m below the bed of the Lake. Consequently, there is no possibility of the saline pit water 'leaking' through the bund, or entering the Lake by any other means.

Furthermore, even if saline water was to 'leak' through the bund after mining, the level of dilution and the slow rates which would be involved are entirely unlikely to have the potential to impose any adverse impact on the fauna of the Lake.

5 AMELIORATION, MONITORING and LICENSING

5.1 IMPACT AMELIORATION

With regard to the proposed development, Section 92D(1)(c)(iv) of the NP&W Act 1974 requires:

> "*details of the measures to be taken to ameliorate the impacts*".

The proposed Lake Cowal Gold Project is located within a highly modified landscape. Most of the general area has long been cleared of native vegetation, with only relatively small stands of regrowth forest and Open Woodland remaining. Only a small proportion of the Lake itself (1.4%) will be affected by the proposed mine, and the operation area is designed as a 'zero-discharge' facility (*ie* all water and contaminants are to remain on the Project site). The potential for adverse impacts on the local environment and on native fauna is limited by the condition of the existing environment and by the specific design elements of the proposed development.

The most significant impact amelioration measure which has been applied to the Lake Cowal Gold Project is that the operation (including the open pit, waste rock emplacements, tailings storages and processing plant) is designed to contain all potential contaminants. There will be no discharge of water or associated contaminants from the operations area into the surrounding environment. The Project will be a nett importer of water, and there is no requirement for any discharge, even under high rainfall conditions. This approach has eliminated a significant proportion of the potential impacts which might otherwise have arisen from the development.

Furthermore, because of the highly modified and degraded nature of the landscape in which the Project is located, the area of natural habitat and vegetation communities which are to be disturbed by the proposed mine is extremely limited. Most of the area to be disturbed (and most of the general landscape) is characterised as cleared agricultural grazing land, with only relatively small areas of remnant Open Woodland to be affected. The main waste emplacement in the northern part of the Project area has been altered in configuration to preserve a proportion of the Open Woodland on a small knoll ('Cowal West Hill') at this locality.

A significant element of the Project is the regeneration of the natural vegetation communities and fauna habitats which once characterised the area but which are presently extremely limited in the local landscape (Section 5.2). In this regard, the Project is considered likely to provide significant beneficial impacts for fauna in the immediate locality, rather than impose negative effects.

Nevertheless, there are features of the proposed development which may potentially impose adverse impacts on the local environment or on native fauna which use it (see Chapter 4). Several of these have been addressed by specific design measures intended to avoid or minimise their imposition on native fauna or fauna habitats. In these instances (the operation of the tailings storages, the powerline from Forbes and the outer surface of the perimeter bund), monitoring of any impacts which may arise will continue throughout the life of the mine (Section 5.4), and supplementary amelioration protocols will be implemented as necessary.

An array of impact amelioration measures are proposed for the gold mine at Lake Cowal, including:

- the application of environmentally sound construction methods for the whole of the operation. These will include the use of sediment discharge control measures wherever stormwater run-off from disturbed surfaces into the surrounding environment is to occur. On the outside of the perimeter bund which is to surround the whole of the operation, the use of hay-bale filters, silt fences and/or settling ponds may be required in appropriate locations to avoid the discharge of sediment into adjacent water courses or into the Lake. These features will be required primarily during the construction phase and prior to the generation of native vegetation communities on the outer bund surfaces. Similarly, on the inner side of the bund, the use of sediment discharge control measures may be required to control the movement of sediment within the operations area;

- construction of the perimeter bund within the Lake itself will also require sediment discharge controls during the construction phase, particularly if the Lake is high and the bund is to be constructed within the water body. Under this scenario, a cofferdam is to be constructed beyond the desired location of the bund, which will contain any sediment discharge from the bund itself. The level of sediment loss from the cofferdam will also be monitored, and if excessive sediment discharge is occurring, a silt curtain within the body of the Lake, outside the cofferdam, will be employed to contain the sediment;

- all exposed finished soil surfaces are to be revegetated as rapidly as possible. To minimise the loss of sediment from finished soil surfaces, a combination of mulching, cover crops and/or the use of fibre matting will be applied, as appropriate. These measures are intended to minimise the quantity of sediment discharge and thus ameliorate the potential for adverse impacts on local watercourses and ultimately on the Lake itself;

- as the whole of the operation is to be contained within a bund and is designed as a 'zero-discharge' facility, there appears little requirement for specific bunding of potential contaminants (such as fuels, oils, chemicals etc). However, the plant, fuel storage facilities and reagent areas will be separately bunded for added security, and to control the extent of any discharge should a spill occur. A set of specific protocols will be generated to manage any spills or accidents which occur;

- the potential for adverse impacts to be imposed on the Lake or neighbouring vegetation communities by the discharge of dust from the mining operation will be addressed by the dust control measures detailed in the Environmental Impact Statement for this proposal (NSR 1995). Primarily, these involve the watering of exposed dust-generating surfaces, the perimeter bund which confines the mining activities, and the progressive vegetation of finished soil surfaces throughout the Project area;

- the potential for adverse impacts, particularly for waterbirds, which may arise from lighting associated with the proposed mining operation will be substantially addressed by the main perimeter bund. This is intended to shield the surrounding environment both from the discharge of water and contaminants from the site and from the effects of noise, dust and lighting. Once the perimeter bund has been constructed, mining operations and all activities within the mine area will be conducted below the top of the bund. This approach, and the distance of the mining operation from the main waterbird breeding areas for most of the native birds of Lake Cowal, will ameliorate the potential impacts of mine lighting. For other endangered species, no impacts are expected, although microchiropteran bats could potentially forage around lights which attract flying insects;

- the potential impacts of noise generated from the proposed mining operations on native fauna, particularly on the wading birds associated with the Lake, has been addressed in detail in Section 4.5 of this FIS. The general noise levels associated with the proposed operation are unlikely to adversely affect the native fauna of the area, and birds are known to become habituated to noise of various types. Although the blasting of rock involves an intense (short-term) noise, this will be ameliorated by the perimeter bund. Blast size will be limited and pattern controlled to minimise ground vibration. It is considered highly unlikely that even this activity will adversely affect the native species in the locality, nor will it impact upon breeding activities of waterbirds in the Lake.

The main impact amelioration measure for noise emanating from the mine project involves the construction of a sound bund 10m above the general workings. Monitoring of the breeding and feeding activities of birds during mine activities (particularly blasting) will be conducted to provide information regarding the impacts of these activities (none are expected). Potential amelioration measures which may be applied, should blasting or other noise generating activities be proved to impose an adverse impact upon native fauna, will include the careful timing of blasting to minimise the disturbance to native fauna in the area (eg at certain times of the day), and possibly the discouragement of animal activity in the vicinity at the time of blasting activities. Pre-habituation of waterbirds to noise by the use of less intense sounds will also be considered;

- there is some potential for impacts on native birds arising from the use of the tailings storages on the Project area, as discussed in Chapter 4 of this FIS. The principal impact amelioration measure which is to be implemented on the Lake Cowal Gold Project has been the design of the tailings storage as a four-cell operation, rather than the usual single large facility storage. The cells are to be used for the deposition of tailings sequentially, with only one of the four cells operating at any time. This design has been adopted to limit the size of the decant pond and also to limit the size of the tailings beaches (which are of a muddy consistency and may potentially bog birds which land on it).

  A detailed monitoring and impact management plan will be prepared for the Lake Cowal Gold Project to avoid or pre-empt any potential of an incident such as that at the Northparkes Mine.

  Other impact amelioration measures which are to be implemented on the tailings storages at the Lake Cowal Gold Project will include:

  - minimisation of the size of the decant ponds, to limit the area of 'attraction' for wetland birds;
  - the control of cyanide levels in the decant pond (by removal or destruction of cyanide prior to discharge, by dilution using cyanide-free water and/or by management of the processing activities in the plant) to ensure that cyanide levels in the decant ponds remain below 50mg CN_{WAD}/L wherever possible;
  - increased monitoring and vigilance when CN levels exceed 50mg CNWAD/L;
  - provision of a hovercraft to rescue birds from the tailings storages;

  A detailed program of contingency measures will be provided with the tailings management plan prior to initiation of tailings operations. Possible impact amelioration measures which will be provided as contingency plans (to be implemented if proved necessary subject to monitoring of bird activity and to additional investigation of their practicability, necessity and efficiency) include;

  - the use of plastic drums tethered by floating rope on the pond surfaces to reduce the likelihood of waterbirds landing on the ponds;
  - the installation of cables above tailings storage beaches fitted with reflective streamers and flags to discourage birds from landing on the beaches;
  - the use of lighting of the tailings storage beaches to discourage wading birds from landing at night;
  - the active discouraging of birds using propane gas guns or other 'hazing' techniques on an irregular basis (if used regularly or frequently, these measures appear to be ineffective);
  - the reduction of cyanide levels to <50mg CN_{WAD}/L using cyanide destruction methods or the optimisation of process parameters;
  - decant reclaim ponds which are used to collect or store highly contaminated water will be closely monitored, and if necessary will be permanently netted. A range of net-sizes may be necessary to prevent small birds from gaining access to the ponds, with netting extending to the ground to deny access to small birds. In addition, ponds may need to be fenced if monitoring

indicates their use by 'terrestrial' mammals, microchiropteran bats, amphibians or reptiles.

- the use of extensive netting of the tailings storage decant ponds, to prevent access by birds. This approach has been employed over extensive areas in the USA (Allen 1990; Klepfer 1990; Schroeder 1990) and can prevent most waterbirds from accessing the ponds;

- if use is being made of the decant ponds by other bird species (such as Regent Honeyeaters or other 'terrestrial' species attracted into the locality by the habitat restoration and rehabilitation program), alternative water sources in more appropriate and more attractive localities may provided and maintained to satisfy the requirements of these species (ie the provision of alternative wetlands);

- large River Red Gums which are to be removed from within the proposed Project area are to be salvaged and re-erected on small islands created from the cofferdam, or along the final pit protection bund, as breeding and roosting resources for native fauna. These dead trees will provide perch sites and potential nest sites in hollows for native birds and microchiropteran bats while the regeneration plantings of River Red Gums along the outer bund perimeter mature;

- the proposed pipeline from the Bland Paleochannel borefield (to the east of Lake Cowal) is to be laid in a covered ditch across the land surface to the eastern border of Lake Cowal. It will then be laid in a trench on the Lake bottom, and buried. No adverse impacts on native fauna are considered likely to arise from the proposed activity on land, as the habitats along the corridor are already disturbed. However, standard impact amelioration measures (minimisation of tree and native vegetation removal, sediment and waste controls) will be applied along the route. Within the Lake, the generation of silt and sediment is considered likely to be of only very localised and transitory relevance for native fauna in the Lake. However, the operation will be monitored and if excessive sediment is generated, the trenching approach will be abandoned in favour of temporarily laying the pipeline on the Lake bed, or a silt skirt can be provided around the barge to control the discharge of sediment as a result of the trenching and filling operation;

- the potential for the powerline from Forbes to the Lake Cowal Gold Project to impose adverse impacts on endangered fauna has been discussed in detail in Chapter 4 of this FIS. The proposed powerline crosses open cleared agricultural land between Forbes and the northern edge of Lake Cowal, and then passes between Lake Cowal and Nerang Cowal before heading south to the Project area. Because Lake Cowal and Nerang Cowal, along with the Bogandillon Swamp to the north, provide a substantial corridor of wetlands for wading and wetland birds in this region, and because of the ephemeral nature of these wetlands, there is likely to be substantial bird movement between them at times.

  To ameliorate the potential impacts of the powerline, particularly in relation to 'bird-strike', a number of measures are proposed, including:

  - adhere generally to the proposed powerline route, which avoids known breeding sites of the wetland birds of Lake Cowal and Nerang Cowal;

  - the use wherever practicable of existing trees and wind breaks to shield the powerline and to force moving birds to fly up and over it;

  - the use of large diameter cables for the powerline between Lake Cowal and Nerang Cowal rather than fine cables (which are 'invisible') to provide better opportunities for native birds to see and avoid the cables;

  - establishment of a monitoring program along the length of the powerline between Lake Cowal and Nerang Cowal to identify areas which are generating problems with 'bird-strike'. This monitoring program may trigger supplementary protocols where 'bird-strike' is identified as a significant problem.

Additional protocols which may be implemented will include:

- the planting of tall eucalypts in the vicinity of the powerline at locations identified as constituting bird movement corridors between Lake Cowal and Nerang Cowal;
- the use of balls and streamers on the powerline cables to highlight their presence and observability for migrating or moving birds;

5.2 HABITAT RESTORATION

Under Section 92D(1)(c)(iv) of the NP&W Act 1974, the Director-General of the NP&WS also requires the provision of detailed information on:

> "*any habitat restoration proposed for the study area, including the expected time taken to restore habitat, any proposals or opportunities to improve habitat and the likely impact on fauna, particularly during the time the habitat is being restored.*"

The proposed Lake Cowal Gold Project has been designed with a substantial "*habitat restoration*" program as a central feature of its operation and as a tangible contribution to the local environment of native fauna. The existing landscape is significantly disturbed and modified, having long been cleared and degraded by agricultural and horticultural activities. The proposed rehabilitation program for the site involves restoration of natural habitats and communities over portions of the site (re-creating natural habitats in areas where they are currently absent), and the provision of supplementary resources for endangered species in the vicinity.

Details of the "*habitat restoration*" program proposed for the Lake Cowal Gold Project are provided in Appendix 10. In summary, the proposed "*habitat restoration*" concepts will include:

- generation of Bimble Box Woodland on three of the completed tailings storage cells, on the lower slopes of the perimeter bund, on the slopes of the waste emplacements, and around the pit and other disturbed Project areas;
- creation of an ephemeral wetland on the remaining tailings cell, being supplied by run-off from the other 3 cells;
- the establishment of a White Cypress-Pine/Spearwood/Dwyers Red Gum Open Woodland (as exists on Wamboyne Mountain) on the upper slopes and tops of the waste emplacements;
- establishment of an enhanced riparian community around the newly created Lake shore (on the outer surface of the perimeter bund), involving re-erection of large River Red Gums as stags, the planting of River Red Gums and Lignum along the shore and on islands constructed from the cofferdam, and supplementary plantings of Lignum and Cane Grass on the islands and shallows along the shore;
- retention of the pit as a deep saline lake with rocky sides and crevices.

The restored and enhanced habitats will provide potential resources for a range of native fauna, including endangered species. Particular resources and features of relevance include:

- Superb Parrot - River Red Gums for roosting, woodlands for feeding;
- Turquoise Parrot - Open Woodland trees for nesting, grasslands for feeding;

- Pink Cockatoo - Cypress Pines for feeding;
- Regent Honeyeater - eucalypts (particularly Red Ironbark, White Box and Yellow Gum) as a food resource;
- Painted Honeyeater - Mistletoe for feeding;
- wetland birds - River Red Gum stags for roosting and/or nesting, islands for shelter and feeding, and in some cases for breeding, dense shore vegetation for shelter and breeding;
- microchiropteran bats - tree-hollows in River Red Gums and eventually Open Woodland trees for roosting, and Open Woodland for foraging. The pit walls will also provide roosting sites for endangered microchiropteran bats.

The main principles which guide the habitat rehabilitation programs during mine operations and as a long-term goal of the decommissioning of the Lake Cowal Gold Project include:

- maximisation of the diversity of habitats re-created, as a means of optimising the numbers of species and individual animals which may ultimately recolonise the site;
- re-creation of natural habitats (such as native grasslands or woodlands) which have been modified or destroyed throughout the region as a result of agricultural activities. This approach should be recognised as a significant contribution to habitat enhancement and involves a substantial improvement (for native fauna) over the current situation;
- the generation or re-creation of specific habitats or resources for endangered species, to improve their local and regional conservation prognosis;
- the use of local shrub and tree species to provide an increased area of relevant habitats and resources for native fauna;
- protection of creeks and watercourses, and of other potential amphibian habitats, in the vicinity of the operating and decommissioned mine site.

Rehabilitation of the Project area is intended to enhance the local environment, and to leave the area with locally valuable fauna habitats. The main features of the final terrestrial environment will include the waste emplacements (to be used as the basis for new 'natural' hill habitats on the Lake shore), the tailings storages (to form low hills and be used for Open Woodland/grassland and wetland habitats), the bunds (to be vegetated with Open Woodland communities), and the pit (to be left as a saline lake).

Specific habitats which can be created on the waste emplacements include:

- 'rock-on-rock' habitats, with exposed rocks and boulders creating complex crevices and rock shelters, which are of particular relevance for reptiles and small mammals. These features would be most appropriate on the northern and eastern sides of the waste emplacements, on the basis of prevailing weather conditions. One possible approach in this regard would involve the inclusion of reject pipes or culvert materials, built into rock slopes to provide 'tunnels' and 'caves' for microchiropteran bats or large reptiles as shelter;
- the possibility of creating rock cliffs or slopes for the use of species such as rock wallabies (which require substantial boulders, crevices and caves for shelter), microchiropteran bats (some of which use rock crevices and caves for roosting), and the Peregrine Falcon (which requires cliff ledges for breeding sites) will be explored; and
- the planting of appropriate trees and shrubs for endangered bird species (eg plantings of Yellow Box and White Cypress-pines trees as a food resource for the

Pink Cockatoo, plantings of mallee and melaleuca thickets for Gilbert's Whistler etc).

The establishment of resources of particular value for certain native fauna species (especially endangered fauna) is a feature of the habitat restoration program proposed for the Project site. Specific protocols which would be of benefit to particular species are noted above. Habitat enhancement for amphibian species is also possible, involving the creation of watercourses and wetlands, and the provision of specific resources (such as rocks and logs for shelter) along creeklines and adjacent to ponds and dams.

As for the terrestrial landscape at Lake Cowal, the Lake shore habitats in the general vicinity of the proposed gold mine have long been substantially altered from their original condition. The shore currently consists of grazed grassland, with a thin band of River Red Gums along the foreshore and occasional patches of Lignum and other wetland plants.

The most significant feature of the proposed gold mine with respect to Lake Cowal will be the extensive perimeter bund to be constructed around the pit. This feature, which will be approximately 3km long and will extend up to 1.1km into the Lake, will present an extensive 'new' Lake shore (replacing an existing 1.84km of shoreline). The bund will be constructed with a gentle slope, to provide long-term stability and to reduce the potential for erosion.

Habitat restoration along the bund will aim to create an enhanced Lake shore habitat, with plantings of Lignum (to provide shelter for a range of waterbirds and amphibians), ungrazed grassland on the bund dominated by native grasses and shrubs (to provide enhanced habitat for native fauna), and substantial plantings of River Red Gums. Large trees which must be removed from the mine area are to be retained and installed either as dead stags along the bund shoreline (to provide roosting habitat for birds) or perhaps laid near the shoreline (to provide shelter for amphibians).

The cofferdam will be breached and modified to create a series of low islands near the bund, with Lignum, Cane Grass and eucalypt stags and live trees, for wetland birds to use as nesting havens. If construction of the cofferdam is not required, the islands should be created anyway during construction of the perimeter bund.

Practical constraints on subsequent uses of the pit include fluctuating water levels and varying water quality. The pit will be subject to groundwater inflow, and will gradually fill over the ensuing 50 years. The groundwater is moderately saline, and water quality in the pit will consequently vary according to the quantity of fresh water entering the pit, either as rainfall or run-off. The water in the pit will be saline, and the water level at maximum fill will be approximately 20m below that of the Lake.

The pit will doubtless provide some habitat for native fauna. Waterbirds may be able to use the water edges for foraging, and the rock ledges of the pit walls will provide nesting sites for some species (microchiropteran bats and raptores). The value of the pit as a foraging resource will depend on the water quality, and the densities of aquatic fauna and flora. Additionally, the species of aquatic fauna and flora which could be introduced to the pit will depend on water quality and salinity.

Other features of the pit which may be of value for native fauna (including endangered species) involve the rock walls. Small holes and crevices will be used by reptiles and microchiropteran bats, and steep cliffs may be used by species such as the Peregrine Falcon (as is the case at the Temora mine). Creation of these features should be encouraged during the excavation of the pit.

5.3 PROPOSED MEASURES

Under Section 92D(1)(c)(iv) of the NP&W Act 1974, the Director-General of the NP&WS also requires this FIS to provide detailed information on;

> "*any measures proposed to reduce possible effects of the development on any local populations of endangered fauna*".

As discussed in detail elsewhere in this FIS, there are no known "*local populations of endangered fauna*" at the proposed Lake Cowal Gold Project site, nor in the immediate vicinity. The endangered fauna species which have been recorded from this general locality involve a single sighting of the Freckled Duck on the waters of Lake Cowal in the mine area, although this species does not breed in this vicinity (as there are no appropriate habitat resources present). No evidence has been obtained for the presence of any 'terrestrial' endangered species, although a few microchiropteran bats or an occasional endangered bird species may possibly be present on the subject site.

The Lake Cowal Gold Project will implement a range of impact amelioration protocols (Section 5.1) and a substantial habitat restoration program (Section 5.2) which is intended to significantly enhance the resources available for endangered species at this locality. Given the intention to impose no adverse impacts upon endangered species from the construction, operation and closure of the proposed Project, and the intended and likely enhancement of the local environment for endangered species, the medium and long term "*effects of the development on any local populations of endangered fauna*" are considered likely to be beneficial rather than adverse.

Extensive consideration has been given to the potential for some elements of the Project's operation to impose adverse impacts upon endangered species in the locality. It is considered unlikely that the location of the mine and its associated infrastructure and operational facilities will impose an adverse effect on native species at this locality, because of the degraded and modified nature of the landscapes present. Similarly, as the mine is designed as a 'zero-discharge' operation, it is considered that there will be no significant adverse effects from sediment transport or contamination of the Lake or adjacent habitats. The Project has been specifically designed "*to reduce possible effects*" from these sources.

The potential for noise arising from the proposed mining activities adversely affecting native fauna in the vicinity has been considered in detail in Section 4.5 of this FIS. There is no evidence to indicate that any of the noise-generating activities are likely to impose any adverse effects on native species, whether endangered or not. Given the ability of waterbirds and other native fauna to habituate to noise, and the distance of the main breeding areas for waterbirds from the proposed mine operations, it is considered that noise associated with the Project will impose no adverse impacts on waterbird breeding at Lake Cowal or on other endangered species. Consequently, supplementary measures to "*reduce possible effects*" on native fauna from noise generation are considered unnecessary. However, a monitoring program will be implemented to document the breeding activities at the Lake and any responses to noise from the Project.

The potential for adverse effects to arise from the use of the tailings storages by endangered species has been addressed in considerable detail in Chapter 4 of this FIS. A detailed management protocol for the tailings storages has been generated (Section 5.1), which is intended to prevent endangered and other native fauna being affected by cyanide in the tailings decant ponds or becoming bogged in the tailings beaches prior to their drying out. An array of contingency measures and intensive monitoring of the tailings storages and animal use of them are also detailed in Section 5.1.

The potential for 'bird-strike' on the powerline from Forbes has also been addressed in detail (Section 4.3), and a monitoring program and impact amelioration measures are detailed in Section 5.4 and 5.1 of this FIS respectively. The likelihood of the powerline imposing significant "*effects ... on any local populations of endangered fauna*" are considered low, but the impacts will be closely monitored and resolved if necessary.

5.4 MONITORING

Under Section 92D(1)(c)(iv) of the NP&W Act 1974, the Director-General of the NP&WS also requires the provision of detailed information on:

> "*any proposed on-going monitoring of the effectiveness of those ameliorative measures*".

An array of monitoring programs is proposed for the Lake Cowal Gold Project. Some of these are intended to monitor the effects of mining operations and associated activities on local populations of endangered and other native fauna. Several are designed to be interactive, which involves providing advice regarding additional protocols or measures which may need to be implemented to reduce the effects of the Project. For example, the powerline from Forbes is to be monitored between Lake Cowal and Nerang Cowal to assess the impacts on avifauna, and the tailings storages are to be monitored on an on-going basis to determine the levels of usage by native species. In both instances, any identified effects on endangered and other fauna species will be addressed by relevant impact mitigation measures. Other monitoring programs will be implemented to assess the rates of re-colonisation of newly formed or restored habitats by native fauna.

The range of specific monitoring programs which are proposed for the Lake Cowal Gold Project include:

- a detailed monitoring program of the Forbes to Lake Cowal powerline, between Lake Cowal and Nerang Cowal is required. The powerline will be regularly monitored and surveyed to assess the specific locations of 'bird-strike' on the powerline by migrating or moving waterbirds. Monitoring will initially be twice-weekly, involving a driven/walked inspection of the corridor, documenting any incidences of 'bird-strike', as identified by carcasses or feathers. Monitoring can either be conducted by the environmental staff of North Mining at Lake Cowal, or could be conducted by an external consultant. In the latter case, it is suggested that a local amateur ornithologist be contracted to conduct the surveys.

  The monitoring program is intended to trigger the implementation of supplementary impact amelioration measures if areas of high bird mortality are located. Subsequent monitoring will be required to determine the effectiveness of the ameliorative measures applied along the powerline;

- a detailed and comprehensive ongoing monitoring program of the tailings storages will be required to determine the use or otherwise of the water resources within them by native fauna, particularly wetland birds. Daily monitoring of the tailings storages by the on-site environmental officer will be required to assess the levels of use of these features by endangered species. Initially, monitoring should be conducted 3 times per day to document bird activities and to implement 'rapid response' measures, such as bird scaring (or 'hazing') or collection of affected birds.

  As with the powerline, the tailings storage monitoring will trigger the implementation of supplementary ameliorative measures, should any significant adverse impact be identified. Given the features of the site and the tailings storage management (see Section 4.3 and 5.1) implementation of these contingency measures would be premature. Subsequently, monitoring of the effectiveness of the measures employed at the Lake Cowal Gold Project will be documented to provide future reference for this and other mine sites;

- monitoring of decant reclaim ponds (into which the tailings storages drain) and other contaminated ponds within the Project area is proposed to assess the use of these resources by native fauna in the vicinity. If fauna do use these features, they will be protected by netting, the effectiveness of which will be monitored by the on-site environmental officer at Lake Cowal;

- a monitoring program will be established for those areas of natural or restored habitats which are generated over the mining area. In particular, the use of re-erected large River Red Gums, of the islands constructed beyond the perimeter bund within Lake Cowal, of areas of planted Lignum and other shallow water vegetation, of the rocky areas on the waste rock stockpile, cliffs and crevices in the pit and of regenerating grassland and Open Woodland communities, will be implemented. The monitoring program is intended to determine the rates of re-colonisation of new habitats by native species and the suitability of the various resources and communities which are created. The monitoring program will best be conducted initially by an external biological consultant, but may be suitable as a research program for University undergraduate or postgraduate studies;

- a continuation of the waterbird monitoring program at Lake Cowal should involve two facets. The first will assess the potential impacts of noise (particularly blasting) on breeding waterbirds by monitoring waterbird activity at breeding sites during blasting periods. The effects of blasting on closer populations of native fauna should also be monitored. In addition, the established survey transects will be substantially maintained with the mine transect being relocated to the outer edge of the perimeter bund. Surveys along this transect will provide information on the rates of recolonisation of this newly created habitat by native waterbirds;

- Monitoring may reasonably continue along the current protocols, involving external consultants, but could alternatively involve University students, and may also require some modification in focus or intensity;

- use of the study area by feral predators (particularly foxes and feral cats) and by vertebrate pest species (particularly rabbits) should also be monitored by the on-site environmental officer (a specific program can readily be developed and provided). Where populations of these species are located or found to be expanding, localised control measures will be required.

5.5 SPECIES to be LICENSED

The Director-General of the NSW NP&WS requires:

> "*an assessment of the endangered fauna species (including a list of those species) which will or are likely to be taken or killed by the proposed development, as ameliorated. In undertaking this assessment consideration should be given to the meaning of "take" as defined by Section 5 (1) of the National Parks and Wildlife Act, 1974. If the Fauna Impact Statement is to accompany a licence application for a General (Section 120) licence to take or kill endangered fauna, then the Fauna Impact Statement must clearly list those species for which coverage is sought*".

The preceding Chapters of this Fauna Impact Statement provide considerable detail on the endangered fauna known or likely to occur on the site, and an assessment of those "*likely to be taken or killed by the proposed development, as ameliorated*".

Section 5(1) of the NP&W Act 1974 defines "*take*" as:

> "*hunt, shoot, poison, net, snare, spear, pursue, capture, disturb, lure or injure, and without limiting the foregoing also includes significant modification of the habitat of the fauna which is likely to adversely affect its essential behavioural patterns*".

Of the endangered fauna known from or likely to occur in the vicinity, only the Freckled Duck has been recorded on the Project site. Several others are known from the region, but the only species considered likely or possibly to be affected by the Project, to the extent of a potential "take or kill", are the Blue-billed and Freckled Ducks (potential effects of the tailings storages) and the magpie Goose and Brolga (potential effects of 'bird-strike', although the species are extremely uncommon in the area).

The species for which a General (Section 120) Licence is required for the proposed Lake Cowal Gold Project are:

the Freckled Duck	***Stictonetta naevosa***
the Blue-billed Duck	***Oxyura australis***
the Brolga	***Grus rubicundus***
the Magpie Goose	***Anseranas semipalmata***

6 QUALIFICATIONS and INFORMATION

Section 92D(1)(c)(v) of the NP&W Act 1974 requires:

> "*details of the qualifications and experience in biological science and fauna management of the person preparing the statement and of any other person who has conducted research or investigations relied upon*".

6.1 QUALIFICATIONS and EXPERIENCE

The qualifications and experience of the author of this Fauna Impact Statement (F Dominic Fanning) is included as Appendix 11 to this FIS.

6.2 INFORMATION and REFERENCES

The Director-General's requirements for this FIS also state that:

> "*all information cited, from which statements or conclusions are made, must be provided or fully referenced*".

The full bibliography of previous investigations, scientific papers and other material referred to for this investigation is included below (Bibliography). In addition, details of the databases which were accessed for information on fauna species through the area are provided in Appendix 6.

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BIBLIOGRAPHY

Allen CH. 1990. Mitigating impacts to wildlife at FM Gold Company's Paradise Peak Mine. In *Proceedings of the Nevada Wildlife/Mining Workshop*. Nevada Mining Association.

Altman RL and Gano RD. 1984. Least terns nesting alongside a Harrier jet pad. *Journal of Field Ornithology* **55:** 108-109. In Hockin D *et al.* 1992.

Andersen DE, Rongstad OJ and Mytton WR. 1989. Response of nesting Red-tailed Hawks to helicopter overflights. *Condor* **91**: 296-299.

AHC. 1992. *Register of the National Estate. Detailed Place report for Lake Cowal.* Australian Heritage Commission, Canberra.

Blakers M, Davies SJJF and Reilly PN. 1984. *The Atlas of Australian Birds.* Royal Australasian Ornithologists Union. Melbourne University Press, Victoria.

Cayley NW. 1984. *What Bird Is That?.* Angus & Robertson, NSW.

Christidis L and Boles WE. 1994. *The Taxonomy and Species of Birds of Australia and its Territories.* Royal Australian Ornithologists Union, Moonee Ponds.

Clancy GP. 1989. A survey of Breeding Ospreys *Pandion haliaetus* in North-eastern Coastal New South Wales, 1980 to 1982. *Corella* **13:** 9-14.

Clancy GP. 1991. *The Biology and Management of the Osprey (Pandion haliaetus cristatus) in NSW.* Species Management Report #6. NSW National Parks & Wildlife Service, Hurstville.

Clancy GP. 1993. The conservation status of the Osprey Pandion haliaetus in New South Wales. In Olsen P (*ed*). *Australian Raptor Studies.* Australian Raptor Association and RAOU, Moonee Ponds.

Cogger HG. 1992. *Reptiles & Amphibians of Australia.* 5th Edition. Reed Books, Chatswood.

Crome FHJ. 1988. To drain or not drain? - Intermittent swamp drainage and waterbird breeding. *Emu* **88(4):** 243-248.

Crome F. 1995. *Waterbird monitoring on Lake Cowal.* Francis Crome Pty Ltd.

Debus SJS, Earle RD, Millard GJ and Parker CR. 1992. Breeding behaviour of a pair of Square-tailed Kites. *Australian Birds* **26(1):** 1-13.

Debus SJS, McAllan IAW and Morris AK. 1993. The Square Tailed Kite *Lophoictinia isura* in New South Wales. *Aust Birds* **26(3):** 104-119.

Debus SJS and Rose AB. 1994. The Masked Owl *Tyto novaehollandiae* in New South Wales. *Aust Birds* **28:** 40-64.

Debus SJS, McAllan IAW and Morris AK. 1993. The Square Tailed Kite *Lophoictinia isura* in New South Wales. *Aust Birds* **26(3):** 104-119.

Dent BR. Unpubl. Personal observations on the breeding of waterbirds at Lake Cowal 1964-1990. Private paper by resident of 'Gumbelah' near Lake Cowal.

DWR. 1990. Draft Water Management Plan for the wetlands of the Lachlan Valley Floodplain. NSW Department of Water Resources, Sydney.

Dwyer NC and Tanner GW. 1992. Nesting success in Florida Sandhill Cranes. *Wilson Bull* **104**: 22-31.

ELCOM. 1988. *Electricity Transmission Line between Coffs Harbour and Grafton.* 'Clause 64' Report. Electricity Commission of New South Wales, Sydney.

Ellis DH, Ellis CH and Mindell DP. 1991. Raptor responses to low-level jet aircraft and sonic booms. *Env Pollution* **74**: 53-83.

EES. 1992a. Lake Cowal waterbird monitoring survey progress report, January 1992. Report to Geopeko Operations and NSR.

EES. 1992b. Lake Cowal waterbird monitoring survey progress report, August 1992. Report to Geopeko Operations and NSR.

EES. 1992c. Lake Cowal waterbird monitoring survey progress report, October 1992. Report to Geopeko Operations and NSR.

EES. 1993a. Lake Cowal waterbird monitoring survey progress report, January 1993. Report to Geopeko Operations and NSR.

EES. 1993b. Lake Cowal waterbird monitoring survey progress report, August 1993. Report to Geopeko Operations and NSR.

EES. 1993c. Lake Cowal waterbird monitoring survey progress report, October 1993. Report to Geopeko Operations and NSR.

EES. 1994a. Lake Cowal waterbird monitoring survey progress report, January 1994. Report to Geopeko Operations and NSR.

EES. 1994b. Lake Cowal waterbird monitoring survey progress report, August 1994. Report to Geopeko Operations and NSR.

EES. 1994c. Lake Cowal waterbird monitoring survey progress report, October 1994. Report to Geopeko Operations and NSR.

EES. 1994d. *1989-1994, Lake Cowal Waterbird Monitoring Survey.* Progress Report prepared for NSR Environmental Consultants P/L and Geopeko Operations Ltd.

EES. 1995. Lake Cowal waterbird monitoring survey progress report, January 1995. Report to Geopeko Operations and NSR.

Forshaw JM and Cooper. 1981. *Australian Parrots.* 2nd Edition. Lansdowne editions, Melbourne.

Fullager PJ. 1991. *Australian Heritage Commission Listing of Lake Cowal on the Register of the National Estate Objection Assessment.* CSIRO Division of Wildlife & Ecology, Canberra.

Fuller RJ. 1982. *Bird Habitats.* In Hockin D *et al.* 1992.

Franklin DC, Menkhorst PW and Robinson JL. 1989. Ecology of the Regent Honeyeater *Xanthomyza phrygia. Emu* **89:** 140-154.

Garnett S. 1992a. *Threatened and Extinct Birds of Australia.* RAOU Report 82. RAOU & Australian National Parks & Wildlife Service, Moonee Ponds.

Garnett S. 1992b. *The Action Plan for Australian Birds.* Australian National Parks & Wildlife Service, Canberra.

Gibbs Sir H. 1991. *Inquiry into community needs and high voltage transmission line development.* Office of the Commissioners of Inquiry, Sydney.

Goldney DC and Bowie IJS. 1987. *Scenic and Scientific Survey of the Central Western Region.* A report to the Australian Heritage Commission.

Grubb TG and King RM. 1991. Assessing human disturbance of breeding Bald Eagles with classification tree models. *J Wildl Manage* **55**: 500-511.

Hall LS & Richards GC. 1979. *Bats of Eastern Australia.* Queensland Museum Booklet #12. The Queensland Museum, Brisbane.

Hallock B. 1990. Elimination of migratory bird mortality at gold and silver mines using cyanide extraction. In *Proceedings of the Nevada Wildlife/Mining Workshop.* Nevada Mining Association.

Hartmann L, Harrison RT and Makel W. 1992. *Potential Impacts of Aircraft Overflights of National Forest System Wildernesses.* Report to Congress. US Dept of Agriculture, Forest Service.

Hatton PJ. 1991. *Draft Water Management Plan for the Wilbertroy/Cowal Wetlands.* Department of Water Resources NSW, Lachlan Region.

Hawking JH. 1991. *Lake Cowal Baseline Monitoring Program: Macroinvertebrates, Initial Survey.* A progress report to NSR Environmental Consultants Pty Ltd June 1991. Unpublished.

Henson P and Grant TA. 1991. The effects of human disturbance on Trumpeter Swan breeding behaviour. *Wildl Soc Bull* **19**: 248-257.

Hindell MA & Lee AK. 1990. Tree preferences of the Koala. In Lee AK, Handasyde AK & Sanson GD (eds). *Biology of the Koala.* Surrey Beatty & Sons Pty Ltd, Chipping Norton.

Hockin D, Ounsted M, Gorman M, Hill D, Keller V and Barker MA. 1992. Examination of the effects of disturbance on birds with reference to its importance in ecological assessments. *J Env Manage* **36**: 253-286.

Hollands D. 1991. *Birds of the Night.* Reed Books, Balgowlah.

Jeffress B. 1990. Waterfowl hazing techniques. In *Proceedings of the Nevada Wildlife/Mining Workshop.* Nevada Mining Association.

Johnson G & Baker-Gabb D. 1994. *The Bush Thick-knee in northern Victoria (Part 1): Conservation and Management.* Technical Report Series #129. Arthur Rylah Institute for Environmental Research. Department of Conservation and Natural Resources, Melbourne.

Kay FR. 1990. NDOW's role: Past, present, future. In *Proceedings of the Nevada Wildlife/Mining Workshop.* Nevada Mining Association.

Klepfer E. 1990. Exclusion techniques used in the mining industry. In *Proceedings of the Nevada Wildlife/Mining Workshop.* Nevada Mining Association.

Lane BA. 1987. *Shorebirds in Australia.* Nelson, Melbourne.

Lane BA. 1989. *West Wyalong Prospect Waterbird Investigation. Winter 1989 Survey Report.* Prepared for NSR Environmental Consultants Pty Ltd.

Lane B. 1990. *West Wyalong Prospect: Waterbird investigation data report.* Prepared for NSR Environmental Consultants Pty Ltd.

Lawler W. 1989. Waterbird breeding at Lake Cowal, New South Wales. *Australian Birds* **23(2):** 32-35.

Lee A and Martin R. 1988. *The Koala A Natural History.* NSW University Press, Sydney.

Lindsey T. 1992. *Encyclopedia of Australian Animals: Birds.* The Australian Museum, Sydney.

Lunney D, Urquhart CA and Reed P (*eds*). 1990. *Koala Summit. Managing Koalas in New South Wales.* NSW National Parks & Wildlife Service, Hurstville.

Marchant S and Higgins PJ. 1990. *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 1. RAOU, Oxford University Press, Melbourne.

Marchant S and Higgins PJ. 1993. *Handbook Australian, New Zealand & Antarctic birds.* Volume 2. RAOU, Oxford University Press, Melbourne.

McGill SL & Comba PG. 1990. A review of existing cyanide destruction practices. In *Proceedings of the Nevada Wildlife/Mining Workshop.* Nevada Mining Association.

Morris AK, McGill AR and Holmes G. 1981. *Handlist of Birds in New South Wales.* NSW Field Ornithologists Club, Sydney.

NPA. 1990. *Lake Cowal Environmental Study.* National Parks Association of NSW Inc, Sydney.

NP&WS. 1992. *Reasons for inclusion of species on Schedule 12 of the NP&WS Act 1974.* National Parks & Wildlife Service, Sydney.

NSR. 1995. *Lake Cowal Gold Project Environmental Impact Statement.* NSR Environmental Consultants Pty Ltd, Hawthorn.

Parnaby H. 1992. *An Interim Guide to Identification of Insectivorous Bats of South-eastern Australia.* Technical Reports of the Australian Museum Number 8.

Phillips B. 1990. *Koalas - The Little Australians we'd all hate to lose.* ANP&WS, Australian Government Publishing Service, Canberra.

Pringle JD. 1987. *The Shorebirds of Australia.* Angus & Robertson, North Ryde.

Rankine & Hill. 1980. *Summary report on proposals for the partial drainage of Lake Cowal.* Consultant's report to the NSW Water Resources Commission by Rankine & Hill Pty Ltd, Sydney.

Reed PC, Lunney D and Walker P. 1991. A 1986-1987 survey of the Koala *Phascolarctos cinereus* (Goldfuss) in New South Wales and an ecological interpretation of its distribution. In *Biology of the Koala.* Lee AK, Handasyde KA and Sanson GD (*eds*). Surrey Beatty & Sons, Sydney.

Richards GC. 1991a. Greater Long-eared Bat. In Strahan R (*ed*). *The Australian Museum Complete Book of Australian Mammals.* Collins Angus & Robertson, North Ryde.

Richards GC. 1991b. Yellow-bellied Sheathtail-bat. In Strahan R (*ed*). *The Australian Museum Complete Book of Australian Mammals.* Collins Angus & Robertson Publ. North Ryde.

Richards GC. 1991c. Little Pied Bat. In Strahan R (*ed*). *The Australian Museum Complete Book of Australian Mammals.* Collins Angus & Robertson, North Ryde.

Robinson M. 1993. *A Field Guide to Frogs of Australia: from Port Augusta to Fraser Island including Tasmania.* Australian Museum/Reed Publication, Sydney.

Schodde R and Mason IR. 1980. *Nocturnal birds of Australia.* Lansdowne Press, Melbourne.

Schrader N. 1990. *Bird Habitat Management.* Appendix D of the Northparkes Mine Site Project.

Schroeder ML. 1990. The netting of cyanide ponds at Copperstone Gold. In *Proceedings of the Nevada Wildlife/Mining Workshop.* Nevada Mining Association.

Schwinghamnier T. 1987. Waterways and wetlands. In Goldney & Bowie 1987. Pp 161-186.

Slater P, Slater P and Slater R. 1989. *The Slater Field Guide to Australian Birds.* Weldon Publishing, Sydney.

Smith A & Mudder T. 1995. Cyanide - dispelling the myths. *Mining Environmental Management.* June 1995.

Southgate RI. 1990. Habitats and diet of the bilby *Macrotis lagotis* Reid (Marsupialia: Peramelidae). In Seebeck JH, Brown PR, Wallis RL and Kemper CM. *Bandicoots and Bilbies..* Pp 303-309. The Australian mammals Society, Surrey Beatty & Sons, Norton.

Strahan R (*ed*). 1991. *The Australian Museum Complete Book of Australian Mammals.* Angus & Robertson Publishers, Sydney.

Strahan R. 1992. *Encyclopedia of Australian Animals: Mammals.* The Australian Museum, Angus & Robertson, Pymble.

Swan G. 1990. *A Field Guide to the Snakes and Lizards of New South Wales.* Three Sisters Productions, Katoomba.

SWC. 1993. *Waratah Transmission Line EIS Flora and Fauna Assessment.* Prepared for Mitchell McCotter and Pacific Power.

Triggs B. 1984. *Mammal Tracks and Signs: A Field guide for Southeastern Australia.* Oxford University Press, Melbourne

Tyler MJ. 1992. *Encyclopedia of Australian Animals: Frogs.* The Australian Museum, Angus & Robertson, Pymble.

Vestjens WJM. 1975. Breeding behaviour of the Darter at Lake Cowal, NSW. *Emu* **75(3):** 121-131.

Vestjens WJM. 1976. Australian Pelican, Darter, Glossy Ibis, White Ibis, Straw-necked Ibis, Royal Spoonbill and Yellow-billed Spoonbill. In *Complete Book of Australian Birds.* Readers Digest. Sydney.

Vestjens WJM. 1977. *Status, habitats and food of vertebrates at Lake Cowal, NSW.* Technical Memorandum No. 12. CSIRO Division of Wildlife Research, Canberra.

Watkins D. 1993. A National Plan for Shorebird Conservation in Australia. RAOU Report #90.

Watson JW. 1993. Responses of nesting Bald Eagles to helicopter surveys. *Wildl Soc Bull* **21**: 171-178.

Wilson SK and Knowles DG. 1992. *Australia's Reptiles.* CollinsAngus & Robertson, Pymble.

Young CJ. 1979. *Examination of the Aquatic Fauna of Lake Cowal, NSW.* Unpublished report. Inland Fisheries Research Station, Narrandera, NSW.

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 1

DETAILS OF THE PROPOSED MINE DEVELOPMENT

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Details of the Proposed Mine Development

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1. Project Overview

The project proposes to develop a large, low-grade gold deposit on the western side of Lake Cowal, in the Central West of New South Wales. The gold resource is contained in a single deposit known as Cowal Main (formerly Endeavour 42).

Ore will be mined over a 7-year period, and the process plant will operate for a further four years, treating stockpiled, low-grade ore.

Waste rock (containing insufficient gold to be able to be processed) will be stored in permanent emplacement structures and rehabilitated. Processed ore (tailings) will be stored in a permanent storage structure and rehabilitated.

Total production will be approximately 2 million oz of gold. The prospect of extending the project life by discovering further gold resources in the vicinity is considered to be good.

Project parameters are summarised in Table 1.

Table 1 Project parameters

Item	Parameter
Average mill throughput	6.0 Mt/year
Operating break-even grade	0.8 g Au/t
Mill operating break-even grade	0.5 g Au/t
Oxide ore reserve	7.1 Mt
Primary ore reserve	33.5 Mt
Low-grade reserve	24 Mt
Waste rock	114 Mt
Project area	681 ha
Proposed mineral lease area	2,800 ha
Peak mining rate	31 Mt/year
Pit diameter	800 m
Pit depth	340 m
Average gold production (first 7 years)	230,000 oz/year
Mine life	7 years
Project life including low-grade processing	11 years

1.2 Land Tenure

Land tenure in the project area comprises freehold and perpetual leasehold, with a game reserve providing lake access for duck shooting, commercial and recreational fishing and other lake uses.

1.3 Site Conditions

Site conditions and water balances have been thoroughly investigated, and from the environmental planning perspective, the project site soils, topography, drainage and materials are extremely favourable: the area is flat and spacious;

evaporation exceeds rainfall, so that minesite waters can be completely contained and recycled; mine materials are not acid-forming; and the tailings storage site sits on a bed of clay at least 7 m thick; and the area has already been substantially cleared for agriculture.

Site conditions are summarised in Table 2.

2 Project Description: Site Facilities

Favourable site conditions and mine rocks and soils means that mining, ore-processing and the safe permanent storage and rehabilitation of mine waste rock and tailings can all be achieved using conventional and straightforward methods.

The project comprises facilities located at the mine site (shown in Figure 1), and road, power and water infrastructure (shown in Figure 2).

The principal features at the minesite are those required to: mine the ore; crush and process the ore to extract the gold; safely and permanently store the barren process residue (tailings) and the mine rock too low in gold to warrant processing; and manage the environment. Individual facilities are described below.

2.1 Pit Protection Bund and Temporary Cofferdam

The open pit must be protected from lake inflow. If construction occurs at high lake levels, a temporary cofferdam will be constructed to allow the pit protection bund to be built in dry conditions. If the lake is dry, the cofferdam will not be needed.

2.2 Open Pit

The open pit will develop the Cowal Main deposit to produce ore, containing commercially extractable gold, and waste rock, containing insufficient gold to warrant extractive processing. The waste will be used in the construction of the tailings storage embankments and the perimeter bund, with the balance stored in two permanent waste emplacements. The environmental and engineering suitability of waste materials for the uses proposed have been thoroughly tested.

2.3 Perimeter Bund

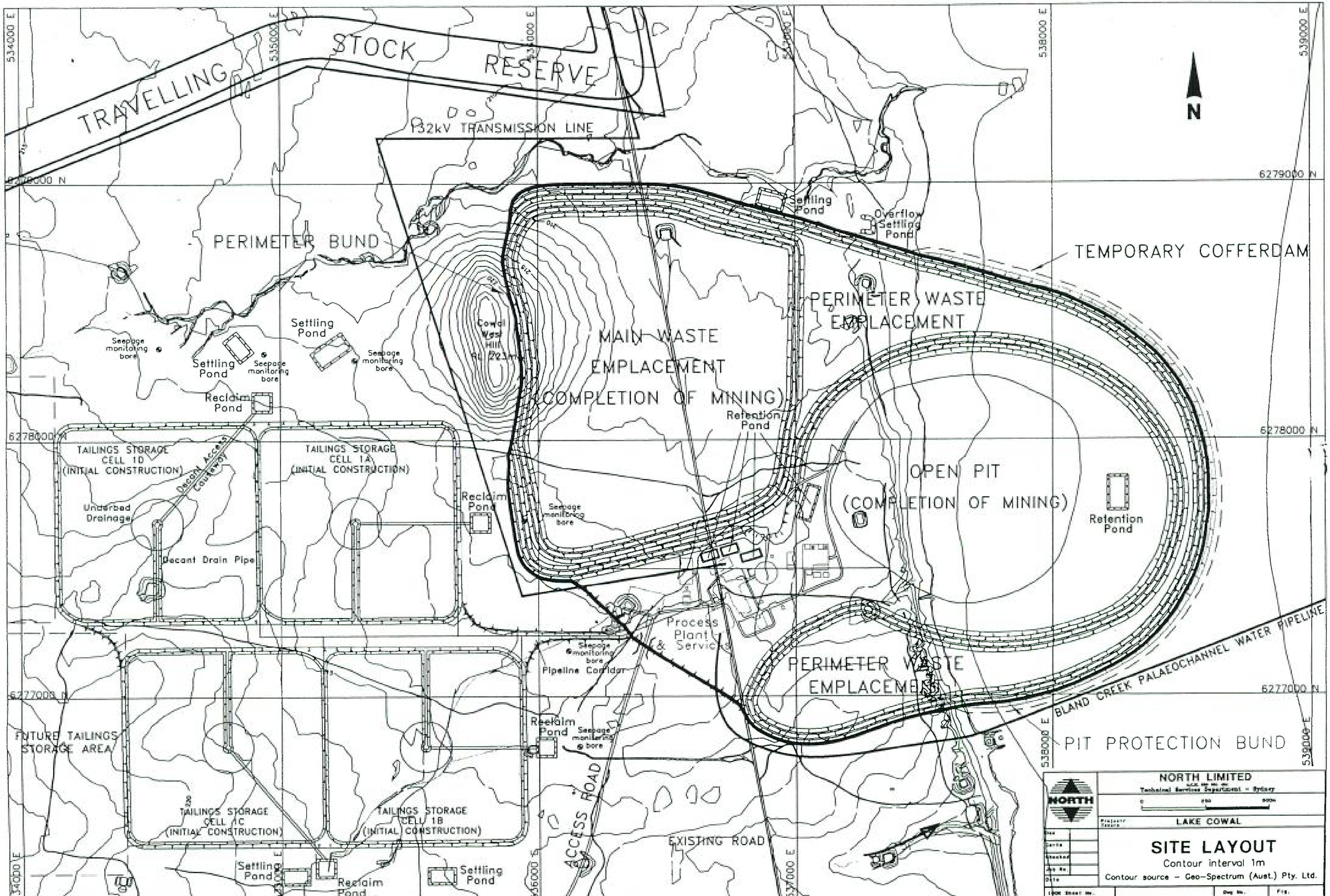
The perimeter bund will be constructed of mine waste and isolates active project areas from the surrounding environment: it keeps minesite water, dust, noise, and light in; and it keeps lake water and catchment runoff out.

2.4 Waste Emplacements

The main and perimeter waste emplacements will store the open-pit waste not required for construction purposes and will sit immediately inside, and form part of, the corresponding sections of the perimeter bund.

Table 2 Summary of site conditions

Feature	Advantage
No connection between the ground water aquifers and the lake.	Ensures no contamination of the lake by saline groundwater. Ensures no drainage of lake water to the mine.
Deep, low-permeability clay base to tailings storage area.	Ensures no contamination of groundwater.
Aquifers below tailings storage dry. Drainage would be to the pit.	Further guarantee that, in the remote possibility of minor seepage to the aquifer, it will be detected by monitoring bores and will drain to the pit, not to the regional groundwater system.
Mine waste not acid generating.	Surface water drainage will be benign. As a precaution, all drainage from mine waste will drain to the pit.
Mine area soils, transported cover and oxidised materials contain soluble salt and some areas contain soluble zinc.	Worst-case leaching to surface water runoff does not significantly add to the lake's natural load. As a precaution, outside batters of perimeter bund will be constructed to final form, compacted, topsoiled and vegetated as soon as possible.
Project area has been cleared for agricultural use for many decades.	Habitat to be affected by the operation is low in value. Long-term rehabilitation will increase habitat and conservation values.
Nearest residence is 3.5 km from the perimeter bund.	Separation ensures no adverse affect to environmental amenity. As a precaution, perimeter bund height will be maintained above the general working level to reduce noise, light and dust.
Main bird breeding habitat areas are more than 2.5 km from the mine.	Separation ensures no adverse affect on either the birds or the breeding habitat.
No rare or threatened flora in the project area	Negligible risk to biodiversity of flora.
Project site not significant for endangered fauna Habitat common within region.	Negligible risk to biodiversity of fauna.
Relatively flat country.	Allows optimum layout of the facilities. Erosion and sediment control is simple.



[redacted] Figure [redacted] Site layout [redacted]

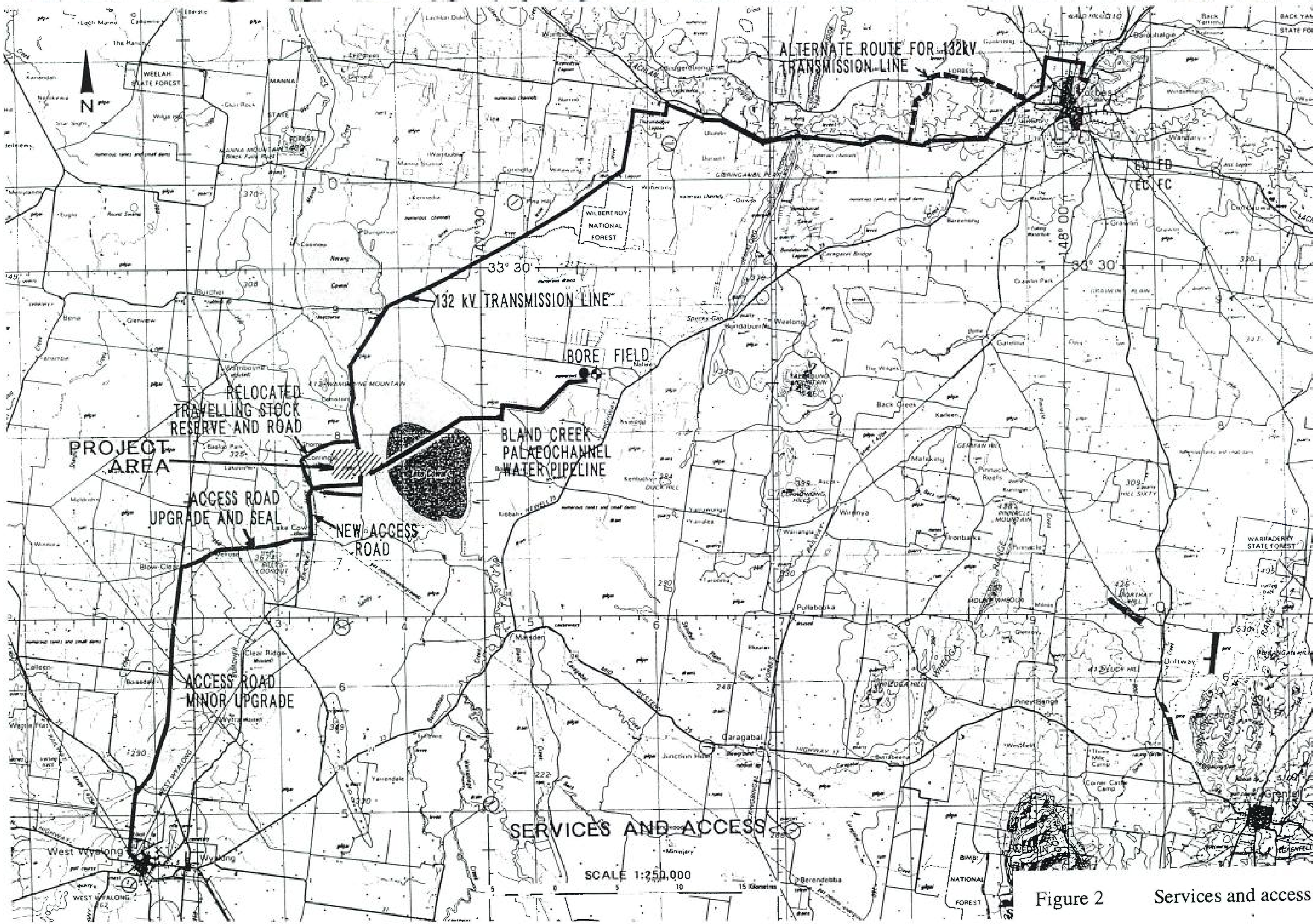


Figure 2 Services and access

2.5 Pit Dewatering Borefield

It is a safety requirement that the walls of the open pit be drained of groundwater, and this will be achieved by a series of bores in a circle set back from the pit walls.

2.6 Ore Stockpiles and Process Plant

Mine soil and rock containing commercially extractable gold (ore) will be stockpiled adjacent to the process plant. The process plant house all facilities required to mill and extract the gold from the ore.

2.7 Tailings Storage

The tailings storage facility provides for the safe and permanent deposition of the barren ore.

The terms 'tailings storage' or 'tailings impoundment' have been used in this EIS. The traditional term 'tailings dam' is misleading in its implied resemblance to a water storage structure. In fact, the tailings impoundment will be a solid structure from side to side and will be little different in its ultimate appearance and physical strength from many low hills occurring naturally in the landscape.

2.8 Water Storages

Water is scarce at Lake Cowal, and a number of storages will be required to conserve the water produced on the site for use or re-use in the process plant. Reclaim ponds will receive the water drained from the tailings storage cells; the retention ponds will collect runoff from within the perimeter bund; and retention ponds and the process water pond will store water from the reclaim ponds and pit dewatering borefield for use in the process plant.

Two stock water dams will also be built as a condition attached to the relocation of the travelling stock reserve.

2.9 Services

Offices, laboratory, car park, sewage plant, workshops, changeroom, mess and sundry other facilities will be provided to administer and service the operation.

2.10 Settling Ponds

Runoff from the outer face of the perimeter bund and tailings embankment will pass through settling ponds to remove readily settleable solids and reduce turbidity. The water will then flow to natural drainage lines

2.11 Public Access

The project will occupy land that currently provides the public with lake access (Game Reserve No. 590 and Reserve (for access) R.94530) and transit (Travelling Stock Reserve No. 17085). Alternative access for both functions will be provided at the start of construction.

3. Project Description: Infrastructure

Project infrastructure (Figure 2) located away from the minesite comprises the following.

3.1 Power Supply

Electrical power for the project will be supplied via a new 132-kV transmission line from the New South Wales grid at Forbes. The powerline will be designed, built, owned and operated by Central West Electricity. Alternatively, power may be generated on site using natural gas in a power station built, owned and operated by a third party.

3.2 Outside Borefield

Water produced at the mine from the pit dewatering borefield, rainfall runoff and tailings water recycling will be insufficient for project needs and must be supplemented from an outside borefield located in the ancestral alluvial sediments of Bland Creek (Bland Palaeochannel).

3.3 Water Pipeline

Bland Palaeochannel water will be pumped by pipeline overland and across the bed of Lake Cowal to the mine. The pipeline will be buried.

3.4 Access Road

Access for personnel and supplies will be by road from West Wyalong. Existing roads and intersections will be upgraded, and a short section of new road will be built along an existing road reserve.

4. Project Development and Operations

4.1 Construction

The following works are required before gold production commences:

- The establishment of the perimeter bund, which provides pit protection from the lake and sound protection around the entire perimeter of the mine, waste emplacements, low-grade stockpile and process plant.
- Stripping of waste from the open pit, and mining and stockpiling of some ore prior to commissioning of the process plant.
- Dewatering of the aquifers to be intersected by the open pit.
- The construction of the tailings storage facility. One cell will store water from the pit aquifer dewatering for subsequent use in ore processing.
- Construction of the outside water supply borefield, storage tank, electrification and pipeline across Lake Cowal.

- Construction of the 132-kV powerline from Forbes around the northern end of Lake Cowal, or a natural gas-fired power station at the site.
- Upgrading of the access road from West Wyalong.
- Fabrication and erection of the processing plant.

The pre-strip contractor is expected to elect to work 24 hours/day, 7 days/week. The other construction work will occur 16 hours/day, 6 days/week with occasional work on the seventh day.

4.2 Mining

Material to be mined will be blasted approximately three times per week, picked up by excavator and trucked to the process plant, low-grade stockpile or waste emplacement.

Waste emplacement operation will maintain the integrity of the perimeter sound bund, with dump operations within the bund at all times, apart from the periods when the bund itself is being raised. The main waste emplacement abutting Cowal West Hill will accommodate at least 38 million m3 and the perimeter emplacement and low-grade stockpile will accommodate 12 million m3.

Mining will be undertaken by specialist contractors, who are expected to elect to work two 12-hour shifts per day, 7 days per week. Mining will be completed in 7 years.

4.3 Ore Processing

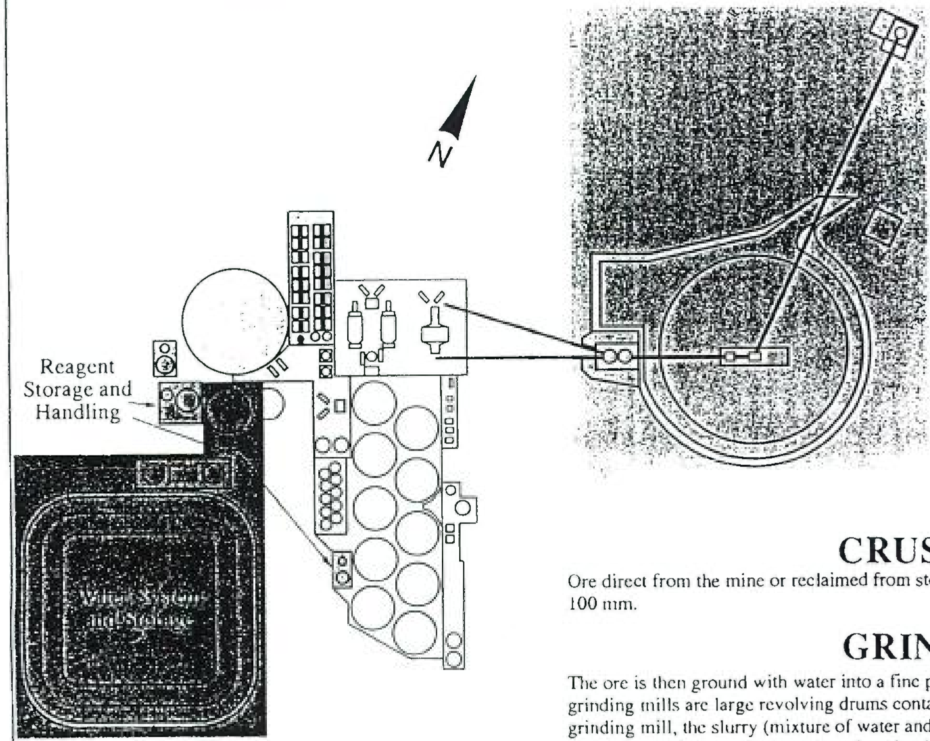
Ore will be milled in three 8-hour shifts per day, 7 days per week, and will be processed according to type. The process plant crushes and fine-grinds the ore to expose the contained gold particles. Oxide ore will be cyanide-leached in a conventional carbon-in-leach (CIL) process. Primary ore will be upgraded by flotation to a sulfide concentrate, which will be reground ahead of cyanide leaching/CIL. The leached gold in cyanide solution is adsorbed onto activated carbon, stripped and smelted to produce gold bullion ingots.

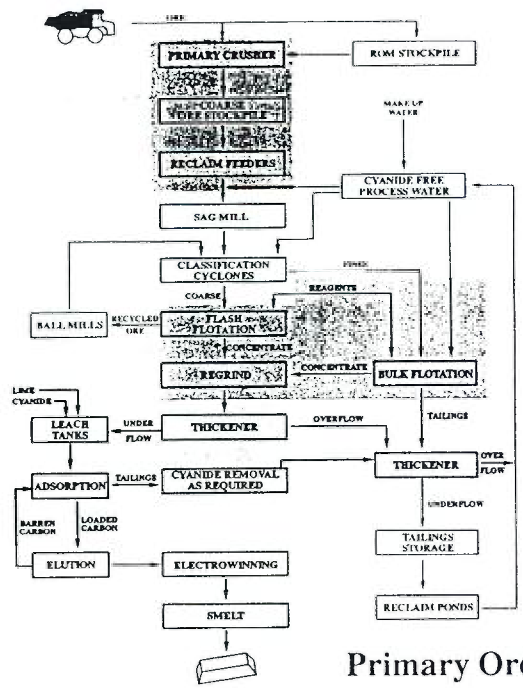
The ingots are shipped to domestic gold refineries for further processing.

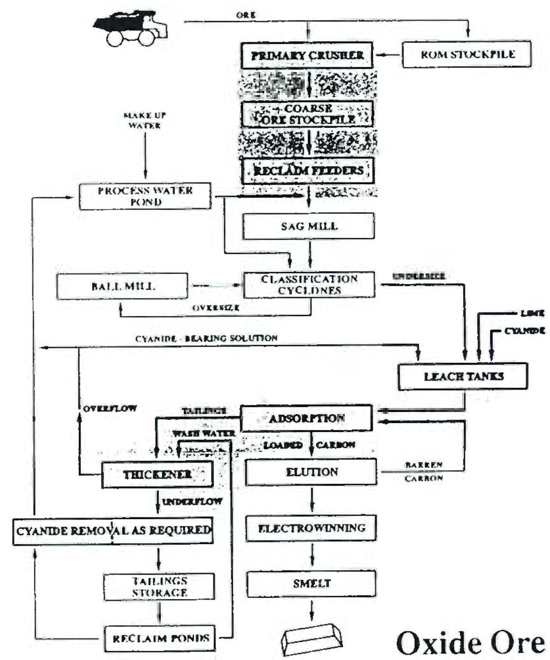
Ore-grade material will be processed for the first seven years; stockpiled low-grade material will be processed from Years 8 to 11.

Process flowsheets are given in Figure 3.

MILLING FLOWSHEET







CRUSHING

Ore direct from the mine or reclaimed from stockpiles is crushed to a size of approximately 100 mm.

GRINDING

The ore is then ground with water into a fine powder, using two stages of grinding. The grinding mills are large revolving drums containing steel balls that break the ore. From the grinding mill, the slurry (mixture of water and ore) passes to the cyanide leaching circuit (in the case of oxide ore) or to the flotation circuit (in the case of primary ore).

FLOTATION

The primary ore slurry is mixed with flotation reagents and air to form a gold-rich froth on the top of the tank. The gold-rich froth is skimmed off, reground and passed to the cyanide leaching circuit.

CYANIDE LEACHING

Lime and sodium cyanide are added to the slurry or concentrate to dissolve the gold. Activated carbon is added to the leach tanks, and the dissolved gold is adsorbed onto the carbon. The gold-loaded carbon is screened from the slurry and pumped to the gold recovery circuit. Oxide slurry is leached in the large tanks. The primary ore flotation concentrate is leached in the small tanks.

WASH THICKENER

In the case of primary ore, the wash thickener recovers excess water from the flotation circuit tailings. The thickened tailings are then pumped to the tailings storage. The recovered water goes to the process water pond for re-use in the grinding circuit. With oxide ore, the wash thickener reduces the level of cyanide in the tailings before they are pumped to the tailings storage.

GOLD RECOVERY

Gold is eluted (removed) from the carbon using a hot cyanide and caustic soda solution. The gold-free carbon is recycled (to cyanide leaching). The gold in the cyanide solution is plated out as a metal on stainless steel wool in the electrowinning cells. The gold is then smelted in a furnace to produce a gold doré bar (impure). The gold bars are sold to a refinery for purification.

Figure 3 Milling flowsheet

4.4 Tailings Management

After the gold has been extracted, the barren slurry (tailings) will be permanently and safely stored in a broad, low, flat tailings storage structure of four cells. The storage system will deposit the tailings in a series of layers, called beaches. Tailings water and rainfall collect in the decant pond in the centre of the cell, drain to the reclaim pond adjacent to the cell and are pumped back to the process plant for re-use.

The embankments around the perimeter and between the cells will be constructed of waste rock and soil from the open pit. The cells will be operated one at a time in a cycle that will allow each layer of tailings to dry out and consolidate before the next layer is placed. The water draining to the decant pond in each cell will be removed for reuse in the process plant, so that the ponds are as small as possible. The site of the tailings storage facility is ideally suited, being underlain by a 7-m thick layer of clay, which should prevent any seepage from the cells.

4.5 Site Water Management

The basic principle underlying the water management plan is that all water entering the active project area will be retained within that area, while runoff generated outside the active project area will be diverted away from it and discharged (after settlement, if necessary) to the natural stream system.

Criteria

The water management system has been designed to:

- Provide a reliable supply of process and potable water to the operations.
- Manage mining lease water in an environmentally safe manner.

The water management system will be able to accommodate both the normally variable rainfall and the occasionally more severe shortages and surpluses of water that may occur over the 11-year project life. With the climatic water deficit and low rates of pit dewatering, it will be possible to use all water entering the active project area for process or other purposes, with no discharge to the natural drainage.

The water management system can retain individual storm events or an annual rainfall in excess of the theoretical 10,000-year average recurrence interval (ARI), because all runoff within the project perimeter is retained, with the open pit as the ultimate receptor. Such severe storms could significantly disrupt gold production, but their minesite runoff would not enter the regional environment.

Construction Phase

During the construction phase, the waters generated on site will be managed as follows.

- Saline groundwater from the dewatering borefield around the pit will be produced before the mill is commissioned and, hence, before the water can be used for processing. This water will be stored in the first tailings storage cell, which will be constructed early for this specific purpose.

- Perimeter bund wall runoff will be directed through settling ponds for the removal of readily settleable material. The ponds will be built at the start of construction; the bund will be built to final shape, topsoiled and revegetated as early as possible after the completion of construction, so as to minimise sediment runoff.

- Sediment eroding from the outer face of the pit protection bund will be trapped and settled by the cofferdam.

- A turbid plume around the dumping face of the cofferdam. If the dispersivity of the material under the prevailing lake conditions is severe, then engineering measures such as gypsum amelioration or geotextile curtains will be used to confine cofferdam material to the dumping face.

- Water impounded inside the cofferdam will be of good quality and will be pumped to the lake when the dam is closed. The turbid residual will be either discharged to the lake after settling or sent to the tailings cell constructed to store the initial pit water.

- General construction area runoff (apart from the outer faces of the perimeter bund) will be confined within the perimeter bunding and gravitate to the pit, which is being excavated to provide material for construction and for pre-stripping. This water will be pumped to the first tailings cell, for later use in the process plant.

The perimeter bunding and containment of site runoff will be essentially in place as early as the third month of construction. Runoff to the natural drainage will be limited to the travelling stock reserve relocation and the outer faces of the initial lifts of the perimeter bunding. This area is a very small proportion (less than 5%) of the overall area under construction activities. These outer faces will be constructed first (with settling ponds) and rehabilitated immediately. Runoff from the remaining 95% of active construction areas will not drain into the lake: in the tailings area, it will be retained within the first tailings storage cell; runoff from the pit, waste emplacements and process plant areas will be retained for future use in the process plant.

Operations Phase

A schematic representation of the water management system during the operations phase is shown in Figure 4.

- Clean runoff from the catchments surrounding the project area will be intercepted by cut-off drains and discharged to the natural water courses. Runoff from the external slopes of the tailings storage and perimeter bund, together with other local runoff, will continue to be directed through settling ponds and discharged to the natural water courses as it was during the construction phase. The settling ponds will be sized to hold runoff from a 12-hour storm with a 1-year ARI.

- Contained waters will comprise recycled process water, all runoff from the waste emplacements and the top and inside of the perimeter bund, and waters from in-pit drainage and dewatering operations.

The priority of use of contained waters will be as shown in Figure 4:

- Recycled Process Water. Water recycled from the tailings storage comprising decant water and underdrainage water will be utilised first, so as to minimise the size of the pond around the decant of the active tailings cell.

- Mine Drainage Surface Water. Water collecting in the bottom of the pit will be used next. Volumes will generally be small, except infrequently during heavy rain (see 'Mine Aquifer Dewatering' below).

- Mine Aquifer Dewatering. Water from the mine dewatering borefield will generally be consumed third. However, the borefield must operate more or less continuously for safety reasons, and accumulations of mine drainage surface water in the bottom of the pit after heavy rain may be used at a reduced rate temporarily so as to allow pit dewatering to continue.

- Project Area Stormwater.

All of the contained waters described above will be pumped to the process water pond and used for dust suppression or ore processing within the area marked 'total containment' on Figure 5.

4.6 Process Water/Water Supply System

Water produced and retained on the project site will be insufficient to meet project requirements after process and evaporation losses, and will need to be supplemented by outside borefield make-up water.

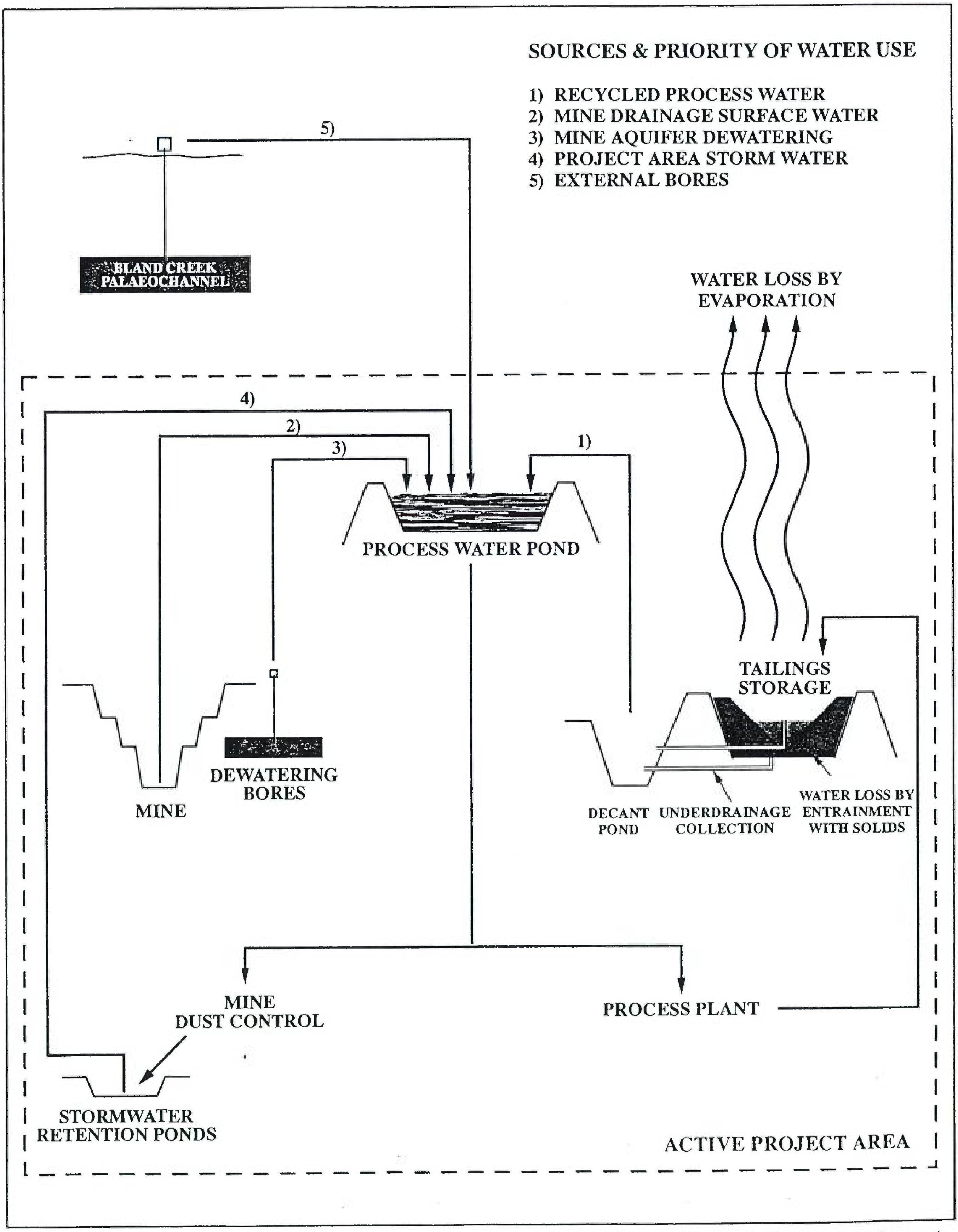


Figure 4 Water management schematic

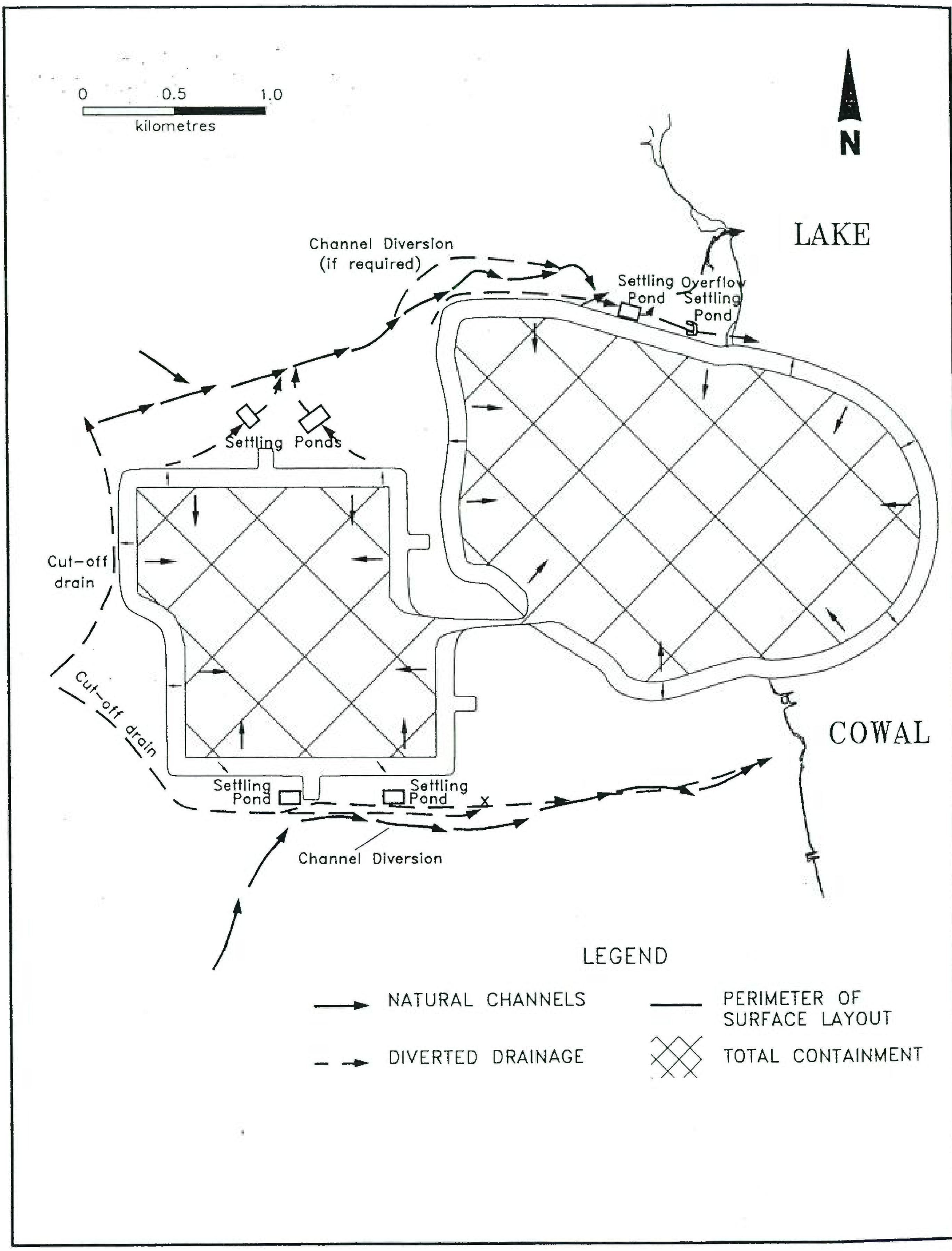


Figure 5 Water management plan

The long-term demand for make-up water from the outside borefield averages 4 ML/day, but actual demand through the life of the project will vary between 0 and 15 ML/day according to:

- The ore type currently being processed.
- The volume of water being produced on the site from rainfall.
- The losses to evaporation.

Potable water will be tapped from the outside borefield supply and purified by a reverse osmosis plant with a capacity of 400 m^3/day.

4.7 Cyanide Management

Cyanide levels in the tailings storages in Australia do not generally attract and kill waterbirds. However, episodes of bird mortality do occur from time to time (and one such episode has recently occurred at Northparkes Mines). At Lake Cowal, cyanide levels in the tailings storage will not be a management issue for the 80% of the time when oxide ore is not being treated.

North propose to manage cyanide levels in the tailings storage during oxide ore processing (20% of the time) so that bird kills are minimised:

- The active cell decant pond will be kept as small as possible, in order to minimise its attraction.
- The non-active cells will be maintained with some water in them and no deterrents. If the circumstances external to the mine cause birds to come to the tailings dams, they will be more likely to land on the non-active, (and non-toxic) cells. When birds threaten to arrive in significant numbers, active deterrence can be implemented.
- The tailings storage will be inspected daily.
- If birds become trapped in soft tailings, they will be rescued by hovercraft, rehabilitated and set released.
- Cyanide levels will be monitored weekly, and more frequently if levels exceed 100 mg CN_{WAD}/L.
- If cyanide levels exceed 100 mg CN_{WAD}/L, then monitoring of the active cell will be significantly increased, and operating techniques reviewed to determine whether cyanide levels can be reduced to safe levels by one or a combination of, the following measures: adjusting plant operating conditions; diluting water in the decant pond; or treatment of the tailings.
- During critical periods, other deterrents, such as cannon, floats and streamers, will be tested experimentally.

North believe that these measures provide assurance that wildlife mortality over the life of the mine will be negligible.

5. Engineering Safeguards

Table 2 has summarised site conditions; the overlap of the deposit and the lake requires the pit protection bund to prevent flooding, but in all other respects, the site conditions are extremely favourable. This, in turn, means that the implementation of safeguards that have become standard current mine planning practice becomes a straightforward matter: the separation of the mine from the surrounding environment is either:

- Achieved by engineering measures (notably the perimeter bund and water management system), or
- Effected automatically by the site conditions themselves (notably the absence of a hydraulic connection between the aquifers underlying the site and both the lake and the tailings storage).

Table 3 shows the engineering measures adopted to mitigate impact under two categories: primary and secondary.

5.1 Primary Measures

Primary measures are directed specifically at ameliorating what would otherwise be a direct adverse consequence of mining, ore processing or waste management. Primary measures therefore encompass the perimeter bunding, location of facilities away from drainage lines, water management according to environmental criteria and control of dust and noise at source.

5.2 Secondary Measures

The secondary measures shown in Table 3 ameliorate the significant potential side-effects of the primary safeguards. The most important of these are:

- The design details of the perimeter bunding: the height buffer above internal work areas, progressive rehabilitation to minimise visual impact and erosion, and treatment of runoff.
- Maintenance of the minimum possible/practicable tailings cell pond size to ameliorate one potential effect of the adopted tailings management system: namely, its potential, occasional use by wildlife.

5.3 Optimisation

The primary and secondary measures represent North's optimised solution to the amelioration of the project's environmental impact and the optimisation of the interaction of primary and secondary safeguards. For example:

- The perimeter bund height of 10 m above the active work areas inside the bund was derived on the basis of cost and benefit comparisons of the noise reduction achievable with margins of different heights. The benefits of greater height margins were considered too small to warrant the cost and visual impact.

Table 3 Measures to mitigate the effects of the project on the regional environment

Primary Mitigation Measure	Effect
1. Design and construct pit protection bund.	Permanently isolates the lake water from the mine.
2. Design and construct perimeter bund.	Permanently isolates the complete operation area from the regional environment. Contains for use all waters inside the bund. Ensures regional environmental values are preserved.
3. Pit dewatering borefield.	Improves pit wall stability and safety.
4. Tailings storage located away from lake and natural drainage lines.	Ensures integrity of structure and permanent isolation from the lake.
5. 7-m-thick, impervious clay under tailings storage.	Provides natural barrier against seepage to groundwater.
6. Tailings deposited by beaching, with consolidation by settling and evaporative drying.	Ensures tailings mass in storage facility is structurally self-supporting; embankment is precautionary only.
7. Flotation process for primary ore.	Maximises utilisation of the gold resource and ensures very low cyanide levels in the tailings decant system for the majority of the mine's life.
8. Dust suppression collection at loading, dumping and plant internal transfer points.	Minimises fugitive dust.
9. Noise specifications defined for equipment.	Controls noise at the source.
10. Make the powerline visible to birds in section between Lake Cowal and Nerang Cowal.	Minimises risk of birds colliding with powerlines.
Secondary Mitigation Measure*	**Effect**
Construct perimeter bund to final form as early as possible. (2)	Allows rehabilitation to commence during the construction phase. Minimises sediment load to the lake. Minimises visual impact.
Maintain height of perimeter bund 10 m above the general working level inside the bund. (2, 9)	Reduces off-site effects of noise, light and dust.
Construct tailings storage to final form using upstream method. (6)	Allows rehabilitation of outer face as soon as it is constructed. Minimises sediment load to the lake.
Final outside batter of perimeter bund and tailings storage structures compacted, topsoiled and vegetated as soon as possible after construction. (2, 6)	Minimises sediment and salt flow to the lake. Preserves the water quality of the lake.
Surface water from outside faces of perimeter bund and tailings storage channelled through settling ponds before flowing to natural drainage channels. (2)	Minimises sediment load to the lake. Preserves lake water quality.
Underdrainage collection system installed near decant above clay base. (5, 6)	Additional precaution by installing underdrainage system.
Tailings decant pond kept to minimum size. (6)	Maximises water recycling. Makes pond unattractive to wildlife.
Monitoring of bird use of tailings pond and cyanide levels; deterrant float system; tailings cyanide destruction as required. (6)	Maintain CN_{WAD} levels at <50 mg/L or as required to achieve no significant waterbird mortality.
Use all mine area groundwater in the process. (3)	Completely isolates the operation from the lake.
Recycle all water in the operations areas. (2, 6, 8)	Ensures all waters are contained, minimises water storage. Enables the site to completely contain the worst possible storm event. Water is only imported as it is required.
Make up water from Bland Palaeochannel. (6, 8, 9)	Guarantees no lake water needs to be used to make-up plant, dust suppression and tailings losses. Water is imported to site only when required.
Wash thickener after CIL circuit and before tailings disposal. (6)	Reduces cyanide levels in the tailings reporting to tailings storage.
Direct flood flows in natural drainage lines away from tailings storge area. (4)	Protects tailings storage structure.

* The number in brackets refers to the primary mitigation measure to which each secondary measure is directed.

At the same time, noise impact analysis showed that the amelioration achieved by the adopted height margin easily achieved acceptable ambient noise levels at the closest dwellings and other receptors.

- The pit protection bund crest height was set approximately 1 m above the highest recorded flood level. A higher pit protection bund was considered unnecessary because at this elevation, Lake Cowal would be unconfined to the north, south and east and would therefore have to assume the dimensions of a vast inland sea before it could rise above its highest previous level. Furthermore, the perimeter bund constructed on top of the pit protection bund will be built to a further 15 m above the highest recorded flood level .
- The incidence of waterbird mortalities on tailings storages around Australia suggested that the optimum solution to this potential impact would be to maintain minimum tailings cell pond sizes, backed up by monitoring, active deterrence and control of cyanide levels.

In a number of important respects, site conditions are so favourable, and simple safeguards so effective, that no optimisation is required. For example:

- The water management system will contain all water produced on active project areas well beyond the most severe conditions that could credibly be postulated.
- Mine dewatering poses no threat to Lake Cowal, because the aquifers and the lake are hydraulically separate.
- The underdrainage system below each tailings cell, the 7-m substrate of underlying clay, and the absence of slope mean jointly that seepage from the tailings storage will be negligible.

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 2

DIRECTOR-GENERAL'S REQUIREMENTS

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NSW
NATIONAL
PARKS AND
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Mr Dominic Fanning
Gunninah Consultants
22 Clarke Street
CROWS NEST NSW 2065

Our reference: A/13088 td:td
Your reference:

DIRECTOR-GENERAL'S REQUIREMENTS FOR PROPOSED GOLD MINE AT LAKE COWAL BLAND SHIRE LOCAL GOVERNMENT AREA FAUNA IMPACT STATEMENT

Dear Mr Fanning,

Thank you for your letter dated and received on 24 April 1995 regarding the requirements for the above development.

The Fauna Impact Statement (FIS) must meet all of the requirements of Section 92D(1) of the National Parks and Wildlife Act, 1974. Pursuant to Section 92D(3), and in addition to the basic requirements set out in Section 92D(1), (which are repeated below in bold lettering), I require the following:

"92D(1) A Fauna Impact statement must:

(a) **be in writing; and**

(b) **be signed by the person who prepared it; and**

(c) **include to the fullest extent reasonably practicable, the following;**

"(i) **a full description of the fauna to be affected by the actions and the habitat used by the fauna;"**

In addition to this requirement:

. a fauna survey is required to be conducted in the area proposed for the development and surrounding areas likely to contribute to fauna habitat (study area). Sampling methodology should specifically target endangered species known or likely to occur in the study area. This will include but is not restricted to the Black-breasted Buzzard (*Hamirostra melanosternon*), Square-tailed Kite (*Lophoictinia isura),* Grey Falcon (*Falco hypoleucos*), Osprey (*Pandion haliaetus),* Magpie Goose (*Anseranas semipalmata*), Freckled Duck (*Stictonetta naevosa*), Blue-billed Duck (*Oxyura australis*), Australasian Bittern (*Botaurus poiciloptilus*), Australian Bustard (*Ardeotis australis*), Brolga (*Grus rubicundus*), Bush Thick-knee (*Burhinus*

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magnirostris), Black-tailed Godwit (*Limosa limosa*), Painted Snipe (*Rostratula benghalensis*), Glossy Black Cockatoo (*Calyptorhynchus lathami*), Pink Cockatoo (*Cacatua leadbeateri*), Swift Parrot (*Lathamus discolor*), Masked Owl (*Tyto novaehollandiae*), Regent Honeyeater (*Xanthomyza phrygia*), Pied Honeyeater (*Certhionyx variegatus*), Painted Honeyeater (*Grantiella picta*), Chestnut Quail-thrush (*Cinclosoma castranotum*), Southern Scrub-robin (*Drymodes brunneopygia*), Shy Hylacola (*Sericornis cautus*), Gilbert's Whistler (*Pachycephala inornata*), Greater Long-eared Bat (*Nyctophilus timoriensis*), Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*), Koala (*Phascolarctos cinereus*), Bilby (*Macrotis lagotis*), Giant Burrowing Frog (*Heleioporus australiacus*). Previous fauna studies may be incorporated as part of this work.

- a full description of the methodology used in the fauna survey (eg. dates of survey, weather conditions, number of traps, configuration of traps etc.) Identification of reptiles, frogs and bats should be confirmed by a recognised authority (eg. Australian Museum) for species of taxonomic uncertainty.

"(ii) an assessment of the regional and statewide distribution of the species and the habitat to be affected by the actions and any environmental pressures on them;"

In addition to this requirement, further assessment should include:

- a description of the local distribution and abundance of endangered fauna known or likely to occur in the study area, and any environmental pressures on them and their habitat.

- a description of the habitats and potential habitats of endangered fauna in the study area, describing habitat distribution within the study area and local distribution of these habitats. Habitat critical to essential behavioural patterns of the endangered species should be identified.

- an assessment of dispersal or movement areas or routes of endangered fauna species known or likely to occur in the study area and any existing or future barriers to interbreeding opportunities between populations of endangered fauna within the local area.

"(iii) a description of the actions and how they will modify the environment and affect the essential behavioural patterns of the fauna in the short and long term where long term encompasses the time required to regenerate essential habitat components;"

In addition to this requirement:

- a description of the location, nature and extent of habitat degradation which may result from the proposed development and the likely effect on endangered fauna known or likely to occur in the study area.

- a description of the possible effects of the development on species of endangered fauna known or considered likely to occur in the study area.

- a discussion of the importance of Lake Cowal as a waterbird breeding habitat, including migratory birds listed in the Japan Australia Migratory Birds Agreement 1981 and the China Australia Migratory Birds Agreement 1988. Consideration of possible impacts on that habitat during mine development, operation and closure is required. Consideration should be made to the values and significance identified by the Australian Heritage Commission when determining the listing of Lake Cowal on the Register of the National Estate.

- a discussion of the issue of noise and its impacts on endangered fauna.

- a discussion of the potential impact of mining operations on water quality, endangered fauna and habitat within Lake Cowal. This should include discussion of the potential impacts of draining water out of Lake Cowal for use in the mine, discharge of water into the Lake, and the possible effects of leakage of saline water through the bund wall after mining is completed.

"(iv) details of the measures to be taken to ameliorate the impacts;"

In addition to this requirement, detailed information should be provided on:

- any habitat restoration proposed for the study area, including the expected time taken to restore habitat, any proposals or opportunities to improve habitat and the likely impact on fauna, particularly during the time the habitat is being restored.

- any measures proposed to reduce possible effects of the development on any local populations of endangered fauna.

- any proposed on-going monitoring of the effectiveness of those ameliorative measures.

- an assessment of the endangered fauna species (including a list of those species) which will or are likely to be taken or killed by the proposed development, as ameliorated. In undertaking this assessment consideration should be given to the meaning of "take" as defined by section 5 (1) of the *National Parks and Wildlife Act, 1974.* If the Fauna Impact Statement is to accompany a licence application for a General (Section 120) licence to take or kill endangered fauna, then the Fauna Impact Statement must clearly list those species for which licence coverage is sought.

"(v) **details of the qualifications and experience in biological science and fauna management of the person preparing the statement and of any other person who has conducted research or investigations relied upon."**

In addition to this requirement:

- all information cited, from which statements or conclusions are made, must be provided or fully referenced.

The Fauna Impact Statement which satisfies the above requirements must be forwarded in writing to the National Parks and Wildlife Service. Should you require any further information please contact the Manager, Threatened Species Unit on (02) 585 6540.

Yours sincerely

19/5/95
for

ROBYN KRUK
Director-General.

12/05/95 tsu txd\dreq\

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 3

METHODS EMPLOYED DURING FAUNA INVESTIGATIONS

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APPENDIX 3 Field fauna investigations conducted at Lake Cowal.

Terrestrial Fauna Investigation

Trapping	515 trap-nights with Elliott small mammal traps - 'A-size' (10cm x 9cm x 30cm); 8th to 12th April 1994 inclusive; 5 nights trapping per site; 103 Elliott traps: T1 (25), T2 (23), T3a & 3b (30), T4 (25); bait - rolled oats/peanut butter/honey; habitats surveyed: Open Woodland, Grassland, Lakeside vegetation, Open Forest; 85 trap-nights with pit-traps; 8th to 12th April 1994 inclusive; 5 nights trapping per site; 17 pit-traps: T1 (3), T 2 (4), T3a & 3b (7), T5 (3). habitats surveyed: Open Woodland, Grassland, Lakeside vegetation.
Spotlighting	22 person-hours spotlighting through all habitats in the study area; evenings of 8th to 11th April 1994 inclusive; records maintained of all species recorded. 8th April 1994 - clear; still; cool 9th April 1994 - clear; still; cool 10th April 1994 - overcast; cool, changing to cold; southerly wind 11th April 1994 - overcast; raining; cold; southerly wind
Amphibian & Bat Taping	5 hours of bat surveys using ultrasonic detectors (10 sites with half an hour of taping at each site); 5 hour of amphibian call taping.
Habitat Searches	approximately 5 days, through all habitats in the study area; 7th to 11th April 1994 inclusive; logs and debris searched, tracks and diggings identified, scats and bones identified (where possible), animals sighted/caught identified.

Waterbird Monitoring

Waterbird Counts	4 transects ranging from 2.0 to 3.5km in length. Conducted in August, October and January in the seasons of 1989/90 to 1994/95. Each transect was walked and birds counted and recorded once each month within a one to two day period.
Breeding Data	Conducted every season by examining all areas of the Lake from a canoe or boat and occasionally by aerial survey (October 1989; January 1990 & 1993). All visible nests and rafts of young were identified, counted and mapped. Holes in trees were not examined.

Waterbird Survey
Data Collection Methods

Introduction

Two important questions in relation to the development of the mine in Lake Cowal are (i) how significant is the proposed mine site itself to waterbirds? and (ii) is it useful to monitor waterbird populations in view of the highly dynamic nature of their populations? This can be elaborated into the following four specific questions:

1. **Is the mine site located in a part of the lake that has particular significance to waterbird occurrence (feeding, resting areas)?**
2. **Is the mine site located in a part of the lake that has particular significance to waterbird breeding?**
3. **Are waterbird populations too dynamic to use these species as monitoring organisms?**
4. **If the answer to question 3 is "yes", then how should the utility of the lake to waterbirds be monitored?**

In order to answer these questions counts of waterbirds and surveys of breeding activity have been carried out since August 1989 (Lane 1989a, b, 1990, 1991a, b, c; E.E.S. 1992a, b, c, 1993a, b, c, 1994a, b, c, 1995a).

This Appendix presents a final analysis of these waterbird survey results. Results of the breeding surveys are well presented by E.E.S. (1995b) (Appendix D of this EIS) and will only be discussed here briefly.

Data Collection Methods

Waterbird counts

In 1989, a transect that encompassed the proposed mine site was established along the shore of the lake. This **Mine Transect** was a section of shoreline 3.5 km long and extended from a few metres above the waterline to 300m out into the lake. Seven other transects of the same width, three along the shoreline and four in the lake proper, were established elsewhere in the lake to act as a comparison with the Mine Transect. Their positions in relation to the Mine Transect are given on Figure 2 in Lane (1990). The three shoreline transects differed in length as follows:

- Transect 2 (T2), further southeast along the shoreline from the Mine Transect near the mouth of Bland Creek, was 3.5 km long;
- Transect 7 (T7), northeast of the Mine Transect on the eastern shore, was 2.5 km long; and
- Transect 8 (T8), directly opposite the Mine Transect on the eastern shore, was also 2.5 km long.

The four lake transects were 2.0 to 2.5 km long but were excluded after preliminary counts because the habitat was not directly comparable with that of the Mine Transect.

It must be recognised that these transects were not fixed absolutely. As the shoreline advanced and receded with changes in lake levels their absolute positions changed; but their radial positions in relation to the Lake's centroid and, therefore, their relative positions along the shore were fixed. Changes in shoreline also meant that the vegetation could change from count to count. However, the transects were in very similar habitats overall - open grassland with scattered redgums above the shore and open water or cane grass in the lake. On any one sampling date, the vegetation the transects covered was very similar. Transect 7 differed somewhat in that it had more relief and therefore more open pools than the other three.

Waterbirds were counted on these transects by walking slowly along the shoreline recording all birds within the transects. Transects were counted in August, October and January in the seasons of 1989/90 to 1994/95. Each transect was counted once in each month within a one or two day period. Table 1 gives the dates of each count, any modifications and the water levels at the time. No counts were done in the season of 1990/91, and the very dry conditions in 1992/93 meant that T7 could not be counted and T2 had to be shortened by 250m. More details on water level fluctuations are given in the main report.

Originally it was hoped that the transect counts could be used to estimate total bird numbers on the lake (Lane 1989a). In October 1989 an aerial reconnaissance was made of the entire lake to estimate total bird numbers in the southern part of Lake Cowal and test this idea, but it was concluded that the transect counts could not be used to estimate total numbers (Lane 1989b). They could only be used to index bird use of the lake.

Table 1. Timing of counts and lake conditions.

Season	Dates of Counts	Transect Modifications	Lake Levels and Conditions
1989/90	9-11/Aug 21-24/Oct early Jan	None	Lake very low early in 1989 but filled to near full by local rains at time of surveys. Much local flooding.
1990/91	No Counts		Flood on Lachlan R. put more water in the lake in mid 1990. Lake levels falling by the latter half of the year.
1991/92	24/Aug 18/Oct 25-26/Jan	None	Lake levels still falling. No heavy local rain.
1992/93	28-29/Aug 27-28/Oct 25-26/Jan	T7 now in lignum area and not counted; T2 reduced to 3.25 km	Lake levels lowest of entire study at the start of the season and rising slightly towards the end. District very dry.
1993/94	30-31/Aug 20-21/Oct 17-18/Jan	None	Lake levels very high after local rains in mid - late 1989. Levels reached peak in about October, then began to fall.
1994/95	20-21/Aug 9-10/Oct 15-16/Jan	None	Water levels declining throughout the season.

Breeding data

Breeding surveys were done every season by examining all areas of the lake from canoe or boat and by occasional aerial reconnaissance (October 1989, January 1990 and January 1993). All visible nests and rafts of young were identified, counted and mapped. However, holes in trees were not checked for duck nests.

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 4

TERRESTRIAL FAUNA REPORT

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LAKE COWAL

PROPOSED GOLD MINE OPERATION
NORTH MINING LIMITED

TERRESTRIAL FAUNA REPORT

F DOMINIC FANNING

August 1995

1 INTRODUCTION and METHODS

1.1 INTRODUCTION

This report considers the native 'terrestrial' fauna and fauna habitats in an area proposed by North Mining Ltd for an open-cut gold mine at Lake Cowal, NSW (see Figure 1 - FIS). The proposed mine area comprises approximately 2800 hectares, with the tailings storage, treatment plant and waste rock stockpile operations covering approximately 600ha on the Lake shores (see Figure 2 - FIS). The open-cut mine itself will ultimately comprise a pit approximately 1km diameter and 350 metres deep, located partly within the Lake (see Figure 2 - FIS).

Limited information is available for much of the 'terrestrial' vertebrate fauna in the general area, with the exception of the avifauna. Lake Cowal is a recognised and significant wetland and waterbird refuge. Several avian surveys and studies have been conducted in the vicinity (Vestjens 1977; bird observer groups), although most studies have concentrated on the birds of the Lake and its immediate environs (Lawler 1989; Lane 1990; Fullagar 1991).

The main report on native fauna of the Lake Cowal area (Vestjens 1977) does, however, include details of the 'terrestrial' fauna, including reptiles, amphibians and mammals, as well as the birds. Information from relevant prior investigations has been included in this report where available, but the fauna of the Lake itself, including the waterbirds, are considered in the second report on this project (Appendix 5 of the FIS).

The aims of this investigation of 'terrestrial' fauna in the vicinity of the proposed North Ltd mining operations at Lake Cowal were:

- to determine the nature of and describe the fauna habitats present on the proposed mine area and in the general vicinity;
- to determine the fauna species present through the area, and their conservation significance;
- to identify sites of potentially high conservation significance which may require further investigation; and
- to address the significance of potential impacts of the proposal on native fauna and fauna habitats, and to recommend impact amelioration measures for the project.

1.2 METHODS EMPLOYED

The sites relevant to the proposed gold mine were surveyed in detail for native fauna, using a comprehensive survey protocol, which included trapping, spotlighting and habitat searches (Table 1). The proposed mine area was subjected to intense scrutiny, and the surrounding environs were also inspected for relevant fauna habitats.

TABLE 1 Field fauna investigations conducted on the study site at Lake Cowal.

Trapping	515 trap-nights with Elliott small mammal traps - 'A-size' (10cm x 9cm x 30cm); 8th to 12th April 1994 inclusive; 5 nights trapping per site; 103 Elliott traps: T1 (25), T2 (23), T3a & 3b (30), T4 (25); bait - rolled oats/peanut butter/honey; habitats surveyed: Open Woodland, Grassland, Lakeside vegetation, Open Forest; 85 trap-nights with pit-traps; 8th to 12th April 1994 inclusive; 5 nights trapping per site; 17 pit-traps: T1 (3), T 2 (4), T3a & 3b (7), T5 (3). habitats surveyed: Open Woodland, Grassland, Lakeside vegetation.
Spotlighting	22 person-hours spotlighting through all habitats in the study area; evenings of 8th to 11th April 1994 inclusive; records maintained of all species recorded. 8th April 1994 - clear; still; cool 9th April 1994 - clear; still; cool 10th April 1994 - overcast; cool, changing to cold; southerly wind 11th April 1994 - overcast; raining; cold; southerly wind
Amphibian & Bat Taping	5 hours of bat surveys using ultrasonic detectors (10 sites with half an hour of taping at each site); 5 hour of amphibian call taping.
Habitat Searches	approximately 5 days, through all habitats in the study area; 7th to 11th April 1994 inclusive; logs and debris searched, tracks and diggings identified, scats and bones identified (where possible), animals sighted/caught identified.

Initial information was obtained from a preliminary site inspection and from topographic maps and aerial photographs. These were reviewed to determine the extent and distribution of adjacent or nearby vegetation communities and fauna habitats, and to locate sites of potentially high fauna value. Previous avifauna surveys (Vestjens 1977; Lawler 1989; Lane 1990; Fullager 1991), and various vertebrate fauna databases (RAOU records; NSW Bird Atlas; NSW Wildlife Atlas) were also accessed where relevant.

Detailed surveys for fauna through fauna habitats on the proposed mine area and in the general vicinity were conducted from the 8th to the 12th of April 1994. Weather conditions throughout the fauna survey ranged from mild clear and sunny at the commencement of operations, to cold windy and overcast with some rain towards the end.

Specific techniques employed for this investigation (Table 1) included small mammal trapping (using Elliott and pit traps) for 'terrestrial' fauna, bat detection surveys, spotlighting surveys, and intensive habitat searches. Trapping transects were established through all relevant sites and vegetation communities (Table 2), including the 'terrestrial' section of the proposed mine area and environs, and in woodland communities nearby (see Figure 3 of the FIS).

Spotlighting surveys were conducted on each evening, through all fauna habitats in the study area. These involved a combination of walked surveys using a hand-held spotlight and a portable 12-volt battery pack, and driven spotlight surveys over greater distances.

Habitat searches involved walking through habitats and specific areas, observing fauna and the indirect evidence for their use of the area (diggings, scratches on trees, scats, nests, bones, feathers, footprints etc).

Bat surveys included the recording of microchiropteran bat calls at 10 locations throughout the study area, using an Anabat II detector. Bat surveys were conducted on the 8th, 9th and 11th of April 1994, and recordings were subsequently analysed by computer. Mist nets and harp traps were not deployed during this investigation, because of the nature of the habitats surveyed (obvious bat 'fly-ways' were not present over the mine area).

TABLE 2 Fauna habitats surveyed for 'terrestrial' fauna in the vicinity of the proposed Lake Cowal Gold Project.

Habitat 1	'Gilgai' community near 'Cowal West' homestead, approximately 1.5km southwest of the proposed pit.
Habitat 2	Small lightly wooded knoll, approximately 1.7km north of the proposed pit.
Habitat 3a	Vegetation along Frog Pond Creek (west side of the road), approximately 1.8km northwest of the proposed pit.
Habitat 3b	Lakeside vegetation along Lake Cowal foreshores.
Habitat 4	Open Forest on the slopes of Wamboyne Mountain, approximately 6km north of the proposed pit.
Habitat 5	Open Woodland approximately 1km southwest of the proposed pit.

2 HABITATS and ENVIRONMENTAL FEATURES

Lake Cowal is the largest inland lake in NSW, comprising an area of 150 sq.km when full (Vestjens 1977). It is filled by local runoff and from the Bland Creek catchment which flows into its southern end, but also receives an influx of water from the north when the Lachlan River floods (Lane 1990). Water levels in Lake Cowal fluctuate markedly according to rainfall and evaporation, and the Lake usually dries up after several consecutive dry years. The Lake provides an important habitat for native waterbirds, and is recognised as of considerable significance in this regard. The aquatic fauna of the Lake are considered in the second report on Lake Cowal (see Appendix 5 of the FIS).

The proposed mine area for the Lake Cowal Gold Project is located on the western shoreline of Lake Cowal. The primary fauna habitats/vegetation communities in the general area include the Lake itself and its associated shoreline and Lignum habitats, patches of remnant Open Woodland, and the predominantly cleared Grasslands that dominate the study area and the general region. Areas of Open Forest occur on the slopes of Wamboyne Mountain, to the north of the proposed mine area, but are not present on the proposed mine area.

All vegetation communities present on the study site and in the general vicinity have long been subject to extensive and intensive grazing, and support little or no understorey. The lack of regenerating saplings suggests that much of the current vegetation communities will gradually disappear unless replacement trees are established.

Open Woodland

The Open Woodland communities are patchily distributed throughout the general region, and include several distinct types, each dominated by a different suite of tree species. Most of these Open Woodland communities share the common characteristic of a sparse and depauperate understorey, with few native shrubs and saplings or recently germinated young trees. The ground layer is generally dominated by grasses, both native and introduced, and weeds, and all of the Open Woodland areas in the vicinity have been substantially modified by a long history of grazing by introduced stock.

The predominant Open Woodland community on the mine area (which will be subject to disturbance by the proposed mining activities) is dominated by Bimble Box *Eucalyptus populnea* to 10 metres, and Belah *Casuarina cristata*. One stand of woodland is located on a small knoll west of the proposed pit, and supports remnant shrub species, although these are nowhere dense. This kind is largely to be avoided by the waste rock stockpile proposed for this location.

The tree mosaic is generally heavily infested with Mistletoe, which provides a significant food resource for many native fauna species. As is typical of the other woodland communities through the study area, the understorey in this habitat has been substantially depleted by grazing, and the groundcover is dominated by grasses and introduced weeds. This community supports very few trees with suitable nesting hollows. Substantial areas of similar gilgai communities are located throughout the landscape, including large tracts to the west, south and east of Lake Cowal.

The somewhat higher ridge to the south of the mine area supports a tall eucalypt woodland with Cypress Pines *Callitris* spp, to a height of 7 metres. There is no shrub layer or tall understorey as a consequence of sheep grazing, and the groundcover is generally dominated by native grasses and introduced weeds. This area has numerous rock outcrops and ground debris, which provide valuable habitat for reptiles and potentially for some small mammals, and some of the larger trees also support hollows.

Open Forest

This habitat occurs principally on the slopes of Wamboyne Mountain, approximately 6km to the north of the proposed mine pit. This fauna habitat comprises an Open Forest community, dominated by eucalypt and cypress species to 25 metres in height, with a groundcover of grasses and introduced weeds. It has been substantially modified and there is a conspicuous lack of understorey and shrub layers as a consequence of long-term heavy grazing. Wamboyne Mountain contains numerous scattered rock outcrops and hollow-bearing trees, which provide important potential habitat for many fauna species.

Lakeside Vegetation

The Lakeside habitat occupies a narrow strip along the foreshores of Lake Cowal, and comprises the ecotone between the aquatic environments and the Grasslands of the adjacent grazing lands. This is a mobile ecotone, changing in location as the Lake Water levels alters.

The major shoreline habitat is that making the high water level of the Lake. This habitat comprises a narrow band of mostly scattered River Red Gums *Eucalyptus camaldulensis* to 25 metres height along the waters edge, with occasional moderately dense stands 25 metres north of the pit centre). The area is also characterised by an understorey of native exotic grasses, with few native shrubs, and scattered patches of Lignum. One area with a small wetland and dense reeds and grasses is located on the Lake shore south of the site. The present Lakeside habitat has long been subject to stock grazing and is consequently substantially modified.

Grassland

Most of the proposed mine area consists of introduced pasture and grasslands, with scattered native trees or occasional stands, particularly in moister locations. Bimble Box *Eucalyptus populnea* is the common species in these areas, especially east of the access road and along Frog Pond Creek. Grassland habitats in the vicinity are generally heavily grazed, and most native plants and fauna have been excluded, except for a range of native grasses and small herbs.

Frog Pond Creek cuts through this community to the north of the proposed mine pit site, and although not in flow during the fauna survey, maintains several pools which provide suitable breeding habitat for amphibians. This is a locally significant habitat, along with other small ponds and soaks in the study area, and several of the farm dams. Additionally, the patches of Bimble Box provide otherwise scarce resources, such as tree-hollows, which are of significance for some elements of the fauna assemblage.

3 FAUNA

3.1 GENERAL SURVEY RESULTS

During this investigation of the proposed Lake Cowal Gold Project, a total of 124 species of native vertebrate fauna have been observed or detected, including 96 bird species, 15 mammals, 7 reptiles and 6 amphibians (Appendix 6 of the FIS). Additional species derived from databases (NP&WS Wildlife Atlas, RAOU Atlas, NSW Bird Atlas) have been included in the fauna inventory, but many of these would not be expected in the immediate vicinity of the proposed mine area, because of the absence of relevant habitats or suitable resources. Data from previous fauna surveys of Lake Cowal and the immediate vicinity (including bird observers clubs and records from a local ornithologist) have also been included in the fauna inventories compiled for the area (Appendix 6 of the FIS).

A substantial number of additional fauna species are included in the databases searched, as the areas involved in these computer searches are substantial. The RAOU records covered an area of approximately 3382 square kilometres (33km north, 24km east, 22km south and 37.5km west of the pit site), and the NSW Bird Atlas records covered an area of approximately 592 sq.km (15km north, 9km east, 22km south and 7km west). The NP&WS Wildlife Atlas records covered an area of 2530 sq.km (33km north, 24km east, 22km south and 22km west of the pit site). Some of the additional species included in those databases are considered unlikely to occur at Lake Cowal, given their habitat requirements and the nature of the site.

MAMMALS

Only three native 'terrestrial' mammal species, the Echidna *Tachyglossus aculeatus*, Yellow-footed Antechinus *Antechinus flavipes*, and Eastern Grey Kangaroo *Macropus giganteus*, were recorded from the mine area or from habitats in the vicinity during this investigation, (Appendix 6 of the FIS). All are common and widespread species, which have also been recorded within the Lake Cowal area in previous fauna studies (Vestjens 1977). The Red Kangaroo *Macropus rufus* was also recorded from the study area by Vestjens (1977), but this species was not observed during this survey.

One semi-aquatic mammal, the Australian Water Rat *Hydromys chrysogaster*, has been recorded previously at Lake Cowal (Vestjens 1977). This species was recorded during this investigation, and is regularly sighted by the geological survey team at the Lake (P Handoe *pers comm*) and by local residents and wildlife enthusiasts. The Platypus *Ornithorhynchus anatinus*, Australia's other semi-aquatic native mammal, is considered unlikely to occur within the study area given the habitats present, but could possibly occur in the Lachlan River north of the study site.

Spotlighting surveys during this investigation detected only one arboreal mammal species, the Common Brushtail Possum *Trichosurus vulpecula*. Possible calls of the Sugar Glider *Petaurus breviceps* were heard from Open Forest and Woodland habitats on Wamboyne Mountain, but strong winds and the infrequency of calls made positive identification impossible. Nevertheless, this species could occur in the general area.

Trapping for 'terrestrial' fauna during this investigation revealed the presence of the Yellow-footed Antechinus *Antechinus flavipes* and the introduced House Mouse *Mus musculus* (Table 3). The former was recorded from a transect located in Open Forest on Wamboyne, Mountain whilst the House Mouse was recorded in high numbers throughout the study area. The Yellow-footed Antechinus is common to abundant throughout its range (Strahan 1992), and the House Mouse is considered a destructive pest throughout Australia.

TABLE 3 Mammal species recorded in Elliott small mammal traps on survey transects in the Lake Cowal study area.

T#	HABITAT	SPECIES NAME	#IND	#TOT
T1	Open Woodland	*Mus musculus*	18	18
T2	Open Woodland	*Mus musculus*	10	10
T3a	Grassland	*Mus musculus*	4	4
T3b	Lakeside Vegetation	*Mus musculus*	11	11
T4	Open Forest	*Antechinus flavipes* *Mus musculus*	4 2	8 2

T# Transect Number
IND Number of individuals trapped.
TOT Total number of individuals trapped, including recaptures.

Data from Vestjens (1977) and the NSW NP&WS Wildlife Atlas indicate that other species of 'terrestrial' mammal fauna occur around the Lake or in the general region. The Red Kangaroo has been recorded from Lake Cowal (Vestjens 1977), and several other macropod species are known from the region (NP&WS Wildlife Atlas), although none have been specifically recorded from the vicinity of Lake Cowal. The Brush-tailed Rock-wallaby is not likely to be present, because suitable habitat does not occur in the immediate vicinity.

During specific surveys for microchiropteran bats through the mine area and the general vicinity (Table 1) 10 species were detected (Table 4). Two of these species, the Little Pied Bat *Chalinolobus picatus* and the Troughton's Bat *Vespadelus troughtoni* are listed on Schedule 12 of the NP&W Act as Vulnerable & Rare, and are discussed in detail below. It should be noted, however, that calls have only been tentatively assigned to these two species, and the identifications are not considered definite.

As indicated in Table 4, all but one of the bat species recorded were located in the vicinity of Wamboyne Mountain, where tree densities and sizes are greatest. Only 5 of the 10 bat species recorded were found over the mine area, of which there were no endangered species, and all are common to abundant over generally extensive distributional ranges. The Open Forest on Wamboyne Mountain will be unaffected by the proposed mine development.

Most of the microchiropteran bat species recorded from the study area are tree-roosting, sheltering during the day in tree-hollows or under patches of exfoliating bark. These animals generally roost in groups ranging from a few individuals to hundreds of bats, with roosts varying seasonally depending on climate and the breeding and food requirements of the bats. Two species, Troughton's Bat *Vespadelus troughtoni* and the Little Pied Bat *Chalinolobus picatus*, roost predominantly in caves, although the latter also apparently uses tree-hollows in some areas (Parnaby 1992).

Given the scarcity of tree-hollows and caves through the habitats within the mine area, few microchiropteran bats are considered likely to be resident at the site, and the habitats are therefore regarded primarily as foraging resources. Some of the Woodland patches contain limited numbers of tree-hollows, and the Bimble Box trees scattered through the Grasslands do support hollows, which may be used by some bats, although competition for the few hollows present is likely to be intense. The narrow strip of River Red Gums on the foreshores of Lake Cowal, although providing numerous suitable roosting hollows, may be of relatively low significance for microchiropteran bats due to heavy use by roosting and nesting waterbirds.

Two additional microchiropteran bat species have been recorded from the general Lake Cowal area, the Little Brown Bat *Vespadelus pumilus* (Vestjens 1977) and the Greater Long-eared Bat *Nyctophilus timoriensis* (NP&WS Wildlife Atlas). The former is widespread, but the Greater Long-eared Bat is an endangered species in NSW. Details of this and the other two possible endangered species at the Lake are provided in Section 4.2 of this report.

TABLE 4 Bat species detected from ultrasonic recordings during this investigation in the Lake Cowal study area.

COMMON NAME	SPECIES NAME	ROOSTING REQUIREMENTS	A	B
Emballuronidae				
White-striped Mastiff Bat	*Tadarida australis*	Tree-hollows	●	✣
Molossidae				
Inland Freetail Bat	*Mormopterus planiceps*	Tree-hollows; bark	●	✣
Vespertilionidae				
Gould's Wattled Bat	*Chalinolobus gouldii*	Any cavity	●	✣
★ Little Pied Bat ?	*Chalinolobus picatus*	Caves; tree-hollows		✣
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	Tree-hollows		✣
Inland Broad-nosed Bat	*Scotorepens balstoni*	Tree-hollows		✣
Little Broad-nosed Bat ?	*Scotorepens greyii*	Tree-hollows		✣
Southern Forest Bat	*Vespadelus regulus*	Tree-hollows	●	✣
Small Forest Bat	*Vespadelus vulturnus*	Tree-hollows	●	
★ Troughton's Bat ?	*Vespadelus troughtoni*	Caves		✣

? Calls were tentatively assigned to these species; identifications are not definite due to limited numbers of calls.

A Michrochiropteran bat species recorded during this investigation on the proposed mine area.

B Michrochiropteran bat species recorded during this investigation in the Wamboyne Mountain/'Coniston' area.

★ Schedule 12 (NP&W Act 1974) Part II Vulnerable & Rare

A range of feral or introduced mammals were recorded during this study. These included destructive species such as the Feral Cat *Felis catus* and Fox *Vulpes vulpes* (spotlight), and the House Mouse (trapped, spotlight). These species are widespread throughout Australia, and are generally common in areas characterised by highly modified environments. Other introduced mammals in the area included stock (cattle and sheep) and the Feral Pig *Sus scrofa*, all of which are known to degrade native habitats to a significant extent.

BIRDS

Ninety-six bird species were recorded on the study area or in the general vicinity during this fauna survey (Appendix 6 of the FIS). These include entirely 'terrestrial' species (such as passerines, honeyeaters, raptors and parrots), essentially aquatic species (such as cormorants, ducks and grebes), species which use a combination of wetlands and 'terrestrial' habitats such as (egrets, herons and ibis), and shorebirds (such as plovers, dotterels and rails). The non-'terrestrial' species are considered in the second report for Lake Cowal (Appendix 5 of FIS).

Of the 70 'terrestrial' birds recorded, 59 species were recorded from the mine area, which represents approximately 34% of the avian species likely or known to have been recorded in the Lake Cowal area (Vestjens 1977; Hatton 1991). An additional 11 species were located in the Wamboyne Mountain/'Coniston' area, most of which are expected to occur occasionally within the mine area. Included amongst these is the Gilbert's Whistler, an endangered species which is discussed in detail below. Many of the species not sighted during the present survey are either migratory or nomadic, and were not present in the region at the time of survey. For a further 11 species, particular habitat requirements are not available within the mine area. The avifauna species diversity at Lake Cowal is moderate, with the general area supporting approximately 15% of the 'terrestrial' avifauna found within NSW (Morris *et al* 1981).

The most significant habitat for 'terrestrial' birds within the mine area was the 'gilgai' Open Woodland community adjacent to the Cowal West homestead. This vegetation community comprises approximately 1.5 sq.km of mixed acacia, casuarina and eucalyptus species infested with prolific mistletoe. Populations of at least 36 species were recorded in this habitat patch, including honeyeaters, parrots, robins, thornbills and fairy-wrens. This assemblage represents 51% of non-waterbird avian taxa found within the study area during this investigation. At the time of survey, the acacias had recently finished flowering, and the mistletoe was coming into full bloom. This circumstance provided a substantial food resource for birds, with honeyeaters feeding on the mistletoe blossom or on insects attracted to the plants, and small passerines foraging on insects. The many old nests through this vegetation community indicates that the area is important during the breeding season (through spring and summer).

Mistletoe-infested acacias are a preferred habitat for the Painted Honeyeater (Blakers *et al* 1984; Garnett 1992a, b), and although this species was not observed during this survey, it is expected to occur in the area on occasions. The Painted Honeyeater has been recorded breeding in the Lake Cowal area (RAOU Atlas records).

The lightly-wooded knoll situated 1.5km north of Cowal West homestead (immediately west of the proposed pit site) also supported a reasonably diverse avian assemblage, particularly parrots. Cockatiels and Red-rumped Parrots were observed examining tree-hollows in this locality, and may use the area for breeding. Owlet Nightjars and Tawny Frogmouths were also recorded at this site during the evening spotlight surveys.

The Grassland habitats throughout the study area supported few avian species despite the density of grass seed, with the occasional Quail observed. Other species recorded infrequently included Richard's Pipit and the Rufous Songlark. The scattered stands of Bimble Box *Eucalyptus populnea* through the Grassland habitats (mostly between the access road and the Lake) contain hollows likely to be utilised by hollow-nesting bird and bat species during the breeding season.

The Lakeside habitat/ecotone, including the narrow band of River Red Gums *Eucalyptus camaldulensis* and the Lignum and grassy understorey, supported many feeding and roosting bird species. These Lakeside (riparian) corridors may also used by migrating and nomadic birds, including endangered species such as the Superb Parrot, to move between more extensive tracts of vegetation or between areas with concentrations of relevant feeding and nesting resources.

However, no avian species of conservation significance, which could be considered entirely dependent on the environmental resources present within the proposed mine area, were observed. Additionally, it should be noted that several bird species were observed foraging and perching on and adjacent to the drill rigs, despite the rigs being in operation.

A small patch of Lignum *Muehlenbeckia cunninghamii*, located about 500-600 metres north of the drill site, supported a higher concentration of birds than did the sparser portions of the Lakeside habitat. The Rufous Night Heron, Intermediate Egret, Little Egret, Australian White Ibis, Australian Crake and Variegated Fairy-wren were observed only at this location, and Whistling Kites, a pair of Little Falcons and a Peregrine Falcon were also observed in this small area of shoreline.

REPTILES

Rocky outcrops and various ground debris on Wamboyne Mountain, and to a lesser extent on the ridge in the south of the mine area, provide excellent microhabitats and shelter for many reptile species. Whilst the majority of the study area, dominated by open Grasslands, is of rather less value for this group of animals, some of the Open Woodland areas contain localised areas of logs and rocks which also provide valuable refuge. The River Red Gums along the shoreline provide fallen logs and tree debris within and beneath which reptiles can shelter, and the somewhat thicker grass layer near the Lake and the stands of Lignum also provide potential resources for reptiles.

A range of widely distributed and abundant reptile species, including one gecko, three skinks, one dragon, one agamid and one elapid, were recorded during this investigation. Species detected during habitat searches included the Lace Monitor *Varanus varius*, Eastern Thick-tailed Gecko *Underwoodisaurus milli*, Spiny-palmed Shinning-skink *Cryptoblepharus carnabyi* and the Eastern Brown Snake *Pseudonaja textilis* (Appendix 1). Reptile species recorded in pit-traps (Table 5) in Open Woodland areas included the

Southeastern Morethia Skink *Morethia boulengeri*, Wood Mulch-slider *Lerista muelleri* and the Bearded Dragon *Pogona barbata*. No endangered reptile species have been recorded in the vicinity, and none are expected on the mine area.

An additional 24 reptile species have been recorded around Lake Cowal or from within the general vicinity (Vestjens 1977; NP&WS Wildlife Atlas). However, the habitats present on the proposed mine area are considered unlikely to be particularly suitable for most of these species, or to provide unique or 'critical' resources.

AMPHIBIANS

Six amphibian species were recorded from pit traps or by sightings through the study area during this investigation (Table 5), including Sloane's Froglet *Crinia sloanei*, Crucifix Toad *Notaden bennettii*, Smooth Toadlet *Uperoleia rugosa*, Peron's Tree-frog *Litoria peronii*, Marsh Frog *Limnodynastes fletcheri* and the Spotted Grass Frog *L tasmaniensis*. All of these species recorded are common to abundant and widespread throughout their ranges.

Although amphibians were recorded from all habitat types/communities surveyed, several areas are especially relevant for amphibians. These include the stands of Lignum and areas of shallow flooded grassy foreshore which line areas of the Lake edge, several pools along Frog Pond Creek that persist when the creek ceases flowing, and a number of farm dams. Localised areas containing logs and rocks associated with depressions in Open Forest and Woodland, and depressions throughout the area in general (including along roadsides) which retain water after rain, provide potential temporary breeding habitat and resources for some frogs. No endangered amphibian species were detected in the study area during this investigation, and none are included on the NP&WS Wildlife Atlas for the region.

A further five amphibian species have been recorded from around the Lake or from within the general region (Vestjens 1977; NSW NP&WS Wildlife Atlas), including the Eastern Sign-bearing Froglet *Crinia parinsignifera*, Painted Frog *Neobatrachus pictus*, Green Tree-frog *Litoria caerulea*, Giant Banjo Frog *Limnodynastes interioris* and the Salmon-striped Frog *L salmini*. These species are all considered common to abundant and are widespread throughout their distributional ranges.

TABLE 5 Fauna species recorded in pit traps in habitats surveyed in the Lake Cowal study area.

T#	HABITAT	SPECIES NAME	TOTAL
T1	Open Woodland	*Limnodynastes fletcheri*	2
		Limnodynastes tasmaniensis	3
T2	Open Woodland	*Notaden bennettii*	1
		Lerista muelleri	1
		Morethia boulengeri	1
		Pogona barbata	1
T3a	Grassland	*Limnodynastes fletcheri*	1
		Limnodynastes tasmaniensis	2
T3b	Riparian Vegetation	*Mus musculus*	4
		Limnodynastes fletcheri	2
		Limnodynastes tasmaniensis	3
T5	Open Forest (remnant)	*Mus musculus*	1
		Crinia sloanei	1
		Limnodynastes fletcheri	2
		Limnodynastes tasmaniensis	2
		Uperoleia rugosa	4
		Morethia boulengeri	1

T# Transect Number

3.2 ENDANGERED 'TERRESTRIAL' FAUNA KNOWN FROM THE VICINITY

No endangered fauna species have been specifically recorded on the proposed mine area at Lake Cowal, but a number of Schedule 12 species have been recorded in and around the Lake, and several others are known from the region. Of those endangered species known from the vicinity, many are waterbirds associated with the Lake and other regional wetlands, including the Australasian Bittern, Magpie Goose, Freckled Duck, Blue-billed Duck, Osprey, Painted Snipe and Black-tailed Godwit, and are considered in the second report on the proposed Lake Cowal Gold Project (see Appendix 5 of the FIS).

A total of 4 endangered 'terrestrial' fauna species (included on Schedule 12 of the National Parks & Wildlife Act as amended in 1992) have been recorded during surveys in the vicinity of the proposed mine area at Lake Cowal, or are included on other databases. Ultrasonic calls which could possibly be ascribed to two endangered microchiropteran bat species (the Troughton's Bat and Little Pied Bat) were obtained during this investigation around Wamboyne Mountain, although these calls could be of other bat species known to occur in the region. The Greater Long-eared Bat has been recorded from the northeastern side of the lake, approximately 9km to the northeast of the proposed pit (NSW NP&WS Wildlife Atlas). One other endangered fauna species, Gilbert's Whistler, was recorded on Wamboyne Mountain (6km to the north) during the field surveys for this report.

Several additional species of endangered 'terrestrial' fauna could be present in the vicinity of the proposed mine and its ancillary operations (Table 6), as individuals have been recorded in the general area (NP&WS Wildlife Atlas, RAOU Bird Atlas). However, there are no data currently available to indicate the presence of any of these species on the proposed mine area, either from this or previous investigations, despite the intensity of studies at Lake Cowal over an extended period. Furthermore, given the generally depauperate and modified 'terrestrial' habitats present, few of the additional species are anticipated to occur on the study area, other than on an occasional and transitory basis. Several are considered unlikely to be present in the vicinity of the mine area (because the habitats available are not suitable), or unlikely to be dependent on the habitats present even if they do occur (given the mobility of the animals concerned). Species in this category (known from the region but considered not relevant to the mine proposal) include the Brolga, Black-breasted Buzzard, Pink Cockatoo, and several species which have been recorded only a considerable distance from the mine area (the Malleefowl, Square-tailed Kite, Brush-tailed Rock-wallaby, Grey Falcon, Bush Stone-curlew and Chestnut Quail-thrush).

The fauna habitats and vegetation communities of the proposed mine area at Lake Cowal, including areas to be disturbed for waste rock emplacements, tailings storages and plant operations, are widely distributed through the landscape in the general region. The disturbed or modified Grassland and Open Woodland communities present on the mine area are characteristic of southwestern NSW. Those areas which are to be disturbed are not considered 'critical' to the local survival of any endangered fauna species, although some individuals may irregularly use them.

One habitat patch of relatively high value, the relatively diverse 'gilgai' Open Woodland community, was located on the mine area, although this vegetation type is widespread through the region. Only an insignificant area of any habitat, relative to their distributions through the general region, will be affected by the proposed development. Furthermore, the habitat reconstruction and rehabilitation protocols recommended for the site are considered capable of enhancing fauna habitats in the medium to long term (converse to expectations for fauna habitat under normal agricultural pursuits). However, retention of the gilgai community would be beneficial, if possible, and an intensive re-creation program is required if it cannot be retained.

The endangered fauna considered of relevance to the Lake Cowal Gold Project are discussed in detail in the FIS.

TABLE 6 Endangered 'terrestrial' fauna (Schedule 12 species) known to occur at Lake Cowal or in the general vicinity.

COMMON NAME	SCIENTIFIC NAME
MAMMALS	
Vespertilionidae	
Little Pied Bat	*Chalinolobus picatus*
Greater Long-eared Bat	*Nyctophilus timoriensis*
Troughton's Bat	*Vespadelus troughtoni*
BIRDS	
Accipitridae	
Black-breasted Buzzard	*Hamirostra melanosternon*
Gruidae	
Brolga	*Grus rubicundus*
Cacatuidae	
Pink Cockatoo	*Cacatua leadbeateri*
Psittacidae	
Superb Parrot	*Polytelis swainsonii*
Swift Parrot	*Lathamus discolor*
Turquoise Parrot	*Neophema pulchella*
Pachycephalidae	
Gilbert's Whistler	*Pachycephala inornata*
Meliphagidae	
Pied Honeyeater	*Certhionyx variegatus*
Regent Honeyeater	*Xanthomyza phygia*
Painted Honeyeater	*Grantiella picta*

4 POTENTIAL IMPACTS of the DEVELOPMENT

No significant adverse impacts, from the proposed mine development need be imposed on any native fauna species or their habitats, provided appropriate management protocols (as discussed in of this report) are implemented. The construction and operation of the mine and its associated treatment plant, stockpiles and tailings storages affect only a small proportion of the habitats present in the general region. However, potential indirect impacts (particularly from sediment or contaminant discharge into the local watercourses or into Lake Cowal) could adversely affect the aquatic habitats if permitted. Potential impacts of the development on native fauna are discussed in detail in the FIS.

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 5

FAUNA OF LAKE COWAL

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LAKE COWAL

PROPOSED GOLD MINE OPERATION
NORTH MINING LTD

FAUNA OF LAKE COWAL

F DOMINIC FANNING

August 1995

1 INTRODUCTION

Lake Cowal is described as "*the largest natural lake in the Lachlan Valley*" (DWR 1990) and as "*the largest natural inland lake in NSW*" (NSR 1994). When full, Lake Cowal and the adjacent Nerang Cowal waterbodies cover an area of 15000-16000 hectares, constituting a significant and substantial wetland. It is a shallow ephemeral lake, which fills naturally by runoff from within its own catchment, and also by flooding from the Lachlan River to the north. During extended dry periods, the Lake dries out completely, and is used for agricultural purposes by the local landholders.

Lake Cowal is regarded as particularly significant for fauna conservation, especially with regard to wetland birds, fish and macroinvertebrates. It has been described as "*one of the most significant water bird concentration areas in NSW*" by the Australian Heritage Commission (see Appendix 9 of the FIS), and is clearly of substantial value for the survival and breeding of many wetland birds in inland NSW (Lane 1990; Rankine & Hill 1980; Vesjens 1977; DWRC 1986; NSR 1994). Over 170 native birds have been recorded using the habitats of Lake Cowal and its immediate vicinity, including approximately 45 species of wading and wetland birds breed at the Lake.

Lake Cowal is also considered of significance for fish, with 9 species (including 5 native species) having been recorded from it. Lake Cowal is a significant inland fishery and during suitable conditions contributes substantially to the freshwater fish catch for NSW. Lake Cowal also supports a substantial diversity and abundance of invertebrate fauna, due to the variety of habitats present.

The variety of habitats and vegetation communities present within Lake Cowal and along its margins provide a diversity of resources and features for native fauna, contributing to the high conservation and wildlife value of the Lake. Broad faunal habitats present include the intermittently flooded foreshores, Open Water, Shallow Waters with Cane Grass, dense Lignum stands - either with or without attendant River Red Gums, and shallow open water with scattered River Red Gums. This variety of habitats and the mosaic of features present in the Lake provide specific resources and features of relevance to the considerable array of avian fauna, as well as to the macroinvertebrate fauna and other vertebrates.

The proposed mining development by North Mining Ltd at Lake Cowal involves the construction of an open-cut pit for the mining of gold and copper. The proposed operation is located on the southwestern side of the Lake, and will involve the excavation of a mine pit surrounded by a bund wall extending approximately 1km into the Lake. Other associated features of the development (the treatment plant, waste-rock stockpile, tailings storages and associated infrastructure) will be located on the Lake shore and floodplain to the west of the proposed pit. The development is intended to provide a range of habitats of relevance to the native fauna of the area, including additional shoreline and lake features of potential value for the wetland and wading birds.

2 PHYSICAL FEATURES

Lake Cowal is "*the largest natural lake in the Lachlan Valley*" (DWR 1990) and Lane (1990) suggests that "*Lake Cowal is the largest freshwater lake in inland NSW and a significant waterbird breeding area on the edge of Australia's arid interior*". Vestjens (1977) also discusses the significance of Lake Cowal for feeding and breeding for waterbird species. The Australian Heritage Commission (see Appendix 9 of the FIS) considers Lake Cowal as "*one of the most significant waterbird concentration areas in NSW*", and the 1980 report by Rankine & Hill comments that Lake Cowal "*is clearly an extremely valuable water bird habitat*".

It is filled by flood-waters from the Lachlan River to the north and, less frequently, from within its own catchment (particularly via Bland Creek) to the south. Once full, and with no other water input, Lake Cowal takes 2-3 years to dry out, at which time the lake bed is used by local landholders for cropping and grazing. When completely filled, Lake Cowal itself is approximately 9km long from north to south and 5 km wide at its widest point, covering some 10800 hectares (NSR 1995). With the adjacent Nerang Cowal (providing an additional 3800 hectares; NSR 1995) a substantial area of lake and wetland is produced when the appropriate seasons have prevailed.

The majority of the lands which comprise Lake Cowal are held under freehold title, with only small Crown Land area occurring as road reserves or travelling stock reserves, and a few Permissive Occupancies. The Lake Cowal Game Reserve which is administered by the NSW NP&WS, primarily to provide access for duck shooting, is located on the western side of the Lake, north of the proposed mining operation.

The general climate of the area is characterised by hot summers and cool winters, with daily maxima at Forbes exceeding 40°C during the summer and mean daily minimum temperatures between 2 and 4°C in winter. Rainfall is distributed relatively evenly through the year, although winter and spring rains tend to be more reliable, whilst summer rainfall is often more abrupt, often producing local flooding as a result of summer storms. Further details of the physical attributes of Lake Cowal and the Wilbertroy/Cowal wetlands are included in the report of the DWR (Hatton 1991).

3 LAKE HABITATS

Several previous reports have discussed the fauna habitats of Lake Cowal (Vestjens 1977; Hatton 1991). For this report, six separate habitats specifically associated with the Lake are recognised, involving the Lake itself and the immediately adjacent shoreline. Vestjens (1977) describes 6 main habitats associated with Lake Cowal, but includes 'pasture and croplands' which are considered peripheral to the Lake ecosystem in this report, and which consequently were not used in assessing habitat use by wetland birds, although these habitats do provide food resources for a number of the wetland birds (particularly the ibis, spoonbills, some egrets, herons and the Masked Lapwing).

TABLE 1 The seven main fauna habitats associated with Lake Cowal used in this report, with the equivalent habitats as described by Vestjens 1977).

This Report	Vestjens	Description
not used	A	Pasture and Crop Areas
Habitat #1	B	Shoreline - areas intermittently flooded
Habitat #2	C	Shallow water with Lignum and eucalypts
Habitat #3	D	Shallow water with River Red Gums
Habitat #4	E	Shallow water with Lignum
Habitat #5	not used	Shallow water with Cane Grass
Habitat #6	F	Open and deep water

Habitat #1 Shoreline Habitat

The shoreline habitat occupies a narrow strip along the foreshores of Lake Cowal, and comprises the ecotone between the aquatic environment and the Grasslands of the adjacent grazing lands. The shoreline areas around the edge of Lake Cowal provide a long and variable habitat which moves in relation to changes in water level in Lake Cowal. These areas have long been subject to stock grazing and are consequently substantially modified. They are also characterised by relatively high levels of human disturbance, with excavated farm tanks and irrigation channels occurring around the Lake.

The upper (full) shoreline is characterised by a River Red Gum *Eucalyptus camaldulensis* community, either as scattered trees or occurring in discrete stands. In some areas, the River Red Gums extend for some distance into the Lake, depending on the frequency of flooding and on water depth, and merge into Habitat #3 (Shallow water with Red River Gums). River Red Gums are generally dominant, with some River Cooba *Acacia stenophylla* also occurring as a riparian open woodland.

Generally, the River Red Gum community along the Lake edge supports a groundcover of grasses and sedges, but there are scattered areas with a sparse undergrowth of Lignum *Muehlenbeckia cunninghamii* and other reeds, or with Cane Grass *Eragrostis australasica* as a swamp understorey at frequently inundated sites. Areas which are generally wet support perennial macrophytes such as Nardoo *Marsilea drummondii* and Water Milfoil *Myriophyllum verrucosum*. Because of changes in water level in the Lake, the shoreline habitats move frequently, and are highly dynamic and productive. Consequently, they are a significant feature for many of the waterbirds of Lake Cowal, and provide substantial feeding resources and habitat.

Habitat #2 Lignum/Eucalypts

A large proportion of the northern margins of Lake Cowal are dominated by dense Lignum growth (see Figure 1 of the FIS). Along the channels which drain into Lake Cowal when it is drier, stands of River Red Gums remain, including both dead and living trees. The combined River Red Gum canopy with a dense Lignum understorey and the intervening channels of open water, provide a diverse habitat for a range of wetland birds, and many species nest and breed in these areas.

The River Red Gum woodland occurs as isolated stands or along drainage channels through the dense Lignum. There are also shrubby thickets of Lignum with a sparse overstorey of Bimble Box *Eucalyptus populnea*, River Cooba and River Red Gum, and areas of shallow water with small islets of earth alongside excavated farm tanks. In the larger areas of open water, Ribbon Weed *Vallismeria spiralis* is common.

Habitat #3 River Red Gum

The northern parts of Lake Cowal and portions of the western shore are characterised by broad open stands of River Red Gum woodland standing in shallow water. These areas do not include either Cane Grass or Lignum as an understorey, and when the Lake is drier, comprise an open grassy River Red Gum woodland. A combination of scattered dead and living trees are characteristic of this habitat, and provide a range of roosting opportunities for birds, as well as shelters for the Australian Water Rat *Hydromys chrysogaster* and sites of particular relevance for some of the native fish.

Habitat #4 Shallow Water with Lignum

Extensive stands of Lignum shrubland occur in the slightly less frequently flooded areas in the northern part of Lake Cowal (see Figure 1 of the FIS). This community covers a large area and consists of very large clumps of Lignum, with intervening shallow channels of water. These habitats provide valuable shelter, breeding and feeding resources for a range of wetland birds, as well as shelter and substrates for a substantial array of macroinvertebrates and fish.

Habitat #5 Shallow Water with Cane Grass

The Cane Grass community is characteristic of a substantial proportion of the western and southern areas of Lake Cowal, and occurs in the lowest and most frequently inundated parts of the Lake, up to a maximum depth of about 2m. This is generally a monotypic community, with Lignum and River Red Gums generally absent. The Cane Grass community provides an array of refugia for some macroinvertebrate fauna and fish, although it has been noted that the diversity of species in these areas tends to be relatively low (Hawking 1995)

Habitat #6 Open Water

A substantial proportion of Lake Cowal, particularly the deeper most frequently inundated areas, are characterised by open water without emergent vegetation. These areas are too deep for either Lignum or Cane Grass, and are generally devoid of trees, except along the eastern shoreline where drowned River Red Gums occur. Open water habitats provide some feeding resources for wetland birds, particularly larger fish-eating species such as the Australian Pelican, cormorants and Darter. Many aquatic birds shelter in open areas of water, because of their isolation from land-based predators. Ducks, grebes, cormorants, the Australian Pelican and Eurasian Coot are often seen in flocks in the open water of Lake Cowal.

The different habitats present provide a variety of resources (food, shelter, breeding sites) for the Lake-dependent fauna at Lake Cowal. The vertebrate fauna of the Lake occurred at different frequencies in the different habitats of the Lake Cowal environment described by Vestjens (1977). Whilst the greatest number of fish species occur in the shallow and riparian areas, they are susceptible to high levels of predation in shallower water. Amphibians are concentrated in Habitat #1 'intermittently flooded riparian areas'. Most of the amphibian species are associated with very shallow water and emergent vegetation along the shoreline, including shallow and flooded grassland, and avoid deeper water environments. Two of the amphibian species (the Green Tree-frog *Litoria caerulea* and Peron's Tree-frog *Litoria peronii*) are capable of using Lignum and trees for shelter.

TABLE 2 The occurrence of vertebrate species in the habitats at Lake Cowal associated with the Lake environment (Vestjens 1977).

Habitat	Fish	Amphibians	Birds	Total
1(B)#	8	9	143 (62)	160 (79)
2 (C)	6	2	94 (46)	102 (54)
3 (D)	6	2	60 (37)	68 (45)
4 (E)	6	2	60 (46)	68 (54)
6 (F)	5	-	21 (20)	26 (25)

\# includes the proposed mine area.
numbers in brackets under Birds and Total indicate wetland or lake-dependent species.

As with the other vertebrate fauna groups, the birds of Lake Cowal are commonly associated with the shallow, frequently inundated shoreline. The number of avian species indicated in Habitat #1 (Table 2) is, however, inflated by the numbers of terrestrial species present. Only 62 lake-dependent species were present. Whilst most of the bird species do not breed along the shoreline, a substantial proportion of the birds of the area use this habitat for feeding. Only 13 wetland/lake birds are considered to rely on the intermittently inundated shoreline habitats (Hatton 1991). During the detailed waterbird surveys of the Lake, the only evidence for breeding activities in the shoreline habitats, at the proposed mine site, involved broods of the Grey Teal (Lane 1990).

4 AVIFAUNA

Lake Cowal is universally regarded as a wetland of major significance for avian fauna, in particular, for wading and wetland birds. The high numbers of waterbirds and the intensity of breeding activities qualify Lake Cowal as a 'wetland of international significance', according to the criteria implemented by the IUCN. "*Its natural condition, size and waterbird populations, make it one of the most important wetlands in South Eastern Australia*" (Lane 1990).

The significance of Lake Cowal for waterbirds and as a conservation feature is related to its size, and natural condition, and to the variety of habitats and features present. "*Because of its size and unregulated water levels Lake Cowal provides opportunities for a number of waterbird breeding events involving very large numbers of birds, yet it dries out frequently enough to produce high biological diversity next time it fills*" (Lane 1990). Lake Cowal is not subject to artificial regulatory systems and consequently follows a natural cycle of drying and refilling. The hydrological regime creates variation in vegetation communities present and in the macroinvertebrate and fish fauna over time, contributing to the value of Lake Cowal for breeding waterbirds.

The value of Lake Cowal for waterbirds is indicated by the numbers of birds which are regularly recorded. In 1989-1990, approximately 50000 waterbirds were located on Lake Cowal, and during the years 1964-1976 up to 147000 waterbirds were located on the Lake (Vestjens 1977). Vestjens recorded 172 birds associated with Lake Cowal, although a significant proportion of those are primarily terrestrial and are not dependent on the Lake itself. A total of 79 wading or lake and wetland-dependent bird species have been recorded from Lake Cowal (Appendix 1) during investigations over the last 20 years (Vestjens 1977; EES 1994; Lawler 1989; Lane 1990; Dent unpubl; Hatton 1991; this investigation). Fifty six species have been recorded on the waterbird survey transects at Lake Cowal (Crome 1995).

Of the 79 avian species associated with the Lake and wetland habitats at Lake Cowal, 8 endangered bird species (as listed on Schedule 12 of the NP&W Act 1974) have been recorded. The Osprey has only been recorded infrequently at the Lake, whereas the Freckled and Blue-billed Ducks are regularly sighted. Several of the wetland species are listed on international conservation treaties to which Australia is a signatory (Table 3), including JAMBA (the Japan-Australia Migratory Bird Agreement), CAMBA (the China-Australia Migratory Bird Agreement), and BONN (the Agreement on Wetland Birds).

Additionally, some unusual species have been recorded from Lake Cowal, including the Magpie Goose *Anseranas semipalmata* and the Wandering Whistling Duck *Dendrocygna arcuata*. Whilst Blakers *et al* (1984) suggest that these are likely to be vagrants, Lawler (1989) considers that the increased availability of wetlands in eastern Australia may have encouraged an increase in these species. Certainly the Magpie Goose appears to be restabilising its former range through southeastern Australia (*pers obs*).

The waterbird surveys conducted in Lake Cowal between 1989 and 1995 involved specific transects at eight locations through the Lake (see Figure 1 of the FIS). These surveys are intended to record the breeding activities and presence of birds in the Lake at the different locations, and to provide a general indication of the activities of waterbirds in the vicinity of the proposed mine.

The water level of Lake Cowal has fluctuated substantially between 1989 and 1994, with flooding events occurring on at least two occasions, providing increased habitat and food resources for some species, whilst decreasing resources and suitable habitat for others (NSR 1995). A large number of bird species which utilise inundated vegetation for breeding were active in their reproduction in October 1989 following a substantial inflow into Lake Cowal, which inundated the northern Lignum and River Red Gum areas. NSR (1995) notes that when water levels drop in the Lake many of the species which utilise inundated vegetation (such as the Darter, cormorants, egrets, ibis and spoonbills) are unlikely to breed due to their susceptibility to land-based predators. Many other species appear to breed in response to water inflows into Lake Cowal. Most of the breeding ducks, the Whiskered Terns, and many of the shorebirds (such as the Masked Lapwing, Red-kneed Dotterel and Banded Stilt) breed most successfully when water inflows provide extensive Cane Grass areas, or inundation of lake shorelines to provide shallow vegetated lake margins.

TABLE 3 Those birds species that are associated with Lake Cowal and are included on Schedule 12 of the NP&W Act 1974 and those under International Treaties to which Australia is a signatory.

COMMON NAME	SCIENTIFIC NAME	TREATIES
Ardeidae		
Cattle Egret	*Ardeola ibis*	JAMBA, CAMBA
Great Egret	*Egretta alba*	JAMBA, CAMBA
★ Australasian Bittern	*Botaurus poiciloptilus*	
Threskiornithidae		
Glossy Ibis	*Plegadis falcinellus*	CAMBA
Anseranatidae		
★Magpie Goose	*Anseranas semipalmata*	
Anatidae		
★Freckled Duck	*Stictonetta naevosa*	
★Blue-billed Duck	*Oxyura australis*	
Accipitridae		
★Osprey	*Pandion haliaetus*	BONN
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	CAMBA
Gruidae		
★ Brolga	*Grus rubicundus*	
Rostratulidae		
★ Painted Snipe	*Rostratula benghalensis*	CAMBA
Charadriidae		
Lesser Golden Plover	*Pluvialis dominica*	JAMBA, CAMBA
Scolopacidae		
Ruddy Turnstone	*Arenaria interpres*	JAMBA, CAMBA
Greenshank	*Tringa nebularia*	JAMBA, CAMBA
Marsh Sandpiper	*Tringa stagnatilis*	JAMBA, CAMBA
Latham's Snipe	*Gallinago hardwickii*	JAMBA, CAMBA
★ Black-tailed Godwit	*Limosa limosa*	JAMBA, CAMBA
Bar-tailed Godwit	*Limosa lapponica*	JAMBA, CAMBA
Sharp-tailed Sandpiper	*Calidris acuminata*	JAMBA, CAMBA
Pectoral Sandpiper	*Calidris melanotos*	JAMBA, CAMBA
Red-necked Stint	*Calidris ruficollis*	JAMBA, CAMBA
Laridae		
Franklin's Gull	*Larus pipixcan*	
Caspian Tern	*Hydroprogne caspia*	JAMBA, CAMBA

★ Schedule 12 species (NP&W Act 1974, as amended 1992).

LOCAL STATUS after Hatton (1991).

JAMBA Japan - Australia Migratory Bird Agreement.

CAMBA China - Australia Migratory Bird Agreement.

BONN Convention on the conservation of migratory species of wild animals.

NSR (1995) suggests that the extent and intensity of regional flooding and rainfall events may have a significant impact on the value of Lake Cowal for breeding waterbirds. Thus, other wetlands in the general region, particularly those associated with the Lachlan Valley, may provide appropriate resources at times when Lake Cowal is less satisfactory for some species. In October 1993, the surveys at Lake Cowal indicated very low numbers of waterbird species on the Lake. EES (1994) suggests this is probably a result of several factors, including heavy regional rainfall in central NSW and the general flooding of the Lachlan River providing alternative habitat throughout the floodplain and high water levels in Lake Cowal inundating the Cane Grass beds and thus eliminating this area as suitable habitat for many species.

A number of avifauna species are noted as having geographical or breeding limits in the Lake Cowal region. Of the wading or wetland birds associated with the Lake itself or dependent on it, 10 species apparently either reach their known breeding or distributional limits at Lake Cowal. Amongst these are the endangered Freckled and Blue-billed Ducks, the Little Bittern, the Brolga (endangered in NSW), the Magpie Goose (endangered in NSW), and four wading species (Table 4).

TABLE 4 Avifauna species with geographical or breeding limits in the Lake Cowal Region.

(After Schrader 1990; Hatton 1991).
A - breeding habitat B - non-breeding habitat

COMMON NAME	SCIENTIFIC NAME	A	B
Ardeidae			
Little Bittern	*Ixobrychus minutus*		x
Anseranatidae			
Magpie Goose	*Anseranus semipalmata*		
Anatidae			
Freckled Duck	*Stictonetta naevosa*		
Pink-eared Duck	*Malacorhynchus membranaceus*	x	
Blue-billed Duck	*Oxyura naevosa*		x
Rallidae			
Banded Rail	*Rallus philippensis*	x	x
Black-tailed Native Hen	*Gallinula ventralis*	x	x
Gruidae			
Brolga	*Grus rubicundus*		x
Recurvirostridae			
Red-necked Avocet	*Recurvirostra novaehollandiae*	x	x
Banded Stilt	*Cladorhynchus leucocephalus*		x

Vestjens (1977) considered the use by waterbirds of the various habitats at Lake Cowal and noted the high value of the intermittently flooded shoreline areas around Lake Cowal, with 82 bird species having aquatic food from this habitat included in their stomachs and 56 bird species (including non-waterbirds) nesting in the area. The variety of microhabitat features along the intermittently flooded shoreline provide specific resources for a number of species. Shallow areas are used by herons, egrets and ibis for feeding, with larger birds feeding in deeper water. Rufous Night-herons feed in the shallow inundated areas at night. Other species which feed in shallow water include the ducks, swans, Black-tailed Native Hen, Purple Swamp Hen and Eurasian Coot, which feed on vegetation in shallow areas, and the Little Black and Little Pied Cormorants, which fish along the Lake edges and in shallow pools. Mud flats are used by a variety of wading species, and the small scattered patches of Lignum provide breeding locations for rallids. Crakes, rails and the Black-tailed Native

Hen and Eastern Swamp Hen feed in the muddy areas around and between Lignum, and plovers and dotterels nest on the ground above the area of inundation.

Hatton (1991) concludes (from Vestjens 1977) that the intermittently flooded shoreline areas are the most critical habitat feature for vertebrate species at Lake Cowal. Hatton notes that 128 avian species, from 45 families (including non-wetland species) utilise the intermittently flooded areas to meet some parts of their habitat or feeding requirements, although only 13 wetland birds rely entirely or substantially on this habitat for their primary requirements (Table 5).

TABLE 5 Bird species relying entirely or substantially upon intermittently flooded shore areas for habitat (after Vestjens 1977).

Rallidae	
Marsh Crake	*Porzana pusilla*
Rostratulidae	
Painted Snipe	*Rostratula benghalensis*
Charadriidae	
Masked Lapwing	*Vanellus miles*
Eastern Golden Plover	*Pluvialis dominica*
Red-kneed Dotterel	*Erythogonus cinctus*
Black-fronted Dotterel	*Charadrius melanops*
Recurvirostridae	
Pied Stilt	*Himanoptus himanoptus*
Red-necked Avocet	*Recurvirostra novaehollandiae*
Scolopacidae	
Greenshank	*Tringa nebularia*
Japanese Snipe	*Gallinago hardwickii*
Black-tailed Godwit	*Limosa limosa*
Sharp-tailed Sandpiper	*Calidris acuminata*
Red-necked Stint	*Calidris ruficollis*

In relation to food requirements, the shallow inundated areas provide a range of resources, including Ribbon Weed and Water Milfoil, which are important food resources for herbivorous birds, and which are also generally rich in invertebrates, plankton, molluscs, Mosquito Fish, Gold Fish and amphibians. Mud flat areas are rich in insect larvae and other arthropods, which provide significant food resources. Conversely, few avian species breed in the exposed shoreline areas, except those which use trees for nesting sites.

The Lignum/eucalypt habitat includes areas with relatively shallow water and dense patches of Lignum, and eucalypts which provide roosting resources. Forty-six wetland bird species were recorded in these habitats by Vestjens (1977), and the Australian Water Rat was also most common in this community. The shallow water and Lignum provide substantial resources for fish and macroinvertebrates, and provide the main feeding habitat for the Little Black and Little Pied Cormorants, grebes and many other waterfowl. The eucalypts are used as display sites and for roosting, as well as for breeding by many species, including the Darter, ibis, cormorants, spoonbills, herons and other waterfowl. Breeding birds which utilise the dense Lignum stands (in Habitats #2 and #4) included the ibis, spoonbills and sometimes the Little Pied Cormorant. Occasional excavated tanks with earthen banks provide roosting and breeding habitat for the Australian Pelican and some of the ducks.

Areas of shallow water in Lake Cowal with River Red Gums (Habitat #3) provide roosting and display sites for a number of waterbirds, and also nesting habitat for raptors, such as the Whistling Kite and White-bellied Sea-eagle. These areas are used extensively for feeding by ducks, swans and cormorants, as well as the Australian Pelican (where fish numbers are high).

The monotypic Cane Grass community, is utilised by a range of bird species for feeding, but few species breed in these environments. Only the Glossy Ibis and Painted Snipe are recorded as using the Cane Grass habitat as a primary feeding site, although a number of other species also feed in Cane Grass areas (Table 5). The Great-crested and Hoary-headed Grebes, Black Swan, Dusky Moorhen, Eurasian Coot, Whiskered and Gull-billed Terns, utilise Cane Grass communities for breeding. However, water levels are a critical feature for the Cane Grass habitat, as these sites are particularly susceptible to flooding or falling water levels.

Open deep water is principally used as a feeding location by cormorants, terns, the Darter and the Australian Pelican, all of which are fish-eating species. The only breeding activities in deep open water are associated with the scattered eucalypts which provide a safe breeding refuge for some species, particularly the Darter and the Little Black Cormorant. Open water is also used extensively by large congregations of waterfowl, particularly ducks, the Black Swan, Australian Pelican and Eurasian Coot.

In addition to the wetland and lake-dependent avifauna present at Lake Cowal, there is a considerable range of avian species which utilise some of the resources available at the Lake, or which use other habitats present in the area. These have been termed "*semi-waterbirds*" by Hatton (1991), and include species such as the Masked Lapwing, plovers, dotterels, gulls, terns, warblers and the Australian Pratincole. Apart from the warblers and Australian Pratincole, these species either breed in the immediate vicinity of Lake Cowal or in the general area, and are considered likely to be dependent on the Lake for some portion of their habitat requirements.

Another substantial range of avian species present in the region includes birds which appear to benefit from the presence of the Lake, but which do not depend directly on its existence for their survival. Included amongst this group of "*non-waterbirds*" are the raptors (of which a few nest in trees within Lake Cowal - the White-bellied Sea-eagle, Whistling Kite and Swamp Harrier), parrots and kingfishers (some of which also nest in the River Red Gums within the Lake), the robins, whistlers, fantails, fairy-wrens and grass-wrens, thornbills and their allies, honeyeaters and chats. Whilst many of these species doubtless benefit from the Lake, none are considered dependent upon it.

5 PISCEAN FAUNA

Lake Cowal is regarded as "*one of the most significant inland commercial fisheries in NSW, being one of the top 5 producers of fish for fourteen of the past twenty three years*" (Rankine & Hill 1980). Commercially important species which are collected from the Lake, include the Golden Perch and the introduced Redfin and European Carp. Commercial yields of these species, between 1956 and 1978, ranged from zero during dry years, to annual yields of 39618kg (1962-63), 17590kg (1975-76) and 5654kg (1976-77) for the 3 fish species respectively (Young 1979).

In some years, Silver Perch, Tench and Murray Cod also provide a portion of the commercial yield from the Lake. However, it is suggested that these species enter Lake Cowal with flood waters from the Lachlan River to the north (Young 1979), and the Lake does not provide suitable habitat to maintain breeding populations in contrast with the Golden Perch, Redfin and European Carp.

A number of other fish species have also been recorded from Lake Cowal, including native fish species (Australian Smelt, Freshwater Catfish, Big-headed and Western Carp Gudgeons) and several introduced species (Mosquito Fish, Goldfish, and Rainbow Trout).

Young (1979) surveyed three aquatic habitats at Lake Cowal for fish fauna. Golden Perch were least abundant in open water of moderate depth and in areas with Cane Grass and River Red Gums along the shoreline, and substantially more common in shallow areas with a combination of Lignum and Cane Grass, and in deeper water along the lower reaches of Bland Creek. The introduced Redfin, by comparison, was most abundant in open water with

Cane Grass, and to a lesser extent in shallow water with Lignum, Cane Grass and a large number of eucalypts. This species was least dense in the lower reaches of Bland Creek where water depth approached 3m or more. The European Carp was considerably more abundant in the most shallow areas, particularly where dense Lignum and Cane Grass provide appropriate food resources and feeding sites.

Variations in water levels in Lake Cowal, and associated changes in the diversity in abundance of invertebrate fauna, are considered by Young (1979), as being of particular relevance to the most abundant fish species in the Lake. The Redfin and Golden Perch rely on smaller fish for a substantial proportion of their diet at Lake Cowal (Young 1979), whereas elsewhere these species generally prefer crustaceans. Young (1979) indicates that the restricted diet of these fish species is related to a limited array of available food resources in Lake Cowal. Conversely, these species display high growth rates in Lake Cowal, equalling or exceeding those recorded at other locations or which have been achieved under artificial conditions. Young (1991) concludes that Lake Cowal provides a particularly suitable and valuable fish habitat for freshwater species in inland NSW.

Young (1979) also notes that the effects of fluctuating water levels at Lake Cowal are also of particular relevance for fish numbers and fish breeding. Golden Perch spawn under the stimulation of rising water levels and specific water temperatures, whilst Redfin and European Carp, which only require certain water temperatures for spawning, will readily breed provided there is sufficient water in the Lake.

6 INVERTEBRATE FAUNA

As a result of the fluctuations in water level at Lake Cowal, invertebrate fauna populations are dynamic, with different groups dominating in the various habitats and under the variety of climatic circumstances. It is in part this variation in the diversity and abundance of invertebrate fauna, which supports the substantial water bird populations at Lake Cowal. Crome (1988) notes that freshwater basins which are permanently full become dominated by Ribbon Weed, fish and fast swimming insect fauna, thus reducing the diversity of food resources for wetland birds.

The Kirra Environmental Group conducted a survey of invertebrate communities at Lake Cowal for the Department of Water Resources (DWR 1991), sampling five different aquatic habitats (Open Water, Lignum, Lignum/Eucalypt, River Red Gum and Cane Grass communities), and recording benthic invertebrates and those on macrophytes and other aquatic vegetation. A total of 24 taxa of invertebrate fauna where recorded during the Kirra study. Of note was the low diversity of invertebrates in the Lake sediments and the significantly higher abundances and diversities on macrophyte vegetation communities. Lignum communities supported the greatest diversity and abundance of invertebrate fauna, whilst open water with River Red Gums supported low species abundances and diversities. Cane Grass communities provided resources for a relatively high diversity of invertebrate fauna, but supported only low densities. The Kirra study indicated that chironomids were the dominant invertebrate taxon, followed by crustaceans and other insect larvae.

As noted, the Lake sediment supports a relatively low diversity and abundance of invertebrate macrofauna. Hawking (1991) reported mainly oligochaete and chironomid species in the sediment, with greater species diversity and abundance in shallow areas than in deeper locations. Maher and Carpenter (1984) recorded high species diversities in the mud substrate of other Lachlan River water bodies, and suggests a range of possible reasons for the low diversity at Lake Cowal. However, Timms (1980) notes that Australian lakes, with few exceptions, are generally depauperate. Maher and Carpenter (1984) suggest that the dramatic changes which occur in Lake Cowal water levels may account for the low abundance in the lake sediment. Sweep net samples also displayed a greater diversity and abundance of macroinvertebrates and of Mosquito Fish and the Australian Smelt in shallow waters.

The diversities and abundances of macroinvertebrate species are greater in vegetated areas of the Lake (DWR 1991; Maher & Carpenter 1984), than in Open Water areas. This observation is likely based on the availability of a range of refugia and of food and other resources for invertebrates in the densely vegetated areas, particularly where Lignum is present. Maher and Carpenter (1984) noted that areas dominated by Lignum supported higher abundances than those dominated either by River Red Gums or in mixed River Red Gum/Lignum areas. Cane Grass communities supported even lower macroinvertebrate populations, due to the finer structure and smaller surface area of Cane Grass, and to easier access for predatory waterbirds (Maher & Carpenter 1984).

Further details of the terrestrial fauna of Lake Cowal are included in Appendix E of the EIS.

7 OTHER VERTEBRATE FAUNA

In contrast to the waterbird fauna, few representatives of the other native vertebrate fauna (excluding piscean fauna which are not considered in this FIS) depend on the habitats present within or immediately adjacent to Lake Cowal. Only 1 mammal, 1 reptile and the amphibian species recorded in the vicinity of Lake Cowal are dependent upon aquatic habitats, and whilst reliant on aquatic habitats, are not restricted to the Lake itself.

Of the 18 species of mammals which have been recorded at Lake Cowal by Vestjens (1977) and Schrader (1990), only one (the Australian Water Rat *Hydromys chrysogaster*) relies on the aquatic environment for its habitat and resource needs. This species appears common in Lake Cowal and uses a range of habitats for food resources, feeding on crustaceans, insects, fish and occasionally birds, and bird eggs. The Australian Water Rat was commonly sighted in shallow water areas with large River Red Gums, and is likely to nest in the trees. None of the other mammal species recorded are likely to be dependent on the presence of Lake Cowal for their survival in the area. No endangered mammal species are known from Lake Cowal itself, although a few microchiropteran bats included on Schedule 12 of the NP&W Act may be present. However, these species are not likely to rely on the Lake for their continued survival in the area.

Eleven species of amphibians (Table 6) have been recorded at and around Lake Cowal (Vestjens 1977; Schrader 1990; Appendix B1 of the FIS). Most of these occur along the shoreline of Lake Cowal and are present in areas which are intermittently flooded, particularly where grasses are present and abundant. The Tree-frogs *Litoria caerulea* and *L peronii* are widespread species and have been recorded by Vestjens (1977) along the shoreline of Lake Cowal, as well as in areas of shallow water with River Red Gums and Lignum.

TABLE 6 Amphibian species recorded in the six main habitats at Lake Cowal (Appendix B1 of the FIS; Schrader 1990; Vestjens 1977).

COMMON NAME	SCIENTIFIC NAME	HABITAT
Myobatrachidae		
	Crinia parinsignifera	A
Sloane's Froglet	*Crinia sloanei*	1
Giant Banjo Frog	*Limnodynastes interioris*	A 1
Fletcher's Frog	*Limnodynastes fletcheri*	A 1
Salmon-striped Frog	*Limnodynastes salmini*	A 1
Spotted Grass Frog	*Limnodynastes tasmaniensis*	A 1
	Neobatrachus pictus	A 1
Crucifix Frog	*Notaden bennettii*	A
Red-groined Froglet	*Uperoleia rugosa*	A 1
Hylidae		
Green Tree-frog	*Litoria caerulea*	A 1 2 3 4
Peron's Tree-frog	*Litoria peronii*	A 1 2 3 4

Vestjens (1977) noted the presence of 30 species of reptiles from the Lake Cowal area. All but one of these are predominantly terrestrial species, although some (such as the Carpet Python, Eastern Tiger Snake, Spotted Black Snake and Eastern Brown Snake) will utilise shallow flooded areas for foraging. The Lace Monitor is an adaptable species which has been recorded in the Lake and on trees some distance from the shore.

The only reptile species known from Lake Cowal which is specifically dependent on aquatic habitats is the Eastern Long-necked Tortoise. This species requires aquatic habitats for its survival and breeding, and has been recorded throughout Lake Cowal. No endangered reptile species have been recorded in the vicinity of Lake Cowal (Vestjens 1977; Fanning 1995b), and none are considered likely to depend on the Lake or its shoreline habitats for survival.

8 AVIFAUNA OF THE MINE AREA

The proposed mining operation by North Ltd at Lake Cowal involves the excavation of an open pit for the extraction of gold and copper ore. The resource body and the pit to access it are located on the southwestern shore of Lake Cowal (see Figure 1 of the FIS), straddling the shoreline and the Lake (when full). It is proposed to surround the pit with a bund extending into the Lake for a distance of approximately 1.1km and with a north-south dimension of approximately 1.4km. The bund will prevent any exchange of water between the Lake and the pit. Ancillary facilities and associated features of the proposed mining operation will be located on the Lake shore. A waste-rock emplacement (up to 25m in height) is proposed immediately west of the open pit. To the south of the waste-rock emplacement will be the treatment plant for the extracted ore, and two tailings storages will be located to the west of the proposed plant site. The proposed operation will involve the removal of waste-rock and over burden in the area of the pit following construction of the bund wall to prevent lake water entering the works area. The overburden and waste-rock will form the major part of the waste-rock emplacement, with subsequent material being treated at the plant and deposited in the tailings storages.

With respect to the fauna habitats of Lake Cowal, a small proportion of 3 habitats will be affected by the proposed mining operation. Approximately 1km of the Lake shoreline and a relatively small proportion of the Cane Grass and Open Water environments will be disturbed by the proposed bund wall and open cut pit. However, the proportion of each of the habitats which will be directly impacted by the construction of the bund and pit does not appear significant (see Figure 1 of the FIS). Whilst there is some potential for indirect impacts on adjacent habitats, no additional habitats are involved.

As indicated in Table 7, a substantial proportion of the waterbirds and lake-dependent species at Lake Cowal utilise the shoreline vegetation communities as principal or a significant element in their feeding habitat. On the waterbird survey transect, in the area of the proposed mining operation, NSR (1994) recorded 46 waterbird species (Table 7), of which only 6 (Australian Pelican, Little Black Cormorant, White-faced Heron, Sacred Ibis, Grey Teal and Pacific Black Duck) were regarded as residents (Table 7). Only one waterbird species, the Grey Teal, has been recorded as breeding in the immediate area of the mine site. Conversely, Hatton (1991) notes a number of bird species which rely entirely upon intermittently flooded shoreline areas for their habitat. Most of these are small wadingbirds, which feed along the shoreline and which nest and breed either in shoreline vegetation or in the scattered Lignum clumps (the Marsh Crake, Painted Snipe, Pied Stilt, Red-necked Avocet, plovers, dotterels and sand pipers).

NSR (1994) notes that shoreline areas tend to support a wide range of microhabitat features, and ephemeral intermittently flooded areas have a higher biological productivity than locations which have been submerged for long periods (Crome 1988). Lane (1989) notes that the "*shore of the lake may be waterbirds most important feeding habitat*", whilst also noting that few species are restricted to this type of environment. During the field surveys conducted for this investigation, only common species were recorded along the shoreline or in the shallow inundated areas and Cane Grass community associated with the proposed mine site. Species commonly sighted included the Eastern Swamphen, Eurasian Coot, Grey Teal, Pacific Black Duck, Australian Pelican, and a few herons and egrets. Given the open nature of the environment in this vicinity, it is considered unlikely that many species would breed here, even without the disturbance caused by exploration activities.

TABLE 7 Records of birds specifically associated with lake habitats at Lake Cowal, including information from this study and from previous investigations.

COMMON NAME	SCIENTIFIC NAME		BREEDING HABITAT	FEEDING HABITAT
Podicipedidae				
Great Crested Grebe	*Podiceps cristatus*	●	1,2,4,5	1,2,3,4,6
Hoary-headed Grebe	*Poliocephalus poliocephalus*	●	1,2,4,5	2
Australasian Grebe	*Tachybaptus novaehollandiae*	●	1,2,4,5,earth tanks	2
Pelecanidae				
Australian Pelican	*Pelecanus conspicillatus*	●	4,earth tanks	3,4
Anhingidae				
Darter	*Anhinga melanogaster*	●	3,2	3,4,6
Phalacrocoraidae				
Great Cormorant	*Phalacrocorax carbo*	●	2,3	3,4,6
Pied Cormorant	*Phalacrocorax varius*	●	2,3	
Little Black Cormorant	*Phalacrocorax sulcirostris*	●	2,3	2,1
Little Pied Cormorant	*Phalacrocorax melanoleucos*	●	2,3,4	2,1
Ardeidae				
Pacific Heron	*Ardea pacifica*	●	1,2,3	1
White-faced Heron	*Ardea novaehollandiae*	●	1,2,3	1
Pied Heron	*Ardea picata*		non-breeding visitor	
Cattle Egret	*Ardeola ibis*		non-breeding visitor	
Great Egret	*Egretta alba*	●	2,3	1
Little Egret	*Egretta garzetta*		2,4	1
Intermediate Egret	*Egretta intermedia*	●	2,3,4	1
Rufous Night Heron	*Nycticorax caledonicus*	●	1,2,3,4	1
Little Bittern	*Ixobrychus minutus*		Unknown	4
★ Australasian Bittern	*Botaurus poiciloptilus*		Unknown	1,2
Threskiornithidae				
Glossy Ibis	*Plegadis falcinellus*	●	2,4	1,5
Sacred Ibis	*Threskiornis aethiopica*	●	2,4	1
Straw-necked Ibis	*Threskiornis spinicollis*	●	2,4	1
Royal Spoonbill	*Platalea regia*	●	2,3,4	1
Yellow-billed Spoonbill	*Platalea flavipes*	●	1,2,3	1
Anseranatidae				
★Magpie Goose	*Anseranas semipalmata*		4	1,2
Anatidae				
Wandering Whistling-Duck	*Dendrocygna arcuata*		4	1,2
Plumed Whistling-Duck	*Dendrocygna eytoni*		1	1,2
Black Swan	*Cygnus atratus*	●	1,2,4,5,earth tanks	1,2
★Freckled Duck	*Stictonetta naevosa*	●	4	1,2
Australian Shelduck	*Tadorna tadornoides*	●	1,2,3,4	1,2
Pacific Black Duck	*Anas superciliosa*	●	1,2,3,4	1,2
Grey Teal	*Anas gibberifrons*	●	1,2,3,4	1,2
Chestnut Teal	*Anas castanea*		Unknown	1,2
Australasian Shoveler	*Anas rhynchotis*	●	Unknown	1,2
Pink-eared Duck	*Malacorhynchus membranaceus*	●	1,2,3	1,2
Hardhead	*Aythya australis*	●	2,3,4	1,2
Maned Duck	*Chenonetta jubata*	●	1,2,3	1,2
★Blue-billed Duck	*Oxyura australis*		2,4	1,2
Musk Duck	*Biziura lobata*	●	2,4	1,2
Accipitridae				
★Osprey	*Pandion haliaetus*			3,6
Whistling Kite	*Haliastur sphenurus*		2,3	
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		3	3,6
Marsh Harrier	*Circus aeruginosus*		Unknown	1,2,3,6
Rallidae				
Buff-banded Rail	*Rallus philippensis*		Unknown	
Baillon's Crake	*Porzana pusilla*		Unknown	
Australian Crake	*Porzana fluminea*		2,4	1,4
Spotless Crake	*Porzana tabuensis*		Unknown	
Black-tailed Native-hen	*Gallinula ventralis*	●	Unknown	1
Dusky Moorhen	*Gallinula tenebrosa*		2,4,5	1
Purple Swamphen	*Porphyrio porphyrio*	●	2,4	1
Eurasian Coot	*Fulica atra*	●	1,2,4,5	1
Gruidae				
★ Brolga	*Grus rubicundus*		non-breeding visitor	

TABLE 7 contd Records of birds specifically associated with lake habitats at Lake Cowal, including information from this study and from previous investigations.

COMMON NAME	SCIENTIFIC NAME		BREEDING HABITAT	FEEDING HABITAT
Rostratulidae				
★ Painted Snipe	*Rostratula benghalensis*		Unknown	5
Charadriidae				
Masked Lapwing	*Vanellus miles*	●	1,5	1
Banded Lapwing	*Vanellus tricolor*	●	Unknown	1
Lesser Golden Plover	*Pluvialis dominica*		Unknown	1
Red-kneed Dotterel	*Erythrogonys cinctus*		1,2,4,5	1
Red-capped Plover	*Charadrius ruficapillus*	●	1	1
Black-fronted Plover	*Charadius melanops*	●	Unknown	1
Recurvirostridae				
Black-winged Stilt	*Himantopus himantopus*	●	1,5	1
Red-necked Avocet	*Recurvirostra novaehollandiae*	●	Unknown	1
Scolopacidae				
Ruddy Turnstone	*Arenaria interpres*		Unknown	1
Greenshank	*Tringa nebularia*	●	non-breeding visitor	1
Marsh Sandpiper	*Tringa stagnatilis*	●	Unknown	1
Latham's Snipe	*Gallinago hardwickii*		non-breeding visitor	1
★ Black-tailed Godwit	*Limosa limosa*		non-breeding visitor	1
Bar-tailed Godwit	*Limosa lapponica*		non-breeding visitor	1
Sharp-tailed Sandpiper	*Calidris acuminata*	●	non-breeding visitor	1
Pectoral Sandpiper	*Calidris melanotos*	●	Unknown	1
Red-necked Stint	*Calidris ruficollis*		Unknown	1
Glareolidae				
Australian Pratincole	*Stiltia isabella*		Unknown	1
Laridae				
Silver Gull	*Larus novaehollandiae*	●	3	1,6
*Franklin's Gull	*Larus pipixcan*	●	vagrant	
Whiskered Tern	*Chlidonias hybrida*	●	5	6
Gull-billed Tern	*Gelochelidon nilotica*	●	5, earth tanks	6
Caspian Tern	*Hydroprogne caspia*	●	non-breeding visitor	
Sylviidae				
Clamorous Reed-Warbler	*Acrocephalus stentoreus*		1,2,4	1,2,4
Little Grassbird	*Megalurus gramineus*		1,2,4	1,2,4
Golden-headed Cisticola	*Cisticola exilis*		Unknown	2

Unknown = breeding habitat unknown
★ Schedule 12 species (NP&W Act 1974, as amended 1992).
* Franklin's Gull is an accidental visitor to Australia (Blakers *et al* 1984).
● recorded on the proposed mine area for the Lake Cowal Gold Project during waterbird surveys from 1989 to 1995.

FAUNA HABITAT CODES

HABITAT #1 Shoreline - areas intermittently flooded
HABITAT #2 Shallow water with Lignum River Red Gums
HABITAT #3 Shallow water with River Red Gums
HABITAT #4 Shallow water with Lignum bushes
HABITAT #5 Shallow water with Cane Grass
HABITAT #6 Open and deep water

SOURCES

Dent BR. 1990. *Personal observations on the breeding of waterbirds at Lake Cowal 1964-1990.*

Environmental & Educational Services 1989-1994. *Lake Cowal Waterbird monitoring survey: Progress Reports.* Prepared for NSR Environmental Consultants P/L and Geopeko Operations Ltd.

Hatton PJ. 1991. *Draft Water Management Plan for the Wilbertroy/Cowal Wetlands.* Dept of Water Resources.

Lane BR. 1990. *West Wyalong Prospect: Waterbird investigation data report.* Prepared for NSR Consultants .

Lawler W. 1989. Waterbird breeding at Lake Cowal, New South Wales. *Australian Birds.* **23** (2): 32-35.

Vestjens WJM. 1977. *Status, habitats and food of vertebrates at Lake Cowal, NSW.* CSIRO Division of Wildlife Research Technical Memorandum No.12, Canberra.

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 6

FAUNA LIST FOR LAKE COWAL

GUNNINAH CONSULTANTS
22 Clarke St Crows Nest NSW 2065
ph: 02 - 9906 5436 fax: 02 - 9906 7770 mobile: 018 - 020 429

APPENDIX 6 Fauna species recorded from the Lake Cowal area during this and previous investigations, and from relevant databases.

COMMON NAME	SCIENTIFIC NAME	THIS STUDY	SOURCE
BIRDS			
Casuariidae			
Emu	*Dromaius novaehollandiae*	●	B,C,D,E,H
Podicipedidae			
Great Crested Grebe	*Podiceps cristatus*		B,D,F,G,H,I,J,K,L
Hoary-headed Grebe	*Poliocephalus poliocephalus*		B,C,D,E,F,G,H,I,J,K,L
Australasian Grebe	*Tachybaptus novaehollandiae*	●	B,C,D,E,F,G,H,I,J,K,L
Pelecanoidae			
Australian Pelican	*Pelecanus conspicillatus*	●	B,C,D,F,G,H,I,J,K,L
Anhingidae			
Darter	*Anhinga melanogaster*	●	B,D,E,F,H,I,J,K,L
Phalacrocoraidae			
Great Cormorant	*Phalacrocorax carbo*	●	B,C,E,F,G,H,I,J,K,L
Pied Cormorant	*Phalacrocorax varius*	●	B,C,E,F,G,H,I,J
Little Black Cormorant	*Phalacrocorax sulcirostris*	●	B,C,E,F,G,H,I,J,K,L
Little Pied Cormorant	*Phalacrocorax melanoleucos*	●	B,C,E,F,G,H,I,J,K,L
Ardeidae			
Pacific Heron	*Ardea pacifica*		B,C,E,F,G,H,I,J,L
White-faced Heron	*Ardea novaehollandiae*	●	B,D,E,F,G,H,I,J,L
Pied Heron	*Ardea picata*		H
Cattle Egret	*Ardeola ibis*	●	F,G,H
Great Egret	*Egretta alba*	●	B,DE,F,G,H,I,J,K,L
Little Egret	*Egretta garzetta*	●	B,E,F,G,H,I,J,L
Intermediate Egret	*Egretta intermedia*	●	B,D,E,F,G,H,I,J,L
Rufous Night Heron	*Nycticorax caledonicus*	●	B,D,E,F,G,H,I,J,K,L
Little Bittern	*Ixobrychus minutus*		H
★Australasian Bittern	*Botaurus poiciloptilus*		H,I
Threskiornithidae			
Glossy Ibis	*Plegadis falcinellus*		B,D,E,F,G,H,I,J,K,L
Sacred Ibis	*Threskiornis aethiopica*	●	B,E,F,G,H,I,J,K,L
Straw-necked Ibis	*Threskiornis spinicollis*	●	B,D,E,F,G,H,I,J,K,L
Royal Spoonbill	*Platalea regia*	●	B,D,E,F,G,H,I,J,K,L
Yellow-billed Spoonbill	*Platalea flavipes*	●	B,C,D,E,F,G,H,I,J,L
Anseranatidae			
★Magpie Goose	*Anseranas semipalmata*		B,D,F,G,H,K
Anatidae			
Wandering Whistling-Duck	*Dendrocygna arcuata*		B,F,K
Plumed Whistling-Duck	*Dendrocygna eytoni*		B,D,G,H,L
Black Swan	*Cygnus atratus*	●	B,D,E,F,G,H,I,J,K
★Freckled Duck	*Stictonetta naevosa*		B,D,E,F,G,H,I,J,K,L
Australian Shelduck	*Tadorna tadornoides*	●	B,D,E,F,G,H,I,J,L
Pacific Black Duck	*Anas superciliosa*	●	B,D,E,F,G,H,I,J,K,L
Grey Teal	*Anas gibberifrons*	●	B,D,E,F,G,H,I,J,K,L
Chestnut Teal	*Anas castanea*		B,D,E,F,G,H,I,J
Australasian Shoveler	*Anas rhynchotis*		B,D,E,F,G,H,I,J,L
Pink-eared Duck	*Malacorhynchus membranaceus*		B,D,E,F,G,H,I,J,L
Hardhead	*Aythya australis*		B,D,E,F,G,H,I,J,K,L
Maned Duck	*Chenonetta jubata*	●	B,C,D,E,F,G,H,I,J,L
★Blue-billed Duck	*Oxyura australis*		B,D,E,F,G,H,I,J,K
Musk Duck	*Biziura lobata*		B,E,F,G,H,I,J,L
Accipitridae			
★Osprey	*Pandion haliaetus*		B,D,E,J
Black-shouldered Kite	*Elanus notatus*	●	B,E,H,J
Square-tailed Kite	*Lophoictinia isura*		D
Letter-winged Kite	*Elanus scriptus*		H
Black Kite	*Milvus migrans*		B,H
★Black-breasted Buzzard	*Hamirostra melanosternon*		B,D,E,J
Whistling Kite	*Haliastur sphenurus*	●	B,D,E,G,H,I,J,L
Brown Goshawk	*Accipiter fasciatus*		B,E,H,J,L
Collared Sparrowhawk	*Accipiter cirrhocephalus*		H
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		B,E,F,G,H,J
Wedge-tailed Eagle	*Aquila audax*	✤	B,C,D,E,H,J,L
Little Eagle	*Hieraaetus morphnoides*		B,E,H,J
Spotted Harrier	*Circus assimilis*		B,H

APPENDIX 6 contd Fauna species recorded from the Lake Cowal area (from all sources).

COMMON NAME	SCIENTIFIC NAME	THIS STUDY	SOURCE
Accipitridae contd			
Marsh Harrier	*Circus aeruginosus*	●	B,D,E,G,H,I,J
Falconidae			
Black Falcon	*Falco subniger*		H
Peregrine Falcon	*Falco peregrinus*	●	B,D,H
Little Falcon	*Falco longipennis*	●	B,C,D,E,H,J,L
Brown Falcon	*Falco berigora*	●	B,C,D,E,H,J,L
Australian Kestrel	*Falco cenchroides*	●	B,C,E,H,J,L
Phasianidae			
Stubble Quail	*Coturnix novaezealandiae*	●	B,E,H,J
Brown Quail	*Coturnix australis*	●	B,E,G,J
Rallidae			
Buff-banded Rail	*Rallus philippensis*		H
Baillon's Crake	*Porzana pusilla*		B,D,H
Australian Crake	*Porzana fluminea*	●	B,E,G,H,J,L
Spotless Crake	*Porzana tabeunsis*		H
Black-tailed Native-hen	*Gallinula ventralis*		B,D,E,F,G,H,I,J,L
Dusky Moorhen	*Gallinula tenebrosa*		B,D,E,F,G,H,I,J,L
Purple Swamphen	*Porphyrio porphyrio*	●	B,D,E,F,G,H,I,J,L
Eurasian Coot	*Fulica atra*	●	B,D,E,F,G,H,I,J,K,L
Gruidae			
★Brolga	*Grus rubicundus*		B,D,F,G,H,I
Rostratulidae			
★Painted Snipe	*Rostratula benghalensis*		B,G,H,L
Charadriidae			
Masked Lapwing	*Vanellus miles*		B,D,E,F,G,H,I,J,L
Banded Lapwing	*Vanellus tricolor*		B,F,G,H,I
Lesser Golden Plover	*Pluvialis dominica*		H
Red-kneed Dotterel	*Erythrogonys cinctus*		B,E,F,G,H,I,J,L
Red-capped Plover	*Charadrius ruficapillus*		B,G,H,I
Black-fronted Plover	*Charadius melanops*		B,E,G,H,I,J,L
Recurvirostridae			
Black-winged Stilt	*Himantopus himantopus*		B,D,F,G,H,I,J,L
Red-necked Avocet	*Recurvirostra novaehollandiae*		B,E,F,G,H,I,J
Scolopacidae			
Ruddy Turnstone	*Arenaria interpres*		G
Greenshank	*Tringa nebularia*		B,F,H,I
Marsh Sandpiper	*Tringa stagnatilis*		F,I
Latham's Snipe	*Gallinago hardwickii*		B,E,G,H,I,J
★Black-tailed Godwit	*Limosa limosa*		B,H
Bar-tailed Godwit	*Limosa lapponica*		H
Sharp-tailed Sandpiper	*Calidris acuminata*		B,F,G,H,I
Pectoral Sandpiper	*Calidris melanotos*		I
Red-necked Stint	*Calidris ruficollis*		H,I
Glareolidae			
Australian Pratincole	*Stiltia isabella*		G,H
Laridae			
Silver Gull	*Larus novaehollandiae*	●	B,D,E,F,G,H,I,J,L
*Franklin's Gull	*Larus pipixcan*		I
Whiskered Tern	*Chlidonias hybrida*		B,D,E,F,G,H,I,J,L
Gull-billed Tern	*Gelochelidon nilotica*		B,E,F,G,H,I,J,L
Caspian Tern	*Hydroprogne caspia*		B,G,H,I
Columbidae			
Feral Pigeon	*Columba livia*		B,H
Peaceful Dove	*Geopelia placida*	✤	B,C,D,E,H,J
Diamond Dove	*Geopelia cuneata*		B,H
Bar-shouldered Dove	*Geopelia humeralis*		D
Common Bronzewing	*Phaps chalcoptera*	●	B,C,E,H,J
Crested Pigeon	*Ocyphaps lophotes*	●	B,C,D,E,H,J,L
Cacatuidae			
Galah	*Cacatua roseicapilla*	●	B,C,D,E,F,H,J,L
★Pink Cockatoo	*Cacatua leadbeateri*		B,D

APPENDIX 6 contd Fauna species recorded from the Lake Cowal area (from all sources).

COMMON NAME	SCIENTIFIC NAME	THIS STUDY	SOURCE
Cacatuidae contd			
Sulphur-crested Cockatoo	*Cacatua galerita*		H
Psittacidae			
★Superb Parrot	*Polytelis swainsonii*		B,E,J
Cockatiel	*Nymphicus hollandicus*	●	B,C,D,E,F,H,J,L
Budgerigar	*Melopsittacus undulatus*		B,D,H,L
Eastern Rosella	*Platycercus eximius*	●	B,D,E,J
Mallee Ringneck	*Barnardius barnardi*	●	B,C,E,H,J
Red-rumped Parrot	*Psephotus haematonotus*	●	B,C,E,F,H,J,L
Mulga Parrot	*Psephotus varius*		E,H,J
Blue Bonnet	*Northiella haematogaster*		B,C,E,H,J,L
★Turquoise Parrot	*Neophema pulchella*		D
Cuculidae			
Pallid Cuckoo	*Cucluus pallidus*	●	B,C,H
Fan-tailed Cuckoo	*Cuculus pyrrhophanus*		H
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		E,J
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		E,H
Gould's Bronze-Cuckoo	*Chrysococcyx russatus*		B
Strigidae			
Southern Boobook	*Ninox noveseelandiae*	●	B,E,F,H,J
Barking Owl	*Ninox connivens*		H
Tytonidae			
Barn Owl	*Tyto alba*		B,D,E,H,J
Podargidae			
Tawny Frogmouth	*Podargus strigoides*	●	H,L
Aegothelidae			
Australian Owlet-nightjar	*Aegotheles cristatus*	●	H
Apodidae			
Fork-tailed Swift	*Apus pacificus*		H
Halcyonidae			
Kookaburra	*Dacelo novaeguineae*	●	B,C,D,E,H,J,L
Red-backed Kingfisher	*Halcyon pyrrhopygia*		B,E,G
Sacred Kingfisher	*Halcyon sancta*		B,D,E,F,G,H,J,L
Meropidae			
Rainbow Bee-eater	*Merops ornatus*		B,D,E,H,J,L
Coraciidae			
Dollarbird	*Eurystomus orientalis*		B,H
Alaudidae			
Singing Bushlark	*Mirafra javanica*		B,H
Hirundinidae			
Welcome Swallow	*Hirundo neoxena*	●	B,E,H,J
Tree Martin	*Cecropis nigricans*	●	B,C,E,H,J,L
Fairy Martin	*Cecropis ariel*		B,E,H,J
Motacillidae			
Richard's Pipit	*Anthus novaeseelandiae*		B,E,H,J
Campephagidae			
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	●	B,C,D,E,H,J,L
Ground Cuckoo-Shrike	*Coracina maxima*		B,C,E,H,J
White-winged Triller	*Lalage sueurii*		B,E,H,J
Muscicapidae			
Blackbird	*Turdus merula*		B
Petroicidae			
Red-capped Robin	*Petroica goodenovii*	●	B,C,D,E,H,J,L
Eastern Yellow Robin	*Eopsaltria australis*	✣	B,C,D,E,J
Jacky Winter	*Microeca leucophaea*	✣	B,C,E,J
Pachycephalidae			
Crested Shrike-tit	*Falcunculus frontatus*		H

APPENDIX 6 contd Fauna species recorded from the Lake Cowal area (from all sources).

COMMON NAME	SCIENTIFIC NAME	THIS STUDY	SOURCE
Pachycephalidae contd			
★Gilbert's Whistler	*Pachycephala inornata*	✣	
Golden Whistler	*Pachycephala pectoralis*		B,C,D,H
Rufous Whistler	*Pachycephala rufiventris*	●	B,C,D,E,H,J,L
Grey Shrike-thrush	*Colluricincla harmonica*	●	B,C,D,E,J
Dicruridae			
Satin Flycatcher	*Myiagra cyanoleuca*		H
Restless Flycatcher	*Myiagra inquieta*	●	B,C,H,L
Rufous Fantail	*Rhipidura rufifrons*		B
Grey Fantail	*Rhipidura fuliginosa*	●	B,C,D,E,H,J
Willie Wagtail	*Rhipidura leucophrys*	●	B,C,D,E,H,J,L
Pomatostomidae			
Grey-crowned Babbler	*Pomatostomus temporalis*	●	B,C,E,H,J
White-browed Babbler	*Pomatostomus superciliosus*		B,E,J
Sylviidae			
Clamorous Reed-Warbler	*Acrocephalus stentoreus*		B,E,H,I,J,L
Little Grassbird	*Megalurus gramineus*		B,E,H,I,J,L
Golden-headed Cisticola	*Cisticola exilis*		B,E,H,J,L
Rufous Songlark	*Cinclorhamphus mathewsi*	●	B,E,H,J
Brown Songlark	*Cinclorhamphus cruralis*		B,C,E,H,J
Maluridae			
Variegated Fairy-wren	*Malurus lamberti*	●	B,C,E,H,J,L
White-winged Fairy-wren	*Malurus leucopterus*		H
Pardalotidae			
Speckled Warbler	*Sericornis sagittatus*		B,E,J
Weebill	*Smicrornis brevirostris*		B,C,D,E,H,J
Western Warbler	*Gerygone fusca*	✣	B,D,E,H,J
Inland Thornbill	*Acanthiza apicalis*	●	B,D,E,J
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	✣	B,C,D,E,H,J,L
Buff-rumped Thornbill	*Acanthiza reguloides*		B,E,J
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	●	B,C,E,H,J,L
Yellow Thornbill	*Acanthiza nana*	●	B,C,E,H,J
Southern Whiteface	*Aphelocephala leucopsis*		B,C,D,E,H,J,L
Spotted Pardalote	*Pardalotus punctatus*		E,J
Yellow-rumped Pardalote	*Pardalotus xanthopygus*		C
Striated Pardalote	*Pardalotus striatus*	●	B,C,E,H,J
Neosittidae			
Varied Sittella	*Daphoenositta chrysoptera*	✣	B,D,E,J
Climacteridae			
White-throated Treecreeper	*Climacteris leucophaea*		B,D,E,J
Brown Treecreeper	*Climacteris picumnus*	✣	B,C,D,E,H,J
Meliphagidae			
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	●	B,C,D,E,H,J
Striped Honeyeater	*Plectorhyncha lanceolata*	●	B,C,E,H,J
Noisy Friarbird	*Philemon corniculatus*		B,H
Little Friarbird	*Philemon citreogularis*	●	B,E,H,J,L
Blue-faced Honeyeater	*Entomyzon cyanotis*	●	B,E,H,J
Noisy Miner	*Manorina melanocephala*	●	B,C,D,E,H,J,L
Yellow-throated Miner	*Manorina flavigula*	●	H
Singing Honeyeater	*Lichenostomus virescens*	●	C,D,E,H,J
Varied Honeyeater	*Lichenostomus versicolor*		B
White-eared Honeyeater	*Lichenostomus leucotis*	✣	B,E,J
Yellow-throated Honeyeater	*Lichenostomus flavicollis*		B,C
White-plumed Honeyeater	*Lichenostomus penicillatus*	●	B,C,E,F,H,J,L
Brown-headed Honeyeater	*Melithreptus brevirostris*	✣	B,C,D,E,J
★Painted Honeyeater	*Grantiella picta*		B,D,E,H,J
Orange Chat	*Ephthianura aurifrons*		B
White-fronted Chat	*Ephthianura albifrons*		B,E,H,J,L
Dicaeidae			
Mistletoebird	*Dicaeum hirundinaceum*	●	B,C,E,H,J
Zosteropidae			
Silvereye	*Zosterops lateralis*		B,H

APPENDIX 6 contd Fauna species recorded from the Lake Cowal area (from all sources).

COMMON NAME	SCIENTIFIC NAME	THIS STUDY	SOURCE
Fringillidae			
European Goldfinch	*Gardeulis carduelis*		B
Passeridae			
House Sparrow	*Passer domesticus*	●	B,E,H,J
Diamond Firetail	*Emblema guttata*		B,E,J
Zebra Finch	*Poephila guttata*	●	B,C,H,L
Double-barred Finch	*Poephila bichenovii*		B,C,D,E,J
Sturnidae			
Common Starling	*Sturnus vulgaris*	●	B,C,D,E,F,H,J,L
Oriolidae			
Olive-backed Oriole	*Oriolus sagittatus*		B,E,J
Corcoracidae			
White-winged Chough	*Corcorax melanorhamphos*	●	B,C,D,E,H,J,L
Apostlebird	*Struthidea cinerea*	●	B,C,D,E,H,J
Artamidae			
Australian Magpie-lark	*Grallina cyanoleuca*	●	B,C,D,E,F,H,J,L
White-breasted Woodswallow	*Artamus leucorhynchus*		B,D,H,I
Masked Woodswallow	*Artamus personatus*		B,H
White-browed Woodswallow	*Artamus superciliosus*		B,C,D,E,H,J
Black-faced Woodswallow	*Artamus cinereus*		B,C,H
Dusky Woodswallow	*Artamus cyanopterus*		B,E,H,J
Grey Butcherbird	*Cracticus torquatus*	●	B,C,D,E,H,J
Pied Butcherbird	*Cracticus nigrogularis*	●	B,C,E,H,J
Australian Magpie	*Gymnorhina tibicen*	●	B,C,D,E,H,J,L
Corvidae			
Australian Raven	*Corvus coronoides*	●	B,C,D,E,H,J,L
Little Raven	*Corvus mellori*	●	B,C,H
Little Crow	*Corvus bennetti*	●	E,J
MAMMALS			
Tachyglossidae			
Short-beaked Echidna	*Tachyglossus aculeatus*	●	H
Dasyuridae			
Yellow-footed Antechinus	*Antechinus flavipes*	✣	
Phalangeridae			
Common Brushtail Possum	*Trichosurus vulpecula*	●	D, H
Petauridae			
Sugar Glider	*Petaurus breviceps*	?	
Macropodidae			
Eastern Grey Kangaroo	*Macropus giganteus*	●	D, H
Red Kangaroo	*Macropus rufus*		H
Emballonuridae			
White-striped Mastiff-bat	*Tadarida australis*	●	D
Molossidae			
Inland Free-tail Bat	*Mormopterus planiceps*	●	H
Vespertilionidae			
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	✣	D, H
★Greater Long-eared Bat	*Nyctophilus timoriensis*		D
Gould's Wattled Bat	*Chalinolobus gouldii*	●	H
★ Little Pied Bat	*Chalinolobus picatus*	✣	
Little Brown Bat	*Vespadelus pumilus*		H
★ Troughton's Bat	*Vespadelus troughtoni*	✣	
Southern forest Bat	*Vespadelus regulus*	●	
Little Forest Eptesicus	*Vespadelus vulturnus*	●	
Inland Broad-nosed Bat	*Scotorepens balstoni*	✣	
Little Broad-nosed Bat	*Scotorepens greyii*	✣	
Muridae			
Water-rat	*Hydromys chrysogaster*		H

APPENDIX 6 contd Fauna species recorded from the Lake Cowal area (from all sources).

COMMON NAME	SCIENTIFIC NAME	THIS STUDY	SOURCE
Introduced Species			
Cow	*Bos taurus*	●	
Sheep	*Ovis aries*	●	
Feral Goat	*Capra hircus*		D
Pig	*Sus scrofa*	●	D, H
Cat	*Felis catus*	●	H
Red Fox	*Vulpes vulpes*	●	H
Brown Hare	*Lepus capensis*	✣	
European Rabbit	*Oryctolagus cuniculus*	●	D, H
House Mouse	*Mus musculus*	●	H
Black Rat	*Rattus rattus*		H
REPTILES			
Chelidae			
Long-necked Tortoise	*Chelodina longicollis*		H
Murray Turtle	*Emydura macquarri*		H
Gekkonidae			
Eastern Spiny-tailed Gecko	*Diplodactylus intermedius*		H
Tree Dtella	*Gehyra variegata*		D, H
Thick-tailed Gecko	*Underwoodisaurus milii*	●	H
Pygopodidae			
Patternless Delma	*Delma inornata*		H
Agamidae			
Bearded Dragon	*Pogona barbata*	●	D, H
Lined Earless Dragon	*Tympanocryptis lineata*		H
Varanidae			
Sand Monitor	*Varanus gouldii*		H
Lace Monitor	*Varanus varius*	●	H
Scincidae			
Spiny-palmed Shinning-skink	*Cryptoblepharus carnabyi*	●	
Robust Skink	*Ctenotus robustus*		D, H
Wood Mulch-slider	*Lerista muelli*	●	
Eastern Robust Slider	*Lerista punctatovittata*		H
Southwestern Cool-skink	*Pseudemoia trilineata*		H
Common Dwarf Skink	*Menetia greyi*		H
Southeastern Morethia Skink	*Morethia boulengeri*	●	H
Scincidae contd			
Blue-tongued Lizard	*Tiliqua scincoides*		H
Shingleback	*Trachydosaurus rugosa*		H
Typhlopidae			
Claw-snouted Blind Snake	*Ramphotyphlops unguirostris*		H
Boidae			
Carpet Python	*Morelia spilotes variegata*		H
Elapidae			
Yellow-faced Whip Snake	*Demansia psammophis*		H
White-lipped Snake	*Drysdalia coronoides*		H
Red-naped Snake	*Furine diadema*		H
Eastern Tiger Snake	*Notechis scutatus*		D, H
King Brown Snake	*Pseudechis australis*		H
Spotted Black Snake	*Pseudechis guttatus*		H
Eastern Brown Snake	*Pseudonaja textilis*	●	H
Curl Snake	*Suta suta*		H
Black-headed Snake	*Suta gouldii*		H
Bandy-bandy	*Vermicella annulata*		H
AMPHIBIANS			
Myobatrachidae			
Eastern Sign-bearing Froglet	*Crinia parinsignifera*		H
Sloane's Froglet	*Crinia sloanei*	●	H
Painted Frog	*Neobatrachus pictus*		D, H
Crucifix Toad	*Notaden bennettii*	●	D, H
Smooth Toadlet	*Uperoleia rugosa*	●	H

APPENDIX 6 contd Fauna species recorded from the Lake Cowal area (from all sources).

COMMON NAME	SCIENTIFIC NAME	THIS STUDY	SOURCE
Hylidae			
Green Tree-frog	*Litoria caerulea*		H
Peron's Tree-frog	*Litoria peronii*	●	D,H
Marsh Frog	*Limnodynastes fletcheri*	●	H
Giant Banjo Frog	*Limnodynastes interioris*		D, H
Salmon-striped Frog	*Limnodynastes salmini*		H
Spotted Grass Frog	*Limnodynastes tasmaniensis*	●	H

★ Schedule 12 species (NP&WS 1974, as amended 1992).

* Franklin's Gull is an accidental visitor to Australia (Blakers *et al* 1984).

? Fauna species heard calling from Open Forest and Woodland habitats; strong winds and infrequency of calls made positive identification impossible.

● Fauna species recorded during this investigation on the proposed lease area.

✣ Fauna species recorded during this investigation restricted to the Wamboyne Mountain/'Coniston' area.

SOURCES

B NSW Bird Atlassers records for 10-minute grids centred on 33°35' x 147°25' and 33°45' x 147°25'.

C RAOU records for 10-minute grids bounded by 33°20' to 33°50'S & 147°00' to 147°40'E.

D NP&WS NSW Wildlife Atlas records for the Lake Cowal area (33°20' to 33°50' & 147°10' to 147°40').

E Avifauna species list for the western Lake Cowal area compiled by the Illawarra Bird Observers Club, Fairy Meadow, NSW.

F Lane BR. 1990. West Wyalong Prospect: Waterbird investigation data report. Prepared for NSR Consultants Pty Ltd.

G Dent BR. 1990. Personal observations on the breeding of waterbirds at Lake Cowal 1964-1990.

H Vestjens WJM. 1977. Status, habitats and food of vertebrates at Lake Cowal, NSW. CSIRO Division of Wildlife Research Technical Memorandum No.12, Canberra.

I Environmental & Educational Services 1989-1994. Lake Cowal Waterbird monitoring survey: Progress Reports. Prepared for NSR Environmental Consultants P/L and Geopeko Operations Ltd.

J Records from the Lake Cowal Region (Properties, Boat trip on the lake, State Forests).

K Lawler W. 1989. Waterbird breeding at Lake Cowal, New South Wales. Australian Birds. 23(2): 32-35.

L Hatton PJ. 1991. Draft Water Management Plan for the Wilbertroy/Cowal Wetlands. Department of Water Resources.

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 7

DISCUSSIONS OF RELEVANT ENDANGERED FAUNA SPECIES

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APPENDIX 7 Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Bush Stone-curlew ***Burhinus magnirostris***

The Bush Stone-curlew is listed on Schedule 12 of the NP&W Act (1974) as a Threatened species, on the basis of:

> *"population and distribution reduced to a critical level; poor recovery potential; threatening processes severe"* (NP&WS 1992).

This species inhabits lightly wooded country and the grassy edges of denser forest on rolling terrain, favouring the shorter-grassed woodlands of coastal and subcoastal districts (Schodde & Mason (1980), often away from water (Lindsey 1992). The surface of the habitat often has a layer of leaf-litter and/or some fallen dead timber, with few or no shrubs or undergrowth present (Marchant & Higgins 1993; Johnson & Baker-Gabb 1994). It has occasionally been recorded in dune scrub, savanna and the fringes of mangroves (Lindsey 1992) and in Victoria has been recorded utilising golf courses and remnant open forest farmland (Johnson Baker-Gabb 1994). Inland records of this species are largely associated to the ranges, large lakes and watercourses (Blakers *et al* 1984).

Distribution

Australia — Widespread in northern and northeastern Australia, while being absent or scattered inland (Marchant & Higgins 1993). The distribution of the Bush Stone-curlew has been seriously reduced in mainland Australia and it has not been recorded in Tasmania since 1895 (Lane 1987; Lindsey 1992).

NSW — Recorded in all regions, but most numerous in the Western Slopes and Plains, and Riverina near the Murray-Darling Basin (Marchant & Higgins 1993; Morris *et al* 1981). This species is generally absent east of the Great Dividing Range, except for isolated populations from Gosford to Glossodia, north to Port Macquarie, and the Northern Rivers region near Grafton and Brunswick Heads (Marchant & Higgins 1993, Morris *et al* 1981).

Regional — Only 5 records are known for this species in the region. These records are located to the northeast of Lake Cowal on cleared land with scattered trees (NP&WS Wildlife Atlas).

Local — Not recorded on the study site during this or any previous investigations.

Abundance — This species is considered by Garnett (1992a) to be "*endangered*" in NSW, where numbers have declined. Morris *et al* (1981) lists this species as "*uncommon*" and estimates its population to range between 1000 and 10000 birds. Watkins (1993) estimates the minimum population of this species to be 15000 birds in Australia and 1000 in NSW.

Status

Australia — Garnett (1992b) regards this species to be "*presently secure*" in Australia.

NSW — Threatened (NP&WS 1992).

Regional — Uncertain, due to the dearth of existing records of this species and limited investigations in the region.

Local — Uncertain, due to the lack of records in the local area.

Decline — The decline in Bush Stone-curlew populations has been attributed to urban development, intensive cultivation, burning and overgrazing (Blakers *et al* 1984; Lane 1987); removal of leaf litter in habitat remnants and predation by foxes and feral cats (Garnett 1992b; Pringle 1987).

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Freckled Duck ***Stictonetta naevosa***

The Freckled Duck is listed on Schedule 12 of the NP&W Act (1974) as a Vulnerable & Rare species, on the basis of:

> "*population severely reduced; concentrates*" (NP&WS 1993).

The Freckled Ducks preferred habitats include open lake and wetland sites, surrounded with thick vegetation such as lignum, paperbarks and cumbungi (Blakers *et al* 1984). This species is a "*specialist filter feeder*" foraging from the bottom of shallow water (Marchant & Higgins 1990). Its' nest consists of a well-formed cup-shaped platform of finely woven twigs, usually of surrounding vegetation (Marchant & Higgins 1990). This species inhabits freshwater wetlands thickly vegetated with lignum, cumbungi or paperbark in NSW, and paperbark swamps in Western Australia.

Distribution

Australia — The Freckled Duck is endemic to southeast and southwest Australia and a vagrant elsewhere. It breeds primarily on the ephemeral wetlands of inland eastern Australia and southwest Western Australia. It occurs closer to the coast during inland droughts when inland breeding strongholds dry out. (Marchant & Higgins 1990)

NSW — Widespread; mostly northwest and the Murray-Darling Basin (Lindsey 1992); vagrant to coastal regions in drought years.

Regional — Twelve records are known for this species in the region of which 6 records are within 5km of Lake Cowal (NP&WS Wildlife Atlas). Other locations include Banar Lake to the northwest of Lake Cowal and the Lachlan River near Forbes (NP&WS Wildlife Atlas).

Local — Not recorded during this or any previous investigations in the local area.

Abundance — Morris *et al* (1981) lists this species as "*uncommon*" in NSW, with an estimated population of 100-10000 birds. A census conducted in 1983 indicated the population to be no more than 19000 (Lindsey 1992).

Status

Australia — Garnett (1992b) regards this species to be "*rare*".

NSW — Vulnerable & Rare (NP&WS 1992).

Regional — Uncertain, due to the dearth of existing records of this species and limited investigations in the region.

Local — Uncertain, due to the lack of records in the local area.

Decline — Historically, the main threat to this species has been being mistaken for game species during the duck-hunting season (Garnett 1992a; Blakers *et al* 1984). Additional threats include breeding habitat destruction or modification by drainage, grazing, burning, clearing, salinisation and flood mitigation works; hunting pressure in coastal areas.

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Blue-billed Duck ***Oxyura australis***

The Blue-billed Duck is listed on Schedule 12 of the NP&W Act (1974) as a Vulnerable & Rare species, on the basis of:

> "*population severely reduced; concentrates*" (NP&WS 1992).

This species inhabits large deep permanent freshwater lakes and swamps, with extensive reed beds (Lindsey 1992). It appears to congregate in large flocks on open water in winter, and disperse to smaller densely vegetated swamps to breed in spring (Marchant & Higgins 1990). The nest is a deep bowl of grass and reeds, hidden in reeds over water.

Distribution

Australia The blue-billed Duck is found mainly in far southwestern Western Australia and in the lower Murray-Darling Basin, and occurs casually in southern Queensland, NSW, Victoria and Tasmania (Lindsey 1992).

NSW Widespread; mainly west of the Great Dividing Range, particularly in the lower Murray-Darling Basin (Marchant & Higgins 1990).

Regional Only 4 records are known for this species in the region. Of these records, 2 are within 5km of Lake Cowal and 2 are located to the northeast of Lake Cowal near the Lachlan River, Forbes (NP&WS Wildlife Atlas).

Local Not recorded during this investigation, but has been recorded by 9 other sources (Appendix 2).

Abundance Morris *et al* (1984) regard this species to be "*moderately common*" with an estimated population of 10000 - 100000 birds in NSW.

Status

Australia Considered "*vulnerable*" by Lindsey (1992), but "*secure*" by Garnett (1992b).

NSW Vulnerable & Rare (NP&WS 1992).

Regional Uncertain, due to the dearth of existing records and limited investigations in the region.

Local Uncertain, due to the lack of records in the local area.

Decline Many freshwater breeding habitats have been destroyed or modified by drainage, grazing, clearing, increasing salinization and groundwater extraction.

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Regent Honeyeater ***Xanthomyza phrygia***

The Regent Honeyeater is listed on Schedule 12 of the NP&W Act (1974) as a Threatened species, on the basis of:

> "*population and distribution reduced to a critical level; concentrates; threatening processes severe*" (NP&WS 1992).

The Regent Honeyeater uses eucalypt woodland and open forest, including wooded parts of agricultural land and some urban areas, and riparian forests characterised by the River Oak *Casuarina cunninghamiana* in NSW (Garnett 1992b). The principle food resources for the Regent Honeyeater include nectar and insects, and the species apparently depends on vigorously flowering eucalypt species, particularly Mugga Ironbark *E sideroxylon*, Yellow Box *E melliodora* and White Box *E albens*. Regent Honeyeaters have also been recorded feeding on Swamp Mahogany *E robusta* and Manna Gum *E viminalis*, as well as a number of other eucalypt species (Garnett 1992a, 1992b).

Distribution

Australia Currently recorded in northeastern Victoria, along the western slopes of the Great Dividing Range in NSW and the central coast of NSW (Garnett 1992a).

NSW Comments as for Australia.

Regional Only 2 records are known for this species in the region. They are located southwest of Lake Cowal and West Wyalong in an area adjacent to Charcoal Tank Nature Reserve (NP&WS Wildlife Atlas).

Local Not recorded on the study site during this or any previous investigation in the local area.

Abundance The species has been investigated by the Australian National Parks & Wildlife Service, and the total population in Australia is estimated to number only about one thousand individuals (Garnett 1992b).

Status

Australia Garnett (1992b) regards this species to be nationally "*endangered*".

NSW Threatened (NP&WS 1992).

Regional Uncertain, due to the dearth of existing records of this species in the region.

Local Uncertain, due to the lack of records in the area.

Decline The reasons for the decline of the Regent Honeyeater appear related to habitat degradation and fragmentation (Garnett 1992a, 1992b). Areas of suitable woodland and open forest, containing sufficient densities of flowering Ironbarks, have been substantially cleared for agricultural purposes, with a more scattered remnant of the relevant trees apparently being unable to support sizeable populations of the Honeyeater. Garnett (1992a) notes that some areas of apparently suitable woodland west of Armidale in NSW were under-utilised by the Regent Honeyeater, with many sites not being used at all, despite the presence of flowering Ironbarks. This is probably related to the limited nature of the available resource, scattered over a relatively wide area.

The aggressive nature of other species of honeyeaters, including the Noisy Miner, Red Wattlebird and Noisy Friarbird, is also thought to disturb the Regent Honeyeater while feeding (Franklin *et al* 1989). Agricultural practices and rabbits generally limit the regeneration of suitable food tree species for the Regent Honeyeater.

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Painted Honeyeater ***Grantiella picta***

The Painted Honeyeater is listed on Schedule 12 of the NP&W Act (1974) as a Vulnerable & Rare species, on the basis of:

> "*population and distribution severely reduced; threatening processes severe; ecological specialist*" (NP&WS 1992).

The Painted Honeyeater inhabits open forests, woodland and scrubland (Lindsey 1992), and feeds almost exclusively on the fruits of mistletoe of the genus *Amyema*, growing on woodland eucalypts and acacias (Garnett 1992b). The Painted Honeyeater is locally nomadic and its patterns of movement are reported to follow the fruiting and flowering cycles of these plants (Lindsey 1992; Blakers *et al* 1984). Painted Honeyeaters are noted as also occasionally eating nectar from mistletoe flowers and insects (Blakers *et al* 1984; Garnett 1992b).

Distribution

Australia — Recorded most frequently from Victoria to northern Queensland on the inland slopes of the Great Dividing Range, and less frequently on the east coast. It also occurs in the Northern Territory and South Australia (Garnett 1992b).

NSW — Scattered throughout NSW, absent from northwestern NSW (Morris *et al* 1981).

Regional — The Painted Honeyeater is included in the various listings for the general region around Lake Cowal, including near the Clear Ridge State Forest (about 17km to the southwest), Back Creek State Forest (27km to the south), and in the vicinity of West Wyalong.

Local — Not recorded during this investigation at the Lake, but has been recorded by 5 other sources (Appendix 2).

Abundance — The Painted Honeyeater, although widespread is "*generally uncommon throughout most of eastern mainland Australia*" (Lindsey 1992), and occurs at low densities throughout its range (Garnett 1992b).

Status

Australia — Garnett (1992b) regards this species to be "*rare*".

NSW — Vulnerable & Rare (NP&WS 1992).

Regional — Uncertain, due to the dearth of existing records of this species and limited investigations in the region.

Local — Uncertain, due to the lack of records in the area.

Decline — Garnett (1992b) suggests that the scarcity of the Painted Honeyeater may be due to displacement by the Mistletoebird *Diacaeum hirundinaceum*, but notes that long term population decline has probably been accelerated by the clearing of woodland for agriculture (especially in the species' breeding range), and a lack of regeneration due to grazing by rabbits and sheep.

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Greater Long-eared Bat ***Nyctophilus timoriensis***

The Greater Long-eared Bat is listed on Schedule 12 of the National Parks & Wildlife Act (1974) as Vulnerable & Rare, on the basis of:

> "*population and distribution suspected to be reduced; threatening processes severe; ecological specialist*" (NP&WS 1993).

This species occurs in "*dry open woodland of southern Australia and around River Redgums that line watercourses and lakes on the open inland plains*" (Richards 1991). It is thought to shelter under loose bark or in tree-hollows, although little is known of its biology (Richards 1991). The Greater Long-eared Bat has a "*slow and deliberate flight*" (Strahan 1992), and forages for large moths and beetles over open water and amongst the trees along rivers and creeks (Richards 1991; Strahan 1992). This species is highly manoeuvrable and is apparently able to hover, although it is not known if it gleans insects from leaves and branches like other Long-eared Bats (Richards 1991).

Distribution

Australia — This species appears to occupy three general areas. The first is from south central Queensland to northern Victoria, west of the Great Dividing Range and east of the arid zone (Hall & Richards 1979). The second is from Alice Spring down through western South Australia to the coast, and the third is in Western Australia from Shark Bay in the north to Albany (Richards 1991). The total distributional range of the species is noted as greater than 1 million sq.km (Strahan 1992).

NSW — Occurs in a strip west of the Great Dividing Range and east of the arid zone (Hall & Richards 1979).

Regional — This species has been recorded adjacent to Lake Cowal (approximately 9km northeast of the proposed pit - NP&WS Wildlife Atlas).

Local — The Greater Long-eared Bat was not recorded during this investigation. It is suspected that this species occurs in the area, because of the near proximity of two records included on the NP&WS Wildlife Atlas.

Abundance This species is considered "*uncommon and poorly known*" by Parnaby (1992), "*very sparse*" by Strahan (1992) and "*uncommon*" by Richards (1991).

Status

Australia — This species is considered "*secure*" by Strahan (1992).

NSW — Vulnerable & Rare (NP&WS 1992).

Regional — Uncertain, due to the dearth of records for the region.

Local — Uncertain, due to the absence of any records within the study area.

Decline The loss of suitable roosting trees (particularly River Redgums along watercourses) is considered a potential threat to this species' conservation.

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Yellow-Bellied Sheathtail Bat ***Saccolaimus flaviventris***

The Yellow-bellied Sheathtail Bat is listed on Schedule 12 of the National Parks & Wildlife Act (1974) as Vulnerable & Rare, on the basis of:

> "*population suspected to be reduced; ecological specialist*" (NP&WS 1993).

The Yellow-bellied Sheathtail Bat roosts in large tree-hollows throughout its preferred habitat, which comprises eucalypt forest in eastern and northern Australia (Richards 1991). It appears to be a rather adaptable species, and is not reliant solely on forest environments for foraging. It generally forages above the tree canopy in forest habitats, but in mallee or open environments it hunts immediately above vegetation at heights closer to the ground.

Distribution

Australia This species is noted by Parnaby (1992) as being infrequently recorded, although it is apparently distributed widely throughout eastern Australia, with a total distribution of more than 1 million sq.km (Strahan 1992).

NSW Widely distributed throughout the state, excluding arid inland areas (Hall & Richards 1979).

Regional No records for the region.

Local Not recorded in the study area during this or any previous investigations in the region.

Abundance The Yellow-bellied Sheathtail Bat is considered rare in widespread habitat (Richards 1991). Its perceived rarity, however, is considered probably due to its flying so high and fast that it is seldom captured (Richards 1991). Parnaby (1992) notes that this species is very rarely caught in bat traps or mistnets in forest areas.

Status

Australia Strahan (1992) considers this species as "*probably secure*" in status.

NSW Vulnerable & Rare (NP&WS 1992).

Regional Uncertain, due to the dearth of records for the region.

Local Uncertain, due to the absence of any records within the study area.

Decline The loss of suitable roosting trees (particularly those with large hollows) and foraging habitat poses a potential threat to this species' conservation.

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Little Pied Bat ***Chalinolobus picatus***

The Little Pied Bat is listed on Schedule 12 of the National Parks & Wildlife Act (1974) as a Vulnerable & Rare Species, on the basis of:

> "*population suspected to be reduced; concentrates; threatening processes severe; ecological specialist*" (NP&WS 1992).

The Little Pied Bat inhabits "*warm-temperate to tropical semiarid to arid woodland*" (Strahan 1992), and is described as a "*dry area bat found near rocky outcrops*" by Hall & Richards (1979). This species generally roosts in small colonies in caves, mines, rock-shelters and occasionally in old buildings (Hall & Richards 1979). However, in some areas it has been recorded to roost primarily in tree-hollows (Parnaby 1992).

Distribution

Australia Widely distributed throughout inland Queensland and NSW (Parnaby 1992) and eastern South Australia (Hall & Richards 1979).

NSW Occurs in the northwestern region of the state (Hall & Richards 1979).

Regional No records for the region (NP&WS Wildlife Atlas).

Local This species was tentaviely recorded during this investigation, in the Mt Wamboyne-'Coniston' area, but not on the proposed Project site. The 'record' may be a mis-identification, given the location and the occurrence of congenerics in the region (Parnaby 1992).

Abundance This species is considered "*sparse*" by Strahan (1992) and "*uncommon*" by Parnaby (1992).

Status

Australia This species is considered as "*probably secure*" by Strahan (1992).

NSW Vulnerable & Rare (NP&WS 1992).

Regional Uncertain, due to the dearth of records and limited number of investigations in the region.

Local Uncertain, due to the dearth of records in the area.

Decline The loss of suitable roosting and foraging habitat is considered a potential threat to this species' conservation.

APPENDIX 7 contd Species profiles for endangered fauna considered of particular relevance to the proposed mine operation at Lake Cowal.

Troughton's Bat ***Vespadalus troughtoni***

Troughton's Bat is listed on Schedule 12 of the National Parks & Wildlife Act (1974) as a Vulnerable & Rare species, on the basis of:

> "*population and distribution suspected to be reduced; concentrates; threatening processes severe; ecological specialist*" (NP&WS 1992).

This species inhabits "*warm temperate to tropical woodland and sclerophyll forest*" (Strahan 1992), and apparently dwells in caves (Parnaby 1992).

Distribution

Australia — Restricted to northeastern Australia on both sides of the Great Dividing Range (Strahan 1992), extending from Cape York in the north to southeastern New South Wales (Parnaby 1992).

NSW — Occurs along the entire coast, on both sides of the Great Dividing Range, except for the far south coast (Parnaby 1992).

Regional — Unknown.

Local — It was tentaviely recorded during this investigation at Lake Cowal near Open Forest in the Mount Wamboyne/'Coniston' area, but not on the proposed Project site. The 'record' may be a mis-identification, given the location and the occurrence of congenerics in the region (Parnaby 1992). Troughton's Bat is considered unlikely to be resident on the mine area, due to the lack of suitable roosting sites, although it possibly uses the area, especially the Open Woodland habitats, for foraging resources.

Abundance This species is considered "*sparse*" by Strahan (1992).

Status

Australia — Considered as "*probably secure*" by Strahan (1992).

NSW — Vulnerable & Rare (NP&WS 1992).

Regional — Unknown, due to the lack of records for this species in the region.

Local — Uncertain, due to a lack of records of this species in the study area. Considered unlikely to be a resident on the Project site.

Decline The loss of suitable roosting and foraging habitat is considered a potential threat to this species' conservation.

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 8

WATERBIRDS & TAILINGS DAMS

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WATERBIRD USAGE OF TAILINGS IMPOUNDMENTS

LAKE COWAL

WATERBIRD USAGE OF TAILINGS IMPOUNDMENTS

1 BACKGROUND

The Lake Cowal Gold mine is a proposed gold mining and ore extraction project on the western shoreline of Lake Cowal. Lake Cowal is an ephemeral waterbody that serves as an important refuge for a number of birds including terrestrial and aquatic species.

The region is predominantly pastoral in a semi-arid climate. The Lachlan River is approximately 30 km to the north east and there are several intermittent creeks and channels running to and from the Lake.

Lake Cowal, on average, is dry three years out of ten and can be an area of high waterbird activity when sufficient water is present. The Lake Cowal Gold Project will have up to four tailings impoundments. These tailings impoundments will be 750 m x 750 m, although the actual surface area of exposed water will be considerably smaller. Tailings will be deposited by beaching and draining. Pond size (free water surface area) will be minimised to enable maximum recycle of water.

There is a paucity of relevant literature about the interaction of Australian waterbirds and mine tailings impoundments. As a consequence this preliminary survey was initiated. Information was collected via telephone conversations with relevant personnel at each mine and is based on their personal experience.

Norths' personnel approached several mines in New South Wales to document their experiences regarding waterbird usage of tailings impoundments. These mines are not dissimilar in location and climate to the proposed Lake Cowal Gold Mine.

In addition, ERA Environmental Services Pty Ltd was commissioned to survey mines in the Top End of the Northern Territory for observations of tailings impoundment usage by waterbirds. This region of Australia is renowned for its high levels of waterbird activity and in the "dry season " (April - November) can experience extended periods, usually six months, with no rainfall. Late in this season many natural waterbodies dry out resulting in deteriorating water quality and habitat. These conditions are considered to be similar to the likely situation at Lake Cowal during prolonged (aseasonal) dry conditions.

2 RESPONSES TO THE SURVEY

2.1 Northern Territory Mines

Six mines were contacted. Five gold mines and one uranium mine. The information was obtained by telephone from current senior environmental officer at each mine.

Zapopan NL Mt Todd

The contact was Thomas Morris who is the Environmental Superintendent at Mount Todd Gold Mine. This mine uses a heap leach extraction process and does not have a tailings impoundment dam. The Mount Todd Gold Mine has a leach pad which contains approximately 100 ppm cyanide and is devoid of vegetation. The leach pad does not usually attract birds.

However, during and after heavy rainfall events, frogs appear in the leach pad. Cormorants and small birds are attracted to the vulnerable frogs. Kites and other predatory birds wheel above the leach pad preying on the smaller birds. This situation led to 22 observed bird mortalities in 1993.

Streamers have been installed to scare the birds away. They were effective against most species with the exception of cormorants.

Pine Creek Goldfields

The contact was Mike Fawcett who is their Environmental Superintendent. Pine Creek Goldfields has a 45 hectare dam that for half the year is covered by cyanide decant. The cyanide concentration is typically less than 10 ppm. During its first year of operation, 50 to 60 bird deaths were recorded. These birds were all Black (Fork-tailed) Kites.

There no longer seems to be many birds attracted to the mine site and very few recent mortalities. Birds deaths are limited to one or two ducks or terns per year. The low number of bird kills is most likely due to a lower cyanide concentration in the water. Periodically a small flock of pelicans lands on the water. The pelicans are effectively hazed, within 16 hours of sighting, using gunshot noise.

The dam has large beaches that would probably appear as tidal flats to the birds and be particularly attractive to migratory wading species The nearby Process Water Dam has no beaches and does not attract birds and consequently has no observed bird deaths.

Union Reefs Gold Mine

The contact was Paul Tett who is their Environmental Officer. Union Reefs Gold Mine has been operating for 12 months. Bird activity is minimal and restricted to waterhens and ducks on the tailings dam. Cyanide concentrations (as predicted by laboratory trials) are typically less than 30 ppm.. There is a decant pond (0.5 ppm cyanide) with no noted bird activity. No bird kills have been recorded. Official records are kept and it is unnecessary to actively discourage birds from using the mine waterbodies. There is no cyanide destruction or detoxification process in place, however the cyanide wash circuit reduces the cyanide concentration of water to the tailings dam.

Rustlers Roost Gold Mine

The contact was Merrilyn Tinsley who is their Occupational Health and Environmental Officer. Rustlers Roost Gold Mine uses a heap leach process and is in its first year of operation. There is a pregnant liquor pond (200 ppm CN), a barren liquor pond (~10 ppm CN), a storm pond (~30 ppm CN) and an intermediate pond.

Bird mortality on site has been four unidentified raptors found on the heap leach stockpiles and one cormorant in the pregnant liquor pond. Two kingfishers were recovered from the plastic lined storm pond launder channel (cyanide concentration approximately 30 ppm). The kingfishers although distressed when retrieved from the water recovered within 15 minutes and were released.

There is an artificial waterbody (the Back Hoe Pit) on site and a large pastoral dam 500 m east of the mine site that is well colonised by vegetation, fish and insects.

Toms Gully Gold Mine

The contact was David Danato who is their Environment Officer. Tom's Gully Gold Mine has several large evaporation ponds, decant ponds and other cyanide bearing waterbodies on the minesite.

Cyanide concentrations are variable (30 - 100 ppm CN) being dependent upon process condition, natural decomposition and dilution.

The mine dewaters approximately six megalitres of water per day to a pond which superficially resembles a natural billabong. The minesite is two kilometres from the Mary River Floodplain.

The tailings dam contents are dark in colour, the free water has a high suspended solid content (to the consistency of sludge) and contains in the vicinity of 25 ppm cyanide. Observations of bird activity around the tailings dam has been restricted to small wader footprints along the edges of the tailings dam.

Bird activity consists of an itinerant bird population on the ore heaps and shorebirds searching for invertebrates around ponds. Waterbirds roost on sparsely vegetated ponds and seek food from well vegetated ponds on the minesite.

Hazing techniques have not been necessary on the mine site as the birds are easily spooked by any disturbance, such as an approaching vehicle. The observed bird deaths over the previous twelve months have been a Whistling Kite and a Black Kite.

ERA Ranger Mine

The contact was Peter Reid who is their Environment Superintendent. Although not a gold mine ERA Ranger mine has been included in this review because it is in the same region as the other surveyed mines and has kept detailed records of bird activity on its site for several years.

Appendix 1 is a table of waterbird abundance and richness at two of the mine's waterbodies during times of both abundance and lack of water in the region. Retention Pond Number 1 with a surface area of approximately 13 hectares, is a relatively clean waterbody with abundant riparian and aquatic plants and aquatic wildlife. Ecologically, this waterbody closely mimics the large, natural billabongs in the area. Ranger mine's tailings dam (surface area approximately 110 hectares is a sterile environment with no riparian or aquatic macrophytic vegetation and no aquatic wildlife.

By carefully examining waterbird richness and abundance data under varying seasonal conditions, the preference and distribution of waterbirds between the two distinct types of waterbodies can be demonstrated.

At Ranger Mine when water is widespread (ie January to July), waterbirds are dispersed and their abundance and richness is at its lowest on any given waterbody. During the late dry/early wet season (August to December) however, when regional surface water is scarce, the waterbirds congregate where water is available, resulting in large numbers of individuals and species in a limited area.

These data show that waterbirds strongly prefer Retention Pond 1 to the Tailings Dam, despite the difference in surface area.

2.2 New South Wales Mines

Three operating mines, situated in similar environments to Lake Cowal were contacted to ascertain the degree of waterbird usage associated with tailings dam operations. The comments from the operations are as follows. Note that all comments were verbal as none of the operations had any formal paperwork available.

In Summary the response from the New South Wales regional mines was:

Northparkes

The contact was Anna McMullen who is the Environmental Advisor for the operation. Anna stated that there have been some odd instances of birds, mainly swans, who get caught in the mud on the dam. An incident form is to be lodged by staff at each occurrence of observed wildlife mortality.

Sheahan Grants

The contact was Heath Sandercock who is the former Operations Manager at the mine site. Heath advised that they had problems with swans who appeared to be determined to settle on the tailings dam. Attempts to reduce the amount of waterbirds attracted to the dam by site personnel were helped by Corkery, an environmental consultant company based in Orange. Several methods, including shotgun noise, fake birds of prey and decoys were tried, with little success. The most successful method of discouraging birds from landing on the dam was gleaned by Corkery from Alcoa, WA. This system involves floating old chemical containers which are connected by rope on the dam's surface. The presence of ropes on the water's surface discourages the swans from landing. This method has succeeded in greatly reducing the incidence of bird mortality although rarely an incident still occurs.

London Victoria

The contact was Rod Chittenden who is the former Mill Superintendent. Rod commented that the birdlife seemed to realise that the water was unsafe when the cyanide levels were in the 80-100 ppm range and would not settle on it. When there was significant rainfall diluting cyanide levels in the tails runoff down to approximately 20 ppm, the birdlife would then settle on the dam with no apparent ill effect. Bird mortality was a rare occurrence and was not considered a problem. Two plovers made the tailings dam their home.

3 CONCLUSIONS

The usage of tailings impoundments by waterbirds at the mines contacted is not considered to be a significant problem. Waterbirds appear to select the more natural waterbodies over artificial and sterile waterbodies. From the observations and data presented it appears that waterbirds are not simply attracted to water surface area but are strongly influenced by other factors such as habitat (beaches, flats, open water and plants), and food sources (plants, invertebrates and fishes). As a result bird mortality on tailings impoundments appears incidental and consequently has not been a problem either on NSW tailings impoundments with climatically similar conditions to those experienced at Lake Cowal, or on NT tailings impoundments located near natural wetlands with high levels of waterbird usage, similar to the situation at Lake Cowal. Therefore bird mortality on the Lake Cowal tailings impoundment is not likely to be a problem. If under some climatic conditions bird usage of the impoundment increases then hazing techniques to discourage them from the artificial waterbodies can be effective.

Appendix 1

Abundance and Richness at ERA Ranger Mine's waterbodies

Period	RP1	RP1	TD	TD Richness
Wet 1980	20	6	40	7
Dry 1980	106	15	50	10
Wet 1981	24	10	7	5
Dry 1981	71	14	29	7
Wet 1982	12	5	24	3
Dry 1982	264	24	22	5
Wet 1983	16	6	14	4
Dry 1983	119	20	26	3
Wet 1984	36	7	5	2
Dry 1984	202	24	15	2

RP1 = Retention Pond No 1
TD = Tailings Dam

Note: Abundance = number of individuals
Richness = number of species
Numbers are averages per visit over a six month period

LAKE COWAL GOLD PROJECT

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APPENDIX 9

AUSTRALIAN HERITAGE COMMISSION LISTING OF LAKE COWAL

GUNNINAH CONSULTANTS
22 Clarke St Crows Nest NSW 2065
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Register of the National Estate
Detailed Place Report for External Use

Identification

Name of Place:	Lake Cowal
Other Names:	Nil
Database No:	016581
File No:	1/07/257/0003
Principal Group:	Natural Environment

Status

Legal Status:	Registered	30/06/1992
Admin Status:	Registered	30/06/1992

Location

Nearest Town:	Burcher
Distance (km):	15.00
Direction from town:	ESE
Area (ha):	15000.00
Address:	Nil
Local authorities:	Forbes Shire (Current LGA) Bland Shire Jemalong S. (Now 1/07/121)

Property Information
Mainly Private Land.

Location/Boundaries
Approximately 15,000ha, 15km east-south-east of Burcher, comprising the area enclosed by a line commencing on the southern boundary of the Parish of Moora Moora at AMG easting: 8330-I&IV-'Wamboyne'-392, then proceeding easterly via that boundary to AMG northing: 8925 (approximate AMG point: 42648925), then due south to rejoin the western boundary of the Parish of Moora Moora, then southerly via that boundary and the western boundary of the Parish of Cadalgulee to a road at AMG point: 43308425, then south-easterly via the western side of that road to AMG northing: 823, then via straight lines joining the latter and following AMG points sequentially: 464810, 466800, 465790, 461780, 45547700, 454760, 455750, 456740 and 452730, then directly to the right bank of Bland Creek at AMG northing: 7216 (44687216), then southerly via that bank to AMG easting: 454, then directly south-westerly to a track at AMG easting: 447 (447695), then westerly via the northern side of that track to AMG easting: 4375, then directly to AMG point: 430715, then northwesterly via straight lines joining the latter and following AMG points sequentially: 424725, 416728, 409728, 398731, 389742, 381750, 373780, 370800, 370808, 36558122, 36558235 and 36728300, then directly northerly to a track at AMG northing: 850 (367850), then northerly via the eastern side of that track to AMG northing: 8665, then via straight lines joining the latter and following AMG points sequentially: 370875 and 380880, then directly to the Burcher-Marsden Road at AMG easting: 377 (377896), then via the northern side of that road to the commencement point.

Description

Lake Cowal is a Freshwater Lake in the Lachlan region. The water level in the lake varies according to rainfall and evaporation. When full it is about 17 x 9.5Km and covers 150 square km. The water of the lake is normally replenished by flood waters from the Lachlan River via a floodway south of Jemalong Weir, water flows across the Jemalong and wylds plains Irrigation areas and enters Lake Cowal East of boobies Island it also enters from the south through Bland Creek. The Northern HALF OF THE LAKE IS SHALLOW AND COVERED BY Eucalyptus camaldulensis AND Muehlenbeckia cunninghamii. THE SOUTHERN PART IS DEEPER AND IS mainly open water. The Banks of the lake comprise a succession of habitats, relating to level and frequency of inundation. An Open Eucalyptus populnea WOODLAND OCCURS ON THE LANDWARD SIDE OF THE HIGH waterlevel of the lake. The highwater level is marked by Stands of e. camaldulensis (RIVER RED GUM) AND A FEW Muehlenbeckia cunninghamii Bushes, which become denser towards the lake centre. In the deeper water Red Gums are absent, while large areas of Ribbon WEED, Vallisnera spiralis, MAY OCCUR. several populations of faunal species recorded at Lake Cowal are outlying or disjunct populations. These are the Red groined toadlet Uperoleia rugosa, THE BLACK-HEADED SNAKE, Unechis gouldii, THE EASTERN GOLDEN PLOVER, Pluvialis dominica, AND THE BLACK-TAILED GODWIT, Limosa limosa. TWO FROG SPECIES, SEVEN REPTILE SPECIES, TEN BIRD SPECIES, AND two mammal species, reach, or almost reach, either their known eastern, western, or southern range limit at Lake Cowal. Species listed in schedule 12 of the New South Wales national Parks AND WILDLIFE ACT RECORDED IN THE AREA INCLUDE THE GREAT EGRET (Egretta alba) WHICH IS LISTED AS "OF SPECIAL CONCERN" AND THREE SPECIES LISTED AS "VULNERABLE AND RARE", THE PEREGRINE FALCON (Falco peregrinus), BROLGA (Grus rubicundrus) AND GREY FALCON (Falco hypoleucos). the area is also habitat to regionally endangered populations of The GIANT BURROWING FROG Heleioporus australiacus, RED-GROINED TOADLET, EARLESS DRAGON Tympanocryptic lineata, BLUE-BILLED DUCK Oxyura australis, MULGA PARROT Psephotus varius AND THE WHITE-WINGED FAIRY WREN Malurus leucopterus. LAKE COWAL IS ALSO HABITAT FOR A REGIONALLY RARE FISH Macquaria ambigus, AND SEVEN REGIONALLY RARE BIRD SPECIES. the lake has been dry on a few occasions; one of these was for approximately 20 years. When containing water Lake Cowal supports large and diverse concentrations of waterbirds, and is a productive commercial fishing area. A few stone artifacts have been found on the shores of the Lake.

Condition

Although used for more than a century for intensive agriculture and water resource development, the natural significance of the area has been maintained by three factors - the flooding cycle, the adequate water quality of catchment runoff to the lake and the retention of substantial waterbird habitat, especially breeding habitat. The lake bottom is used for cereal cropping or for pastures for sheep and cattle when the lake is dry. Some commercial fishing is done in the lake, and this results in the death of some waterbirds. Several feral animals occur in the area, with cats and foxes being abundant. The area is a popular site for Duck shooting, with some indiscriminate shooting of waterbirds occurring. Several exotic fish species, including goldfish and European carp are found in the Lake.

AHC Official Statment of Significance

Lake Cowal is one of the most significant waterbird concentration areas in nsw. It is an important site for migratory birds, and supports a high diversity of bird species with 172 species recorded in the area, including a breeding population of 82 species, of which 38 are waterfowl. It regularly supports very large numbers of waterbirds, particularly ducks, IBIS, geese, swans, coots, and waders including migratory waders protected under international migratory bird treaties. Twelve of

AHC Official Statment of Significance (continued)

these species are listed in the china Australia migratory bird agreement (camba) and ten species listed in the Japan Australia migratory bird agreement (jamba). The intermittent nature of the lake makes it of high value for waterbirds. The biological richness of the lake when recently filled is evidence of its importance to many waterbirds, many of which migrate Between the Wetlands of inland Australia in response to their cyclic drying and filling. Bird species which breed in the area, and which are listed in schedule 12 of the New South Wales national parks and Wildlife act (1983) (ENDANGERED FAUNA), INCLUDE THE MAGPIE GOOSE (Anseranas semipalmata) which is listed as "rare and vulnerable" and the freckled Duck (Sticonetta naevosa) WHICH IS IS LISTED AS "THREATENED". THIS SPECIES is also listed as rare nationally by the royal australian ornithologists Union. The concentration of large numbers of waterfowl in a relatively Small and accessible area makes Lake Cowal a good site for researching the breeding and feeding behaviours, and the general ecology, of waterbirds. Baseline studies being undertaken as part of a mining exploration program at Lake Cowal are contributing to understanding of the cyclic behaviour of inland ephemeral lakes. The knowledge gained from these studies will contribute to a wider understanding of their hydrology and ecology. The Lake also demonstrates Well the range of vegetation types associated with lakes that are replenished by River floodwaters.

Bibliographic references

BRICKHILL J.(UNDATED). UNPUBLISHED AERIAL SURVEY COUNTS OF WATERBIRDS AT LAKE COWAL 1977-991 BY THE NEW SOUTH WALES NATIONAL PARKS AND WILDIFE SERVICE.
DEPARTMENT OF WATER RESOURCES NEW SOUTH WALES (1991) DRAFT WATER MANAGEMENT PLAN FOR THE WILBERTROY/COWAL WETLANDS. DEPT OF WATER RESOURCES, FORBES.
FULLAGAR P (1991). LISTING OF LAKE COWAL ON THE REGISTER OF THE NATIONAL ESTATE OBJECTION ASSESSMENT (UNPUB) AUSTRALIAN HERITAGE COMMISSION, CANBERRA.
GELL P A (1992). LAKE COWAL WATERBIRD MONITORING SURVEY JANUARY 1992. REPORT BY ENVIRONMENTAL & EDUCATIONAL SERVICES PTY LTD FOR GEOPEKO.
GOLDNEY D C & BOWIE I J S (1987). SCENIC AND SCIENTIFIC SURVEY OF THE CENTRAL WESTERN REGION. A REPORT TO THE AUSTRALIAN HERITAGE COMMISSION. HUMPHRIES S L, CROME F H J & FAITH D P (1991). PRINCIPLES AND GUIDELINES FOR A BIOLOGICAL MONITORING PROGRAM IN LAKE COWAL. CSIRO DIVISION OF WILDLIFE AND ECOLOGY, CANBERRRA.
LANE B A (1990). WEST WYALONG PROSPECT WATERBIRD INVESTIGATION FINAL REPORT. REPORT BY B A LANE PTY LTD TO NSR ENVIRONMENTAL CONSULTANTS PTY LTD FOR PEKO-WALLSEND OPERATIONS LIMITED.
LANE B A (1991a). REPORT FOR LAKE COWAL WATERBIRD BREEDING ACTIVITY, JANUARY 1991. REPORT BY B A LANE PTY LTD TO NSR ENVIRONMENTAL CONSULTANTS FOR GEOPEKO.
LANE B A (1991b). LAKE COWAL WATERBIRD MONITORING SURVEY, AUGUST 1991. FOR GEOPEKO.
LANE B A (1991c). LAKE COWAL WATERBIRD MONITORING SURVEY, OCTOBER 1991. FOR GEOPEKO.
LAWLER W (1989) WATERBIRD BREEDING AT LAKE COWAL NEW SOUTH WALES. AUSTRALIAN BIRDS 23 (2), 32-35.
NEW SOUTH WALES NATIONAL PARKS AND WILDLIFE SERVICE (1991). LAKE COWAL PROPOSED LISTING IN THE REGISTER OF THE NATIONAL ESTATE.(UNPUB) NSW NPWS, SYDNEY.

Bibliographic references (continued)

NSR (1991). LAKECOWAL AREA ENVIRONMENTAL BASELINE - PROGRESS REPORT 1. CONSULTANTS REPORT FOR GEOPEKO.
SCHWINGHAMNIER T (1987). WATERWAYS AND WETLANDS. IN GOLDNEY & BOWIE P161- 186.
VESTJENS W J M. (1977). STATUS, HABITATS AND FOOD OF VERTEBRATES AT LAKE COWAL NSW. CSIRO DIVISION OF WILDLIFE RESEARCH, TECHNICAL MEMORANDUM NO. 12.
VESTJENS W J M (1975). BREEDING BEHAVIOR OF THE DARTER AT LAKE COWAL NSW. EMU 75(3):121-131.
VESTJENS W J M. (1975). FEEDING BEHAVIOR OF SPOONBILLS AT LAKE COWAL NSW. EMU 75(3):132-6.

• • • End Of Report • • •

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 10

IMPACT MITIGATION & HABITAT RESTORATION

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6. Impact Mitigation: Decommissioning and Rehabilitation

6.1 Rehabilitation Context and Goals

Lake Cowal's shores and bed have been developed and managed for agriculture, but its conservation value as a wetland co-exists with current land uses as a modified but clearly still functioning and resilient ecosystem.

On the other hand, the original dryland ecosystems around the lake have been extensively cleared of most trees and shrubs for agricultural purposes.

Although parts of the decommissioned project area could be returned to grazing capability, the cost of re-establishing an essentially commercial agricultural land-use would probably not meet normal economic criteria. In these circumstances, North considers that rehabilitation of the post-mining land surfaces and topography primarily for flora and fauna conservation is the most appropriate course. For some facilities (for example, the tailings cells), a rehabilitation choice between wetland and dryland exists. Being locally the most heavily modified, dryland has been the preferred option (see Cowling/RAOU in Appendix H). At the same time, agricultural uses for the most suitable areas (such as wheat or rice production on the nitrogen-enriched tailings) will also be investigated; and trials have been proposed (see Section 6.6.2).

The mine and process plant have a minimum active life of 11 years. This time is available for progressive rehabilitation, research and development, and improvements in methods. Community views on lines of inquiry, progress and decommissioning detail will be sought throughout this period. The ultimate goal is for the project area to become an asset of long-term community value and interest.

6.2 Planning Information and Objectives

6.2.1 Information Base

A comprehensive base of information has been compiled from which to plan the rehabilitation concept and, in due course, to design the program in detail (see Section 6.7)

Studies of materials, site conditions and engineering have been listed in Table 4.1 and are either included in appendices or cited as references available on request:

- Soils (Barker & Wild in Appendix L).
- Mine materials geochemistry (EGi in Appendix M).
- Hydrological, geotechnical and engineering investigations (Coffey, 1995a, e; Knight Piésold, 1994, 1995).

Studies of the existing environment and rehabilitation options are included as appendices:

- Flora (Clements & Rodd in Appendix F).
- Fauna (Gunninah in Appendix A).
- Wildlife habitat re-establishment options (Cowling/RAOU in Appendix H).

Collective mining industry rehabilitation experience from current projects in the region has been noted:

- The value of topsoil having its microflora and fauna still viable and, conversely, the decline in the quality of stored topsoil.
- The importance of precise level control on drainage grading works.
- The importance of plant propagation from seeds of local provenance.
- The successful germination of native seedlings from wind-sown seed.

Note has also been taken of the freshwater habitat management objectives of NSW Fisheries (1993).

6.2.2 Objectives

Cowling/RAOU in Appendix H (Options for Wildlife Habitat Restoration) recommend conserving the major areas of remnant bush on the site (which has been done, see Section 2.1.1) and set rehabilitation priorities as follows:

- First priority: re-establishment of dryland ecosystems (open woodland/ grassland).
- Second priority: restoration or replacement of wetland habitats.

A rehabilitation objective can therefore be set:

> Return of the project area to modified natural dryland and wetland ecosystems that have conservation value as flora and fauna habitat and that are compatible with the character and functions of the surrounding environment.

This will require:

- The stable and safe condition of the site.
- Drainage and soil erosion control.
- No residual toxic hazards on the site and no contamination of surrounding land and water.
- Revegetation of the project area to self-sustaining communities.
- Passive safeguards and minimal active maintenance.

The concept to achieve these conditions is described below.

6.3 Progressive Rehabilitation

Progressive rehabilitation maximises the work completed during the operational period. This is desirable for several reasons: personnel and machinery are available, trials can be conducted, and methods can be improved. However, the production of tailings right up to the end of operations means that this component of the overall rehabilitation work will remain to be done at decommissioning.

For these reasons, the project's waste management system has been designed to make areas available for rehabilitation as early as possible, and this is particularly evident in the design and construction methods adopted for the perimeter bund (Plate 6.1), waste emplacements and tailings storage embankments.

An indicative progression of rehabilitation could be as outlined in Table 6.1.

A plan schematic of progressive rehabilitation is shown in Figure 6.1.

Plate 6.1 Example of initial bund rehabilitation, Northparkes Mines

6.4 Rehabilitation Concept

6.4.1 Landform

The decommissioned landform will be generally as achieved at the end of mining and processing. Options to rehandle material are uneconomic and appear to be of limited environmental or amenity value (see Section 6.9.1).

6.4.2 Habitat

The rehabilitation concept, in general accordance with the recommendations of Appendix H, provides notionally for the following:

- Bimble-box woodland on three tailings cells, on the lower slopes of the perimeter bund, on the pit perimeter waste emplacement and on tidied-up project areas generally.
- White Cypress-pine/Spearwood/Dwyers Red Gum woodland on the upper slopes and top of the waste emplacement.
- Riparian community of River Red Gum and Lignum around the new shoreline of the lake, with Lignum and Cane Grass on the new island-

Table 6.1 Indicative progress of rehabilitation

Year	Rehabilitation Works
-2 (1996)	• Starter embankment of tailings cell 1B. • Pit protection bund.
-1 (1997)	• Perimeter bund to AHD 223 m (Plate 6.1). • Starter embankments of tailings cells 1A, 2A and 2B.
+1 (1998)— completion of construction	• Completed construction areas. • Cofferdam. • First embankment lifts of tailings cells 1A, 2A and 2B.
+2 (1999)—operations	• Second embankment lifts of tailings cells 2A and 2B.
+3 (2000)—operations	• Waste emplacement perimeter bund lift to AHD 228 m. • Second embankment lifts of tailings cells 1A and 1B (with subsequent lifts available for rehabilitation in Year +5 [2002], +7 [2004] and +9 [2006]).
+4 (2001)—operations	• Waste emplacement perimeter bund lift to AHD 233 m (with subsequent lifts progressively available for rehabilitation to the end of mining in Year +8 [2005]). • Third embankment lifts of tailings cells 2A and 2B (with subsequent lifts available for rehabilitation in Year +6 [2003], +8 [2005] and +10 [2007]).
+8 (2005)—end of mining	• Waste emplacement top surfaces.
+11 (2008)—end of ore-processing; decommissioning	• Final tailings storage surfaces. • Process plant. • Roads and other infrastructure not required for community purposes.

and-shallows habitat immediately offshore.

- Ephemeral wetland in tailings Cell 1B. Natural colonisation by ephemeral wetland species will occur readily.
- Pit to remain as a saline lake.

Replanted trees can provide food and roosts for endangered fauna that may, or could potentially, occur. For example, Red River Gum can provide food for the Superb Parrot and a range of other parrots, and White Cypress-pine can provide food for the Pink Cockatoo. A range of eucalypts and mistletoe can respectively aid the Regent and Painted Honeyeaters.

At the end of construction, selected large trees that have been cleared may be retained as perches and nesting sites, and nesting boxes will be constructed around the mining lease.

6.5 Methods

6.5.1 Landform, Drainage and Revegetation

The major landforms will be completed to the design batters and berms described in Figure 2.12 (pit protection bund), Figure 2.13 (perimeter bund) and Figure 2.22 (tailings storage perimeter embankments). Some break up of straight-line profiles should be possible, particularly on the top of the waste emplacement.

Run-of-mine production of all four mine soils and rock types (Table 6.2) up to Year +4 provides flexibility in deciding on final surface treatment.

The completed landforms will be topsoiled from stockpiles, reseeded and mulched. The slopes of the perimeter

Table 6.2 Waste production by type and year

Waste Type	Waste (Mt)	Year Produced
Oxidised transported cover	36.7	-1 to +3
Soft oxide	25.4	-1 to +4
Hard oxide	10.3	+1 to +4
Primary	41.4	+2 to +6

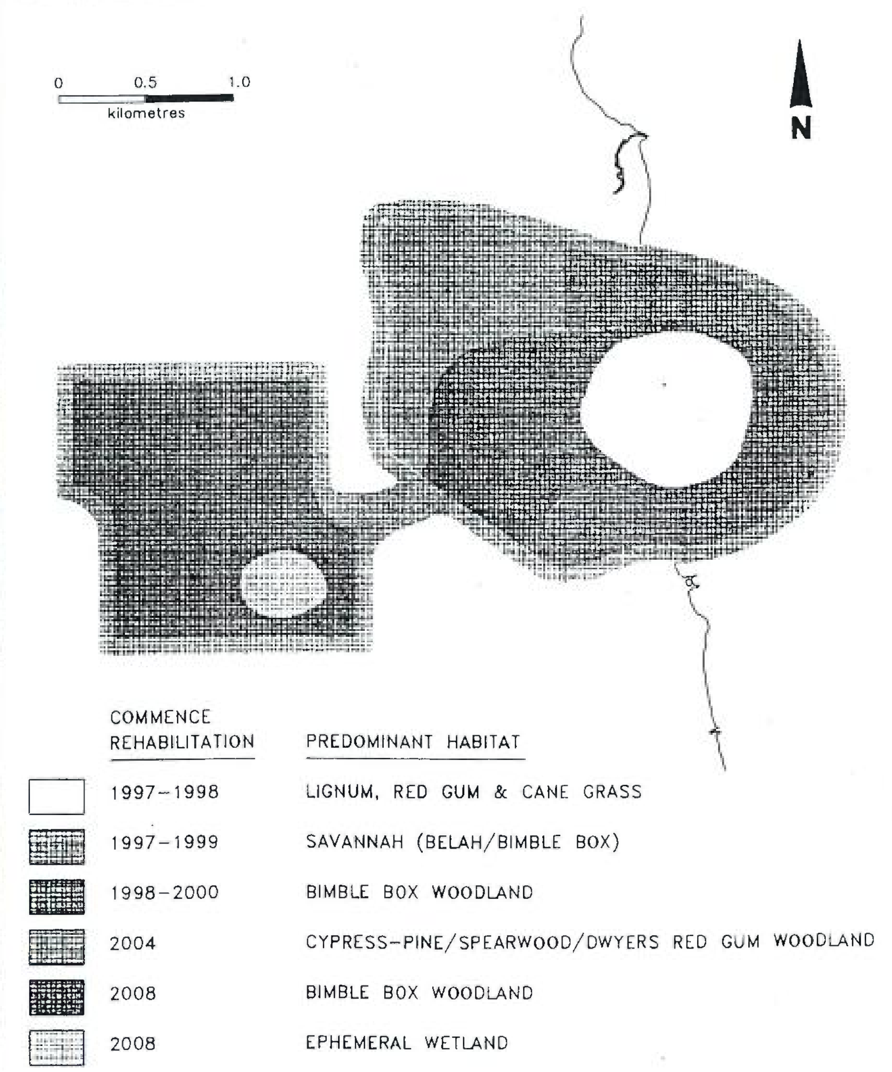

Figure 6.1 Plan schematic of progressive rehabilitation

bund and the tailings storage embankments will already have been flattened as shown during initial construction.

Outer Perimeter Bunding: Dryland Sector

The outer embankments will have been completed so as to avoid concentration of runoff that would require special drainage structures. Erosion should not occur at the average final slope of 1:4 after revegetation. Monitoring during the 11 years of the project will confirm this; erosion problems will be remedied by additional drains, if necessary.

Outer Perimeter Bunding: Riparian Sector

Comparison of the waterbirds associated with the four monitoring transects shows Transect T2 attracts the most diverse assemblage of species. Transect T2 comprises extensive shallows with Lignum and has been adopted as the model for rehabilitation of the nearshore zone around the pit protection bund.

When the perimeter bund surface around the pit has stabilised, the cofferdam will be reshaped as a series of islands and shallows for waterbird habitat (Plate 6.2; Figure 6.2). The new land–lake interface comprising the cofferdam, pit protection bund and unaltered sections of the existing shoreline will be revegetated with Cane Grass, River Red Gum and Lignum (in a range of microhabitats in general accordance with paragraph 20 of Appendix H, p. 7).

Evidence from existing shoreline earthworks is that the land-forming for waterbird habitat will be successful. For example, the flooded crab-claw feature to the south of the pit is a farm dam when the lake is low (the photograph in Plate 6.2 was taken from this structure; it can be seen on the shoreline to the south of the pit on Figure 3 of the Executive Summary); similarly, the channel excavated by North Exploration for boat access has remained stable through rainfall and wave action.

Perimeter Waste Emplacement
The perimeter waste emplacement will be revegetated with *E. populnea* (Bimble-box) woodland.

Tailings Storage
The tailings cells will end up as low, flat-topped rises similar to the surrounding flat to gently undulating terrain. The re-establishment of Bimble-Box woodland is the provisional objective for Cells 1A, 2A and 2B. Cell 1B will be completed as a wetland.

The tailings facility has been sized to maximise desiccation and strength. This, in turn, minimises the period required to complete consolidation once tailings deposition has stopped (Plate 6.3) and minimises the time before the final beaches are strong enough to support trucks and other mobile machinery at the end of operations.

The advice of Cowling/RAOU (Appendix H) is that conservation values are generally better served by the dryland rehabilitation option (Plate 6.4), and this can be developed on three of the four tailings cells. The shallow vee to the central decant may be retained in these cells, with the decant towers removed and drainage provided to Cell 1B. Cell 1B will be completed as an ephemeral

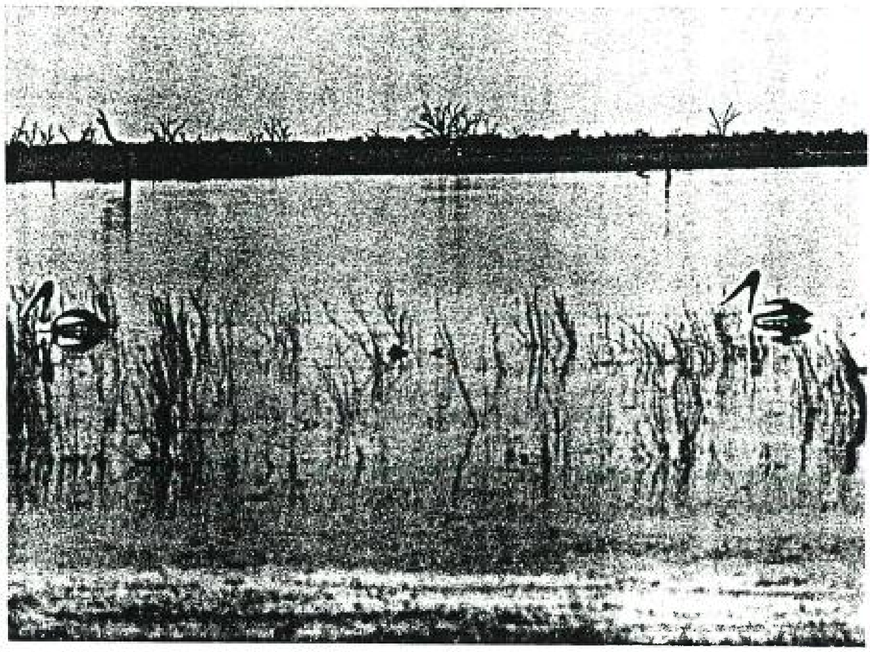

Plate 6.2 Shallows and island waterbird habitat can be established in the lake offshore from the pit protection bund. With the currently cleared shoreline (at back) revegetated, the overall habitat quality can be improved

wetland. Alternatively, the three dryland cells may be completed as a domed surface, either by reworking the tailings, or by adding a cover of soft waste from stockpiles, or by altering the tailings deposition regime in the final stages of deposition in each cell (Plate 6.5).

Regardless of whether the three dryland cells are completed as a vee or as a dome, runoff from each will be directed to the fourth cell (1B).

Water quality in all four cells will be good. Residual cyanide species in the tailings will either degrade or report as metal cyanide compounds that are insoluble, of low biological availability and of low environmental risk. Emergent vegetation in the wetland cell will help to settle suspended solids.

Design details for the decommissioning of the tailings cells will be finalised in consultation with government agencies under MREMP procedures (see Section 7.2).

Main Waste Emplacement
The main waste emplacement will be completed to a rocky habitat similar to what occurs naturally on the hills and ridges along the western shores of Lake Cowal. (in accordance generally with paragraph 16 of Appendix H, p. 7) Hard, non-acid-forming, low-salinity waste material will be available run-of-mine in Years +6 and +7 for this purpose.

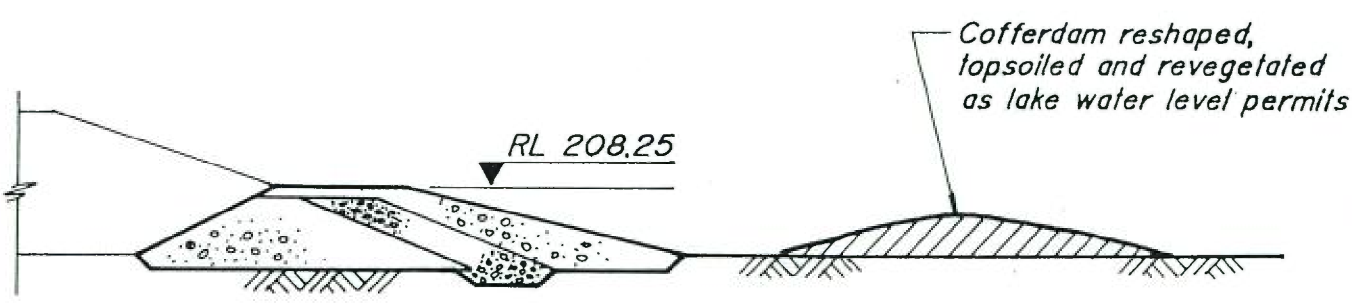

Figure 6.2 Pit protection bund and cofferdam decommissioning: waterbird habitat

The main waste emplacement abuts the lower elevations of Cowal West Hill, which is currently an open *Callitris glaucophylla* (White Cypress-pine) woodland (Plate 6.6). This community will be extended to the upper slopes and top of the emplacement, which will be completed as a rocky feature (Plate 6.7) similar to the higher hills in the area, with a similar flora of *Eucalyptus dwyeri* (Dwyers Red Gum) and *Acacia doratoxylon* (Spearwood).

This type of community has colonised old mining areas at Billys Lookout (Plate 6.8; see also Transect 19 in Table 3 of Appendix F).

Eucalyptus populnea (Bimble Box) will colonise the lower elevations. Drainage from the waste emplacement can be directed to Lake Cowal (if quality permits, as expected) or can remain directed to the pit (which is its ultimate destination under severe rainstorms during operations). In the latter case, the pit will be able to accommodate the 100-year ARI, 72-hour rainstorm runoff from the main waste emplacement (234 ML), tailings storage (364 ML), perimeter bund internal drainage (117 ML), pit surround (143 ML) and the pit itself (104 ML). This totals 962 ML and would raise the lake level in the pit by less than a metre (Coffey, 1995f).

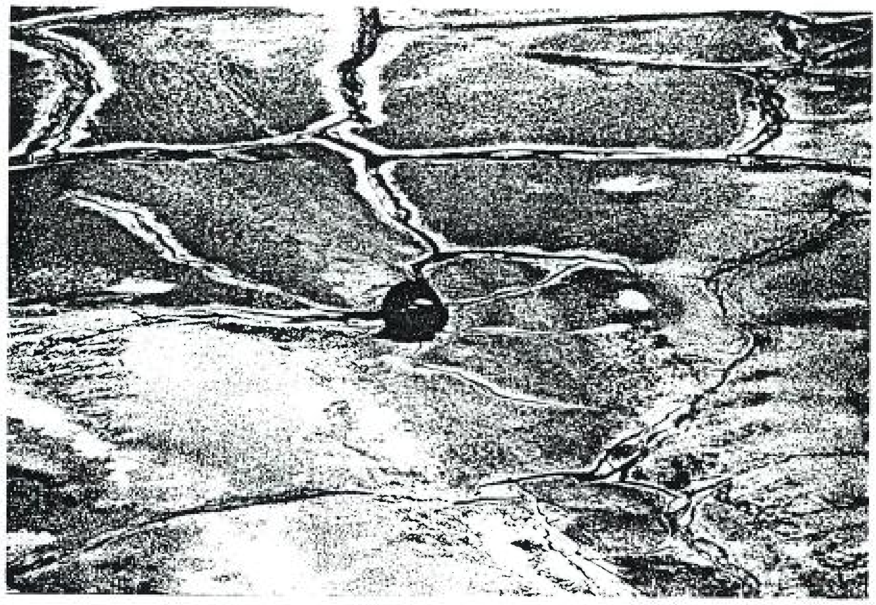

Plate 6.3 Example of air drying and consolidation of a completed tailings beach (Northparkes Mines)

Pit

The pit will be decommissioned by stopping the borefield pumps when the processing of the low-grade stockpile is complete. The existing, 2-m safety berm around the perimeter will be retained, and a lookout will be established.

A lake will form in the pit from groundwater and rainfall runoff (Plate 6.9).

The pit will provide approximately 25 m of cliff wall habitat for raptors and other birds, bats, and reptiles.

The lake in the pit will be saline. Investigations will be carried out to determine if the lake could be developed for recreational use or the stocking of fish.

General Site and Infrastructure Rehabilitation

At the conclusion of mining and ore processing, the principal other areas requiring decommissioning and rehabilitation areas are:

- Plant site.
- Mining contractor's yard.
- Borefield and water supply pipeline.
- Powerline.
- The access road and haul roads.
- The run-of-mine ore stockpile site.
- Low-grade stockpile area.
- Other sites of project activity.

David Schlunke

Plate 6.4 The nest and eggs of the Painted Quail, a ground-dwelling bird severely reduced regionally by bush clearing. This nest is in remnant Dwyers Red Gum woodland on the hill next to the Temora Mine. The Painted Quail has now moved into areas replanted as part of the mine's rehabilitation program

In general, all buildings, processing facilities and mobile equipment will be removed, and concrete foundations will be buried.

All compacted areas will be ripped and all drillholes filled in or capped. All remaining stockpiled topsoil will be spread.

Facilities or infrastructure of possible use, such as the borefield pipeline or powerline, can be retained if required.

After removal or burial of structures and equipment, these areas will be tidied up, levelled and prepared for revegetation. In the mine area, this will generally be to Bimble Box woodland.

6.5.2 Topsoil Volume

The recommended stripping depth for Soil Units A and B (100 mm: Appendix L) provides a total volume of topsoil over the project area of 68,000 m^3.

In the generally flat terrain, a recovery loss of 15% would be conservative. This gives a volume available for respreading of approximately 57,800 m^3, with possibly some minor increases from the incorporation of subsoil with topsoil during the stripping process, which is undesirable but difficult to avoid.

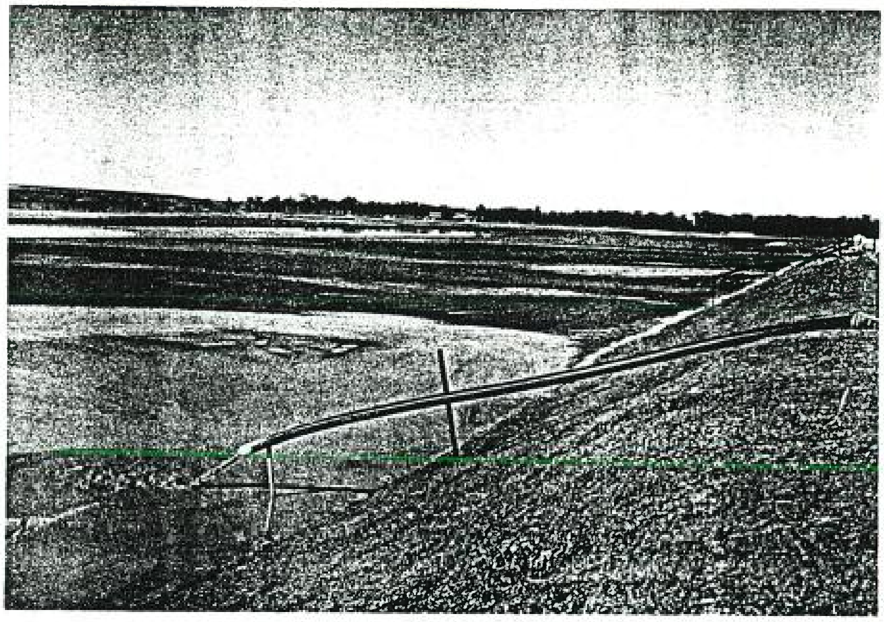

Plate 6.5 Tailings deposition cycling in a multiple cell system can be changed from each cell in turn (entire perimeter) to all cells (from two embankments only). This would convert the vee falling to the central decant into a uniform slope across the entire facility

The available topsoil spread over the completed waste emplacements (252 ha), low-grade stockpile (45 ha) and three tailings cells (180 ha) would therefore provide nominal cover of about 120 mm.

In practice, North will spread topsoil to the recommended depth of 100 mm as soon as possible after stripping, so as to derive maximum effectiveness from the soil organisms and seed. This would apply to all early-stage rehabilitation.

The balance of stored topsoil would remain available for later-stage rehabilitation, but its effectiveness would be reduced.

6.5.3 Vegetation Clearance and Topsoil Handling

North will protect the utility of topsoil for rehabilitation as follows:

- Areas to be stripped will be identified and flagged, so that operators know where to clear and which areas are to be left alone.
- Seeds of groundcover species (grasses and herbs) incorporated into the stripped biomass and topsoil will promote fast revegetation where the soil can be spread immediately.
- Stripping will be restricted to the minimum area necessary to allow operations to advance.

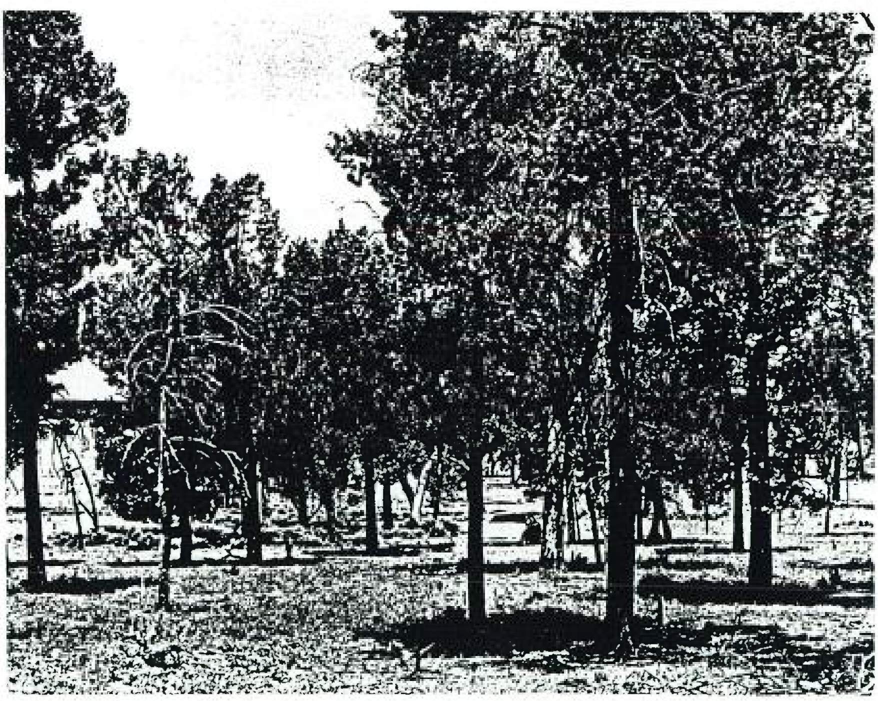

Plate 6.6 White Cypress-pine woodland on Cowal West Hill will be conserved and extended to colonise completed upper faces, and possibly the top, of the main waste emplacement

- Prior to recovering topsoil, trees will be removed and placed as dead-log microhabitat.
- Topsoil will be stripped by scraper, where practicable, to maintain a precise stripping depth.
- Topsoil will be respread as soon as possible after collection or placed in long-term stockpiles.
- Stockpiles will be located near but outside the area where they will be used.
- Topsoil stockpiles will be low (<2 to 3 m tall), to minimise compaction and loss of structure, and will be flat-topped, so that seeds germinate and grow and thereby slow the deterioration of stockpiled soil quality.

6.5.4 Surface Preparation

The surfaces of flat areas to be rehabilitated will be ripped across-slope to promote rainfall infiltration and reduce runoff and erosion.

Plate 6.7 Example of natural (self-sown) regrowth on rocky mine waste emplacement at Ardlethan, New South Wales. A more complete cover could be achieved by active measures

Compacted areas will be more fully ripped.

The conditions created by fertilising and irrigation are unsustainable in the long term, and there will be no broadacre application of these methods. However, there may be some application for fertiliser in special cases, such as trials of the direct revegetation of tailings.

6.5.5 Fire

Newly vegetated areas will be protected from fire. When trees have become established sufficiently to set seed, prescribed cool burns may be required to reduce the wildfire hazard and protect fire-susceptible communities, such as Lignum.

6.5.6 Sediment Control during Construction

Settling ponds will be constructed at the start of the construction phase, so that settleable solids eroded from active construction faces of the perimeter bunding are retained.

No settling ponds will be constructed for the lake section of the bund because the cofferdam will provide this function. The cofferdam will not be reshaped until the pit protection bund and corresponding section of the perimeter bund have been completed and rehabilitated.

6.6 Rehabilitation Monitoring and Research

6.6.1 Routine Monitoring

Sites of rehabilitation will be monitored. Routine monitoring results will be integrated with the results of formal experimental trials (see Section 6.6.2), and subsequent rehabilitation work will be modified accordingly.

6.6.2 Rehabilitation Trials

Rehabilitation trials will be established on already disturbed ground and on test cells of tailings early in project development to determine the following:

- Success of seeds of different mixes.
- Surface treatments and revegetation methods.
- Techniques aimed at reducing the requirement for topsoil by direct tubestock planting into weathered waste rock or tailings.
- Feasibility of growing grain crops on tailings.

In addition, Cowling/RAOU (Appendix H) recommend a number of habitat enhancement measures for experimental development:

- Boxes and artificial hollows as nest sites.
- Conservation of logs and ground debris.
- Cliff, rock crack and ledge habitat.
- Re-introduction of regionally extinct species.
- Exclosure plots to remove the influence of feral animals.

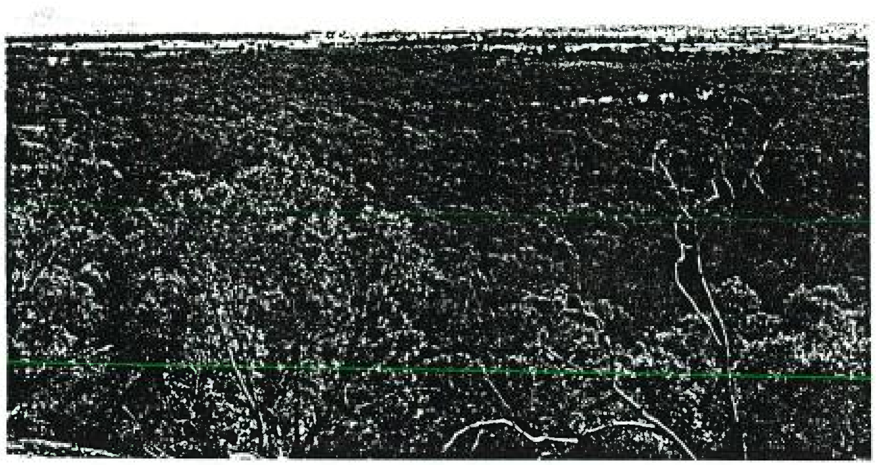

Plate 6.8 Natural (self-sown) post-mining regrowth (foreground) on Billys Lookout

6.7 Detailed Rehabilitation Plan and Implementation

The principles and concepts presented in this section will be translated by the first mining, rehabilitation and environmental management plan (MREMP: see Section 7.2) into a specific plan and schedule during the detailed design phase of the project. Construction is the period of greatest topsoil availability, and the integration of topsoil salvage with stripping and earthworks will be the plan's immediate priority. Implementation of the plan will begin at the start of construction.

The MREMP process will develop detailed landform/drainage/habitat plans for areas coming up for completion and rehabilitation.

6.8 Decommissioning and Long-term Outlook

An impression of the rehabilitated project area is given in Figure 6.3. The waste emplacements will be finished to an irregular skyline, and this will become progressively redefined by the regrowing vegetation. Similarly, the tailings storage will assume the profile of the plants growing on its surface and embankments.

The final slopes and elevations are similar to what occurs in the natural landforms in the hinterland of the western shore of Lake Cowal. Therefore, while the underlying geometry will always be discernible to close inspection, the general appearance of the surface structures will soften over time.

The open pit void will remain as the main visual evidence of mining (see Plate 6.9). It will be visible from the air, from the tops of adjacent waste emplacements or at ground level from the top of the safety bunds, and from more distant lookouts (see Section 4.13, Visual Amenity).

The evidence of farms and other operating mines in this climatic and geological environment is that the rehabilitation objective can be attained. On agricultural land, success is readily achieved; for example, at Northparkes Mines (1995) and at the Lake Cowal properties 'Lakeside' and 'Laurel Park'. River Red Gum regenerates naturally around Lake Cowal whenever water conditions suit; this and other species (such as White

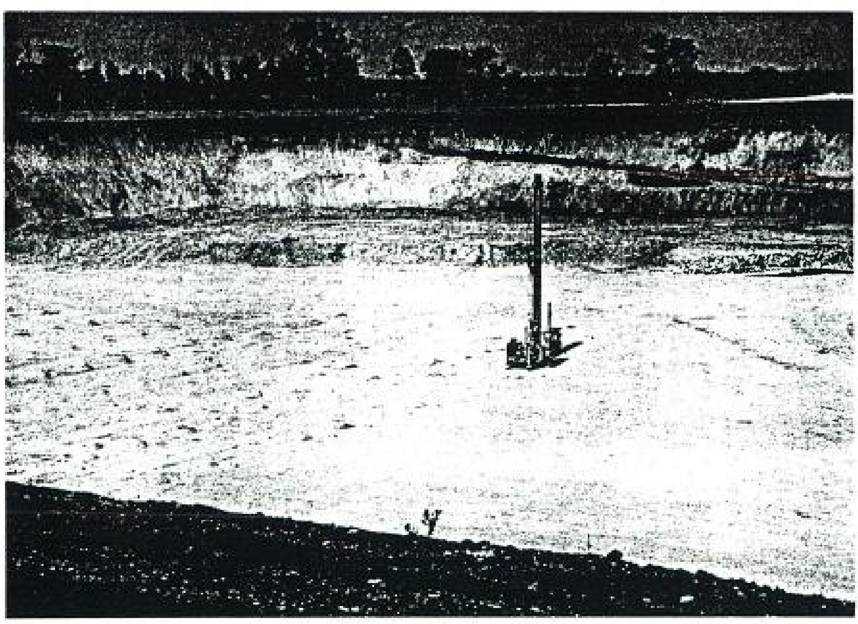

Plate 6.9 With the rocky floor becoming the surface of a lake, the final void will look not dissimilar to this (Northparkes Mines)

Cypress-pine) have to be actively suppressed to prevent their recolonisation of grazing land. Mining landforms properly constructed also enjoy similar success (Climax, 1995). In general, the passage of time will bring a modified ecosystem having habitat value for plants and animals (Plates 6.10 and 6.11).

Similarly, there are a number of examples of island-and-shallows habitat along the western shoreline of Lake Cowal (Plates 6.12 and 6.13). Many of these have been created by agricultural improvements, such as farm dams. These landforms indicate that the cofferdam decommissioning proposal is feasible.

The expectation of successful habitat re-establishment applies even to the cliff habitat created by completed open pits: at the Temora Gold Mine, three pairs of Peregrine Falcon have nested successfully. There are a number of other creatures, such as swallows and bats, whose range covers the project area, but who do not occur there now because their specialised habitat requirements are not met, and they could move in.

6.9 Options

6.9.1 Agriculture vs Conservation

The general allocation of rehabilitated areas to conservation or agriculture will be primarily determined by land capability. Some areas will have potential for both, and the choice will be made according to local community preference. North will develop options in detail and facilitate the public review.

6.9.2 Filling in the Pit

The pit cannot be filled in as an integral part of the mine plan. It can only occur by double-handling waste material already mined, placed, and rehabilitated. It is of questionable environmental benefit: established rehabilitation would be destroyed; the evaporation that would keep the groundwater level at the pit lake level (some 25 m below the pit rim) could not occur, and groundwater levels would rise. Ultimately, the water table would rise to its piezometric level (above the present land surface) and would need to be contained by the inside face of the perimeter bund. In addition, the original topography could not be restored, as the tailings storage structures would remain and swelling on excavation makes it impossible for the pit to hold all the material originally mined from it.

In any event, the cost of returning mined material to the pit would make the project infeasible.

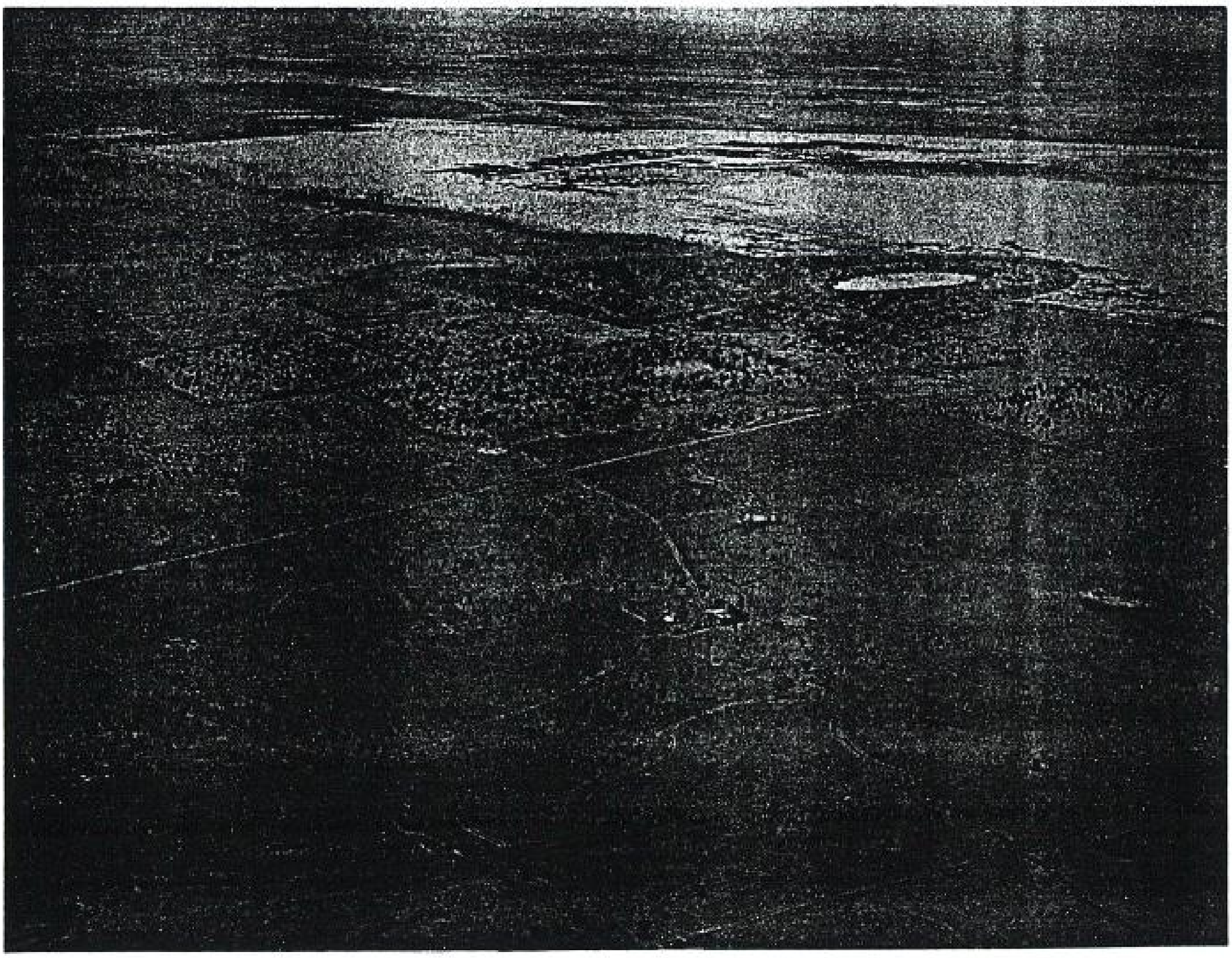

Figure 6.3 Impression of project area after rehabilitation

Plate 6.10 Stock exclusion has achieved this regrowth on Transect 62 (see Appendix F). Species include Eucalyptus populnea *(Bimble Box),* E. microcarpa *(Western Grey Box),* Acacia decora *(Western Golden Wattle) and* Callitris glaucophylla *(White Cypress-pine)*

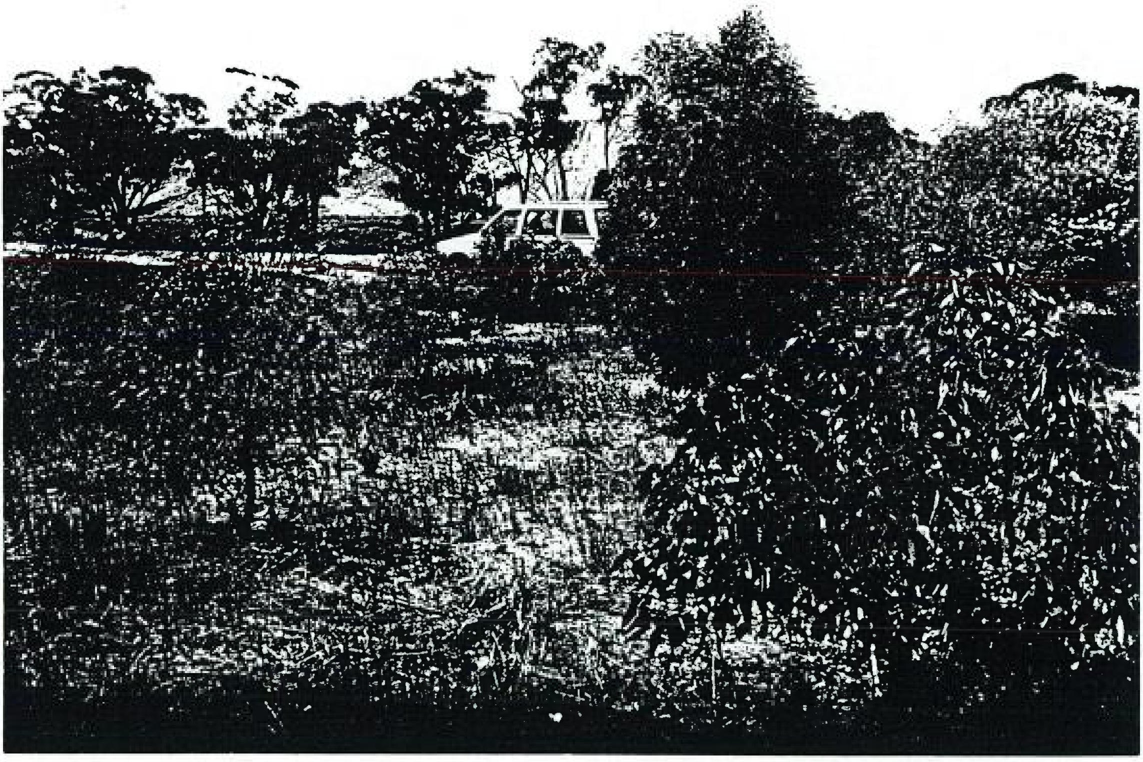

Plate 6.11 Regeneration on completed tailings storage cells at the Temora Gold Mine

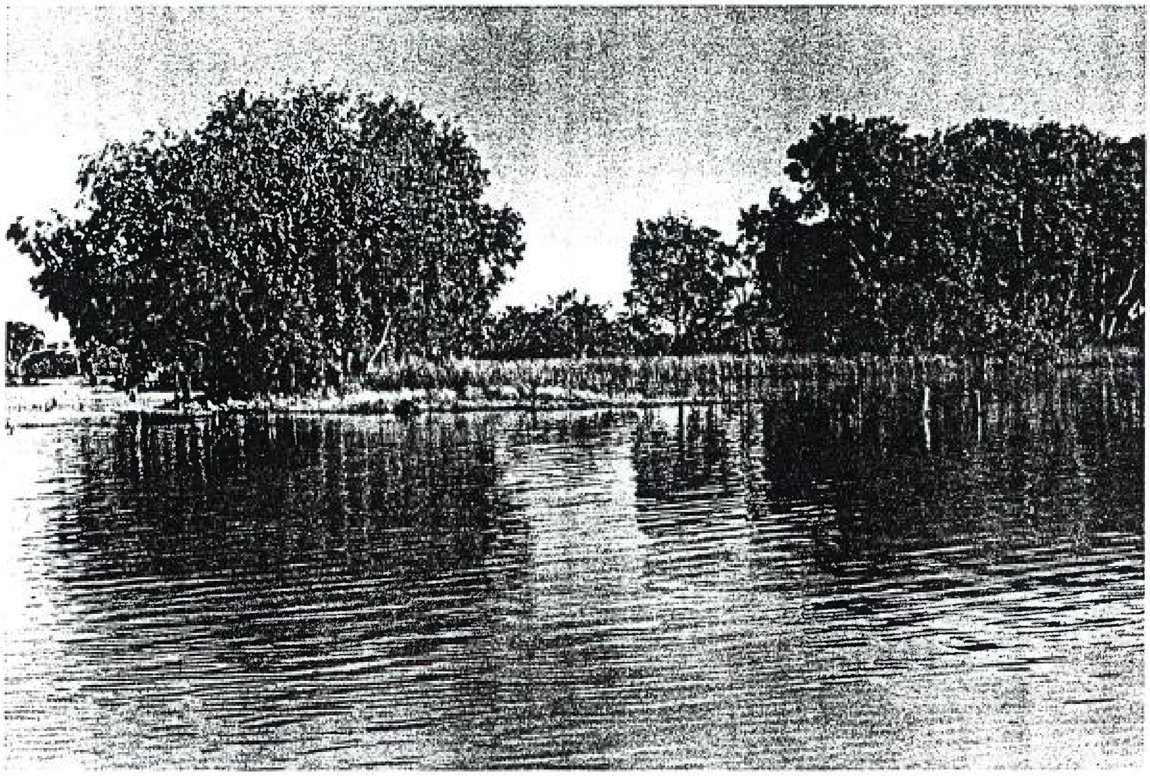

Plate 6.12 Flooded farm dam in Lake Cowal to the north of the project area provides an example of the type of island-and-shallows habitat to be created by reshaping the decommissioned cofferdam

Plate 6.13 Artificial islands-and-shallows with Lignum

LAKE COWAL GOLD PROJECT

NORTH MINING LTD

FAUNA IMPACT STATEMENT

APPENDIX 11

QUALIFICATIONS AND EXPERIENCE OF THE AUTHOR

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33 King William St Greenwich NSW 2065.
phone: 02 - 439 5436 fax: 02 - 439 7770

ACADEMIC QUALIFICATIONS :

BSc with 1st class Honours, University of NSW, 1977.

EMPLOYMENT HISTORY :

1975 to 1979	-	Technical Officer (research assistant) School of Biological Science, UNSW.
1979 to 1990	-	Professional Officer (assistant researcher) School of Biological Science, UNSW.
1983 to 1989	-	Principal Environmental Consultant and Partner, Gunninah Consultants.
1989 to present	-	Director and Principal, Gunninah Holdings Pty Ltd, environmental consultants.
1989 to 1992	-	Scientific Associate of the Zoological Parks Board of NSW at Taronga Zoo.
1990 to July 1991	-	Research Fellow, Platypus Breeding and Conservation Research Program, the Conservation Research Centre, Taronga Zoo.
1990 to present	-	Visiting Fellow, School of Biological Science, UNSW.

RELEVANT EXPERIENCE and EXPERTISE :

Research field trips for UNSW from 1974 to 1990, throughout NSW, South Australia, Queensland and the Northern Territory, studying the native vertebrate fauna of Australia.

Micro-computer programming (the development of dedicated programs for biological research) and the use of micro-computers for data analysis and report preparation.

Wildlife illustration (three books published) and photography of native wildlife.

Conference convenor - an international workshop on Platypus Conservation at Taronga Zoo, 1988, to discuss the directions for future research into the biology of the Platypus and methods for the management of the species in captivity.

RELEVANT EXPERIENCE and EXPERTISE (continued):

Design of research studies and development of research techniques and equipment, including electronic and data acquisition equipment, radio-tracking techniques, design and implementation of research programs on the conservation and captive management of the Platypus. This last program involved the identification of land use practices throughout the range of the Platypus and analysis of their impacts, determination of the effects of pollutants, erosion and waterway controls on the species, assessment of the habitat and food requirements of the Platypus, analysis of the environmental limitations of Platypus in the wild, and determination of the appropriate captive maintenance techniques for this species.

Management of environmental consulting business (Gunninah Consultants), involved in biological and physical environment assessment, Environmental Impact Statement and Fauna Impact Statement preparation, impact analysis, environmental management, and ecosystem management for rare species, presentation of expert evidence at Commissions of Inquiry and in the Land & Environment Court.

Design, co-ordination and supervision, and execution of fauna and flora surveys and of natural resource surveys, ranging from one-day surveys of the fauna and flora of proposed developments to broad conservation assessments of large areas - one thousand to one million hectares (for example, proposed logging operations in southeastern and northeastern NSW, proposed army bases in NSW). Surveys have involved soils analysis, vegetation and wildlife identification and assessment, habitat evaluation, pollutant identification and assessment, recommendations regarding impact amelioration, and the design of management options.

Research, compilation, writing and presentation of consulting reports (from 5 to 300 pages), promotional material (for the Conservation Research Centre at Taronga Zoo), a journal (production editor of the *Australian Biologist* Special Issue 1990), a workshop proceedings and scientific research papers.

Author and illustrator of books on Australian animals, including two on the Platypus.

RESEARCH INTERESTS :

Conservation and habitat management of the Platypus and other native fauna (particularly the Koala and kangaroos).

The ecology, environmental requirements and life histories of native fauna.

Computing and technology in biological research, including the application of GIS and other remote-sensing techniques, and the development and application of radio-telemetry for biological survey and research.

The development of methods for environmental survey.

PROFESSIONAL :

Member of the Australian Institute of Biology - MAIBiol
member of Executive and Chairman of Credentials Committee (1989/91),
Deputy Registrar (1991/92).

Member of the Environment Institute of Australia - MEIA
member of committee to establish Professional Credentials for Environmental Practitioners (1991).

Member of - the Ecological Society of Australia,
the Royal Zoological Society of NSW,
the Royal Australasian Ornithologists Union,
the Australian Wildlife Management Society,
the Australian Mammal Society (past Executive Member & Treasurer).

Past Scientific Associate of the Zoological Parks Board at Taronga Zoo.
Visiting Fellow in the School of Biological Science at the University of NSW.

PUBLICATION LIST

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CONSULTANCIES

Additional publications include the majority of consultancy reports on projects listed in the *Projects List* for GUNNINAH CONSULTANTS.

BOOKS

Illustrator of

Monotremes and Marsupials by TJ Dawson. Edward Arnold. 1983.

The Platypus by TR Grant. NSW University Press. 1984, 1989.

Author and illustrator of

Platypus published by Houghton Mifflin. 1991.

SCIENTIFIC PAPERS

Fanning FD. 1977. Temperature regulation of the Australian water rat, *Hydromys chrysogaster*. Honours thesis, University of NSW.

Fanning FD and Dawson TJ. 1977. Is *Hydromys* really a water-rat ? *Aust Mamm Soc Bull* **4(1):** 25.

Fanning FD and Dawson TJ. 1978. Thermoregulation of the Australian water rat, *Hydromys chrysogaster*. *Aust Mamm Soc Bull* **5(1):** 19.

Dawson TJ, Fanning FD and Bergin TJ. 1978. Metabolism and temperature regulation in the New Guinea monotreme *Zaglossus bruijni*. *Aust Zoologist* **20(1):** 99-103.

Dawson TJ, Grant TR and Fanning FD. 1979. Standard metabolism of monotremes and the evolution of homeothermy. *Aust J Zool* **27:** 511-515.

Fanning FD. 1980. Nests of the Feathertail glider, *Acrobates pygmaeus* (Burramyidae: Marsupialia), from Sydney, New South Wales. *Aust Mammal* **3:** 55-56.

Fanning FD and Watkins KM. 1980. Growth and development in *Acrobates pygmaeus* (Burramyidae: Marsupialia). *Aust Mammal* **3:** 57-69.

Fanning FD and Dawson TJ. 1980. Body temperature variability in the Australian water rat, *Hydromys chrysogaster*, in air and water. *Aust J Zool* **28:** 229-238.

Fanning FD and Dawson TJ. 1980. Thermal energetic problems of a small semiaquatic mammal, *Hydromys chrysogaster*. *Aust Mamm Soc Bull* **6(2):** 33-34.

Dawson TJ and Fanning FD. 1981. Thermal and energetic problems of semiaquatic mammals: a study of the Australian water rat, including comparisons with the platypus. *Physiol Zool* **54(3):** 285-296.

SCIENTIFIC PAPERS continued

Fanning FD. 1982. Reproduction, growth and development in *Ningaui* sp. (Dasyuridae: Marsupialia) from the Northern Territory. pp 23-37 in *Carnivorous Marsupials*. Archer M (ed). Royal Zool Soc NSW, Sydney.

Whitford D, Fanning FD and White AW. 1982. Some information on reproduction, growth and development in *Planigale gilesi* (Dasyuridae: Marsupialia). pp 77-81 in *Carnivorous Marsupials*. Archer M (ed). Royal Zool Soc NSW, Sydney.

Fanning FD and Dawson TJ. 1984. Insulative components of the thermal balance of semiaquatic mammals. pp 319-322 in *Thermal Physiology*. Hales JRS (ed). Raven Press, New York.

Fanning FD. 1988. Australia's Mr Platypus. *Aust Geographic* **12:** 64-65.

Fanning FD and Dawson TJ. 1989. The use of heart rate telemetry in the measurement of energy expenditure in free-ranging Red Kangaroos. pp 239-244 in *Kangaroos, Wallabies and Rat-kangaroos*. Grigg G, Jarman P and Hume I (eds). Surrey Beatty & Sons, Sydney.

Lutz PL, Dawson TJ, Bonnet E and Fanning FD. 1989. Oxygen affinities of Monotreme blood: Hypoxic adaptations. *J Exp Zoology* **251:** 285-289.

Wicken AJ and Fanning FD. 1989. The Australian Institute of Biology and a Biological Council of Australia: Their Roles and Relationships. *Australian Biologist* **2**(3): 15-18.

Fanning FD and Hughes RL. *In press*. Unearthing more questions than answers. In *Strategic Planning for Conservation I: The Platypus*. Woodside DP and Fanning FD (eds). CSIRO Publications, Melbourne.

Woodside DP and Fanning (eds). *In prep. Strategic Planning for Conservation I: The Platypus. Proceedings of a Symposium at Taronga Zoo*. CSIRO Publications, Melbourne.

Fanning FD, Woodside DP and Kotlash A. *in prep*. Habitat Criteria and Platypus Populations: A Modelling Approach.

Hawkins M and Fanning FD. 1992. Courtship and mating behaviour of captive Platypuses at Taronga Zoo. In Augee ML (*ed*). *Platypus and Echidnas*. Royal Zoological Society of NSW, Sydney.

GUNNINAH CONSULTANTS

ENVIRONMENTAL ASSESSMENT and MANAGEMENT in the BIOLOGICAL and PHYSICAL ENVIRONMENT

REPORTS and PUBLICATIONS

1983

Fauna survey for proposed open cut mine extension near Warkworth, Hunter Valley. Buchanan Borehole Collieries.
Prepared for Dames & Moore, Sydney.

Preliminary survey of flora and fauna along proposed rail link from Glenfield to East Hills.
Prepared for Dames & Moore, Sydney.

1984

Flora and fauna survey on a proposed hard rock quarry at Seaham Hill, near Raymond Terrace, NSW.
Prepared for BMI Limited.

Fauna survey - Grain Handling Facility at Port Kembla inner harbour.
Prepared for Dames & Moore, Sydney.

Preliminary fauna survey on proposed army training facilities southwest of Cobar, NSW.
Prepared for Dames & Moore, Sydney.

Preliminary fauna survey on proposed army training facilities northeast of Tamworth, NSW.
Prepared for Dames & Moore, Sydney.

1985

Army training facilities project, northwest of Cobar, NSW - Fauna Survey.
Prepared for Dames & Moore, Sydney.

Army training facilities project, schools training area, Bathurst/Orange, NSW - Fauna Survey.
Prepared for Dames & Moore, Sydney.

1986

Fauna survey for the F4 Freeway Section - Dog Kennel Road, Prospect to Coleman Street, Mays Hill.
Prepared for the Dept of Main Roads.

Fauna survey for BMI - Dunmore Quarry proposed extension.
Prepared for BMI Limited, Sydney.

1987

Wombats on the Hume Highway from Hoddles Crossroads to Marulan.
Prepared for the Dept of Main Roads.

1988

Tantawangalo State Forest Study Area - vegetation project.
Prepared for the Forestry Commission of NSW.

Tantawangalo State Forest South Study Area - fauna report. I. Terrestrial mammals with observations on arboreal species.
Prepared for the Forestry Commission of NSW.

Natural resource survey on the South Rockton section of Bondi State Forest, southern NSW.
Prepared for the Forestry Commission of NSW.

Natural resource survey on the North Rockton section of Bondi State Forest, southern NSW.
Prepared for the Forestry Commission of NSW.

1989

Fauna and flora survey, Palm Beach subdivision.
Prepared for Douglas Martin & Associates.

Wombats on the Hume Highway: a supplementary report.
Prepared for the Roads & Traffic Authority, NSW.

Nepean Dam flood protection measures - supplementary environmental surveys - preliminary report.
Prepared for the Water Board.

Nepean Dam flood protection measures - supplementary environmental surveys - final report.
Prepared for the Water Board.

Natural Habitats Study - Half Moon Farm, Hawkwesbury River.
Prepared for the Hawkesbury City Council and the Department of Planning.

A Natural Resource Survey of Rockton Section, Bondi State Forest. III. Birds, Reptiles and Amphibians.
Prepared for the Forestry Commission of NSW.

Widening of Forest Way: Vegetation Survey.
Prepared for the Roads & Traffic Authority.

1990

Fauna survey on a proposed bridge and approaches over the Woronora River between Sutherland and Bangor.
Prepared for the Roads & Traffic Authority.

Koalas in the Southeast Forests.
Prepared for the Forestry Commission of NSW and the National Parks & Wildlife Service of NSW.

1990 continued

An environmental survey of the Myanba Creek catchment in Coolangubra State Forest, southern NSW.
Prepared for the Forestry Commission of NSW.

Koala Surveys: Compartments 950 and 953, Tantawangalo State Forest.
Prepared for the Forestry Commission of NSW.

An environmental survey of the upper Wog Wog River catchment (Mines Road area) in Coolangubra and Nalbaugh State Forests, southern NSW.
Prepared for the Forestry Commission of NSW.

Duck Creek Survey for Parramatta City Council.
Prepared for Macquarie Park Research Ltd, Sydney.

Proposed Concrete Batching Plant, West Gosford: Fauna Survey and Environmental Assessment.
Prepared for DG Stevens and Associates, Sydney.

Platypus: Conservation Status and Future Management. Final Report.
Prepared for the Australian National Parks & Wildlife Service, Canberra.

Widening of Forest Way: Vegetation Survey. Hews Parade to Ralston Avenue.
Prepared for the Roads & Traffic Authority.

Report on Proposed Sand Mining at Sackville, NSW.
Prepared for Merit Apparel Pty Ltd.

Proposed Limestone Mine at Attunga, NSW.
Appraisal of EIS for Attunga Residents Action Group.

Proposed Canal Development at Dunbogan, NSW.
Appraisal of EIS for the Total Environment Centre.

Physical constraints to urban development. In Cardew, R. *Wyong Urban Growth Study.*
Prepared for the NSW Department of Housing.

Description and evaluation of potential release areas. In Cardew, R. *Wyong Urban Growth Study.*
Prepared for the NSW Department of Housing.

Aspects of the flood hazard on the Central Coast. In Cardew, R. *Wyong Urban Growth Study.*
Prepared for the NSW Department of Housing.

Implications of climatic change on urban growth on the Central Coast. In Cardew, R. *Wyong Urban Growth Study.*
Prepared for the NSW Department of Housing.

Survey of Vegetation along New Line Road.
Prepared for the Roads & Traffic Authority.

Gold Ridge Mine - Solomon Islands. Freshwater fauna survey and contaminant analysis.
Prepared for Douglas Martin & Associates.

Proposed Gunnedah Power Station - Gunnedah Coal Company. Report on flora and fauna surveys and assessment of potential environmental impacts.
Prepared for Douglas Martin & Associates.

1991

An environmental survey of the Stockyard Creek catchment in Coolangubra State Forest, southern NSW.
Prepared for the Forestry Commission of NSW.

An environmental survey of the Jingo Creek catchment in Nullica State Forest, southern NSW.
Prepared for the Forestry Commission of NSW.

AGL Site, Tennyson Road, Mortlake: A Fauna Survey.
Prepared for AGL.

Fauna and conservation study on Australian Defence Industries land at St Marys, western Sydney.
Prepared for Masterplan Consultants Pty Ltd.

Fauna and Flora study on SEPP 26 Littoral Rainforest at Crescent Head, NSW.
Prepared for Douglas Martin & Assocs Pty Ltd.

Environmental Guidelines for International Projects.
Prepared for AIDAB, through Environmental Services Australia.

Surveys for Koalas and other animals on coupes to be logged in the Tantawangalo State Forest in southeastern NSW.
Prepared for the Forestry Commission of NSW.

Surveys for Koalas along a roadline in the Tantawangalo State Forest in southeastern NSW.
Prepared for the Forestry Commission of NSW.

Fauna and Flora Surveys for a Gold and Antimony mine near Tamworth.
Prepared for Douglas Martin & Assocs Pty Ltd.

Resolution of land use conflict between Titanium-mining and 'endangered' fauna near Tea Gardens, NSW.
Prepared for Mineral Deposits Ltd.

Wombats on the Hume Highway: implementation of impact mitigation measures.
Prepared for the Roads & Traffic Authority, NSW.

Assessment of the native fauna and the potential impacts of the proposed construction of single dwellings on fourteen blocks in the Kedumba Valley.
Prepared for the Kedumba Pastoral Company Pty Ltd.
Presentation (expert witness) in Land & Environment Court.

1992

Interactions between Koalas and Roads: a Review and Assessment of Preventative Measures.
Prepared for the Roads & Traffic Authority, NSW.

Comprehensive fauna surveys in the State Forests of the Tenterfield District northern NSW.
Prepared for the Forestry Commission of NSW.

Fauna Impact Statement for Commission of Inquiry on a Titanium-mining venture at Saltwater, NSW.
Prepared for Mineral Deposits Ltd.

1992 continued

Submissions to the Commission of Inquiry on a Titanium-mining venture at Saltwater, NSW. Prepared for Mineral Deposits Ltd.
Presentation of expert evidence to Saltwater Commission of Inquiry.

Rehabilitation of SEPP 26 Littoral Rainforest at Crescent Head, NSW.
Ongoing: for J & B Debrincat.

Assessment of impact on fauna of a proposed subdivision at Avalon, Sydney.
Prepared for A B Holt, Sydney.

Assessment of impact on fauna of sand and soil extraction at Elderslie, Sydney.
Prepared for Johnstone Environmental Technology, Sydney.

Vegetation mapping and conservation assessment on rural land at Coolongolook, NSW.
Prepared for Riverford Homes Pty Ltd.

Assessment of impact on fauna of an export woodchip industry in NSW. Input into preparation of EIS for SEPL.
Prepared for Margules Groome Poyry Pty Ltd.

Assessment of impact on fauna of a proposed subdivision at Glenhaven, Sydney.
Prepared for Warren & Associates Pty Ltd.

Possible biological and hydrological impacts of the extraction of water from the Duck River, Sydney.
Prepared for Parramatta City Council.

Goulburn Wool Scour Ltd proposed wastewater management operation: assessment of environmental significance for native fauna and flora.
Prepared for Phil Warren and Associates Pty Ltd.

Assessment of impact on fauna of road widening on the Pacific Highway, between Port Macquarie and Taree.
Prepared for Roads & Traffic Authority, NSW.

Assessment of impact on vegetation of road widening along New Line Road, Cherrybrook.
Prepared for Roads & Traffic Authority, NSW.

Assessment of impact on fauna of proposed Titanium-mining operation on Moffats Dune near Raymond Terrace, NSW.
Prepared for RZM Pty Ltd.

Advice on fauna requirements for a proposed house at Corrimal, NSW.
Prepared for Unisearch Ltd.

Management of wildlife issues on Australian Defence Industries land at St Marys, western Sydney.
Ongoing; for Australian Defence Industries.

EIS studies on fauna and flora impacts of a chemical laboratory development at Wagga Wagga, NSW.
Prepared for Warren & Associates Pty Ltd.

Assessment of impact on fauna of proposed subdivision at Kenthurst, Sydney.
Prepared for Peter M McCartney Pty Ltd.

Assessment of impact on fauna of proposed subdivision at Annangrove, Sydney.
Prepared for Peter M McCartney Pty Ltd.

1993

Monitoring of the impacts of a Titanium-mining operation on the Eastern Chestnut Mouse, and recolonisation of mined land by fauna, Hawks Nest, NSW.
Ongoing: for Mineral Deposits Ltd.

Monitoring of Platypus populations above and below a major dam expansion project in northern NSW, at Pindari Dam near Inverell.
Ongoing for the NSW Department of Water Resources.

Management of wildlife issues on Australian Defence Industries land at St Marys, western Sydney.
Ongoing; for Australian Defence Industries (from 1992).

Rehabilitation of SEPP 26 Littoral Rainforest at Crescent Head, NSW.
Ongoing: for J & B Debrincat (from 1992).

Assessment of impact on vegetation, native fauna and fauna habitats of road widening along the Great Western Highway, Linden.
Prepared for the Roads & Traffic Authority, NSW.

Assessment of impact on fauna and fauna habitats of road widening along New Line Road, Cherrybrook.
Prepared for the Roads & Traffic Authority, NSW.

Assessment of impact on fauna of proposed Titanium-mining operation at Big Swan Bay near Lemon Tree Passage, NSW.
Prepared for RZM Pty Ltd.

Assessment of impact on fauna and fauna habitats in an SEPP wetland of a proposed retirement village at Toukley.
Report prepared for P J Donnellan, Solicitors, Gosford.
Presentation (expert witness) in Land & Environment Court.

Assessment of impact on flora, fauna and fauna habitats of a proposed water and sewerage treatment works at Fern Bay, NSW.
Prepared for CMPS&F Ltd, Sydney, and the Hunter Water Corporation.

Environmental Impact Statement of a proposed Titanium-mining operation near Stockton, NSW.
In preparation for Mineral Deposits Ltd.

Assessment of impact on fauna of proposed Titanium-mining at Nabiac, NSW.
In preparation for RZM Pty Ltd.

Review of fauna survey and report for proposed forestry operations in north coastal NSW.
Prepared for GHD Pty Ltd and the Forestry Commission of NSW.

Review of fauna surveys and assessment of impact on fauna of proposed development at North Bonville, NSW.
Prepared for GHD Pty Ltd.

Monitoring of the impacts of a Titanium-mining operation on the Queensland Blossom Bat, and recolonisation of mined land by fauna at Saltwater, NSW.
Ongoing: for Mineral Deposits Ltd.

Assessment of impact on fauna and fauna habitats of a proposed mining operation near Mt Isa, western Queensland.
Prepared for Placer Explorations Ltd, Sydney.

1993 continued

Preliminary assessment of impact on fauna and fauna habitats of a proposed tourist development on the Murray River, near Albury, NSW.
Prepared for Masterplan Consultants, Sydney.

Assessment of impact on fauna and fauna habitats of a proposed power transmission line between Lismore and Mullumbimby, NSW.
Prepared for Sinclair Knight Partners and Pacific Power.

Fauna and flora surveys; assessment of impacts of a proposed subdivision at Dural, NSW.
Prepared for Context Landscape Design and Australian Housing & Land.

Fauna and flora surveys and assessment of impacts of a proposed Telecom repeater tower in Kur-in-gai Chase National Park, NSW.
Prepared for Hirst Consulting Services and Telecom.

Assessment of impact on fauna of a proposed subdivision at Avalon, Sydney.
Preparation of evidence for presentation (expert witness) in Land & Environment Court.

Submissions on native fauna to a Commonwealth Commission of Inquiry on the Shoalwater Bay Area, Queensland.
In preparation for GEO-PEKO Ltd.
Expert evidence presented to the Commission of Inquiry.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of a proposed major bypass road at Bangor, western Sydney.
Prepared for the Roads & Traffic Authority, NSW.

Assessment of impact on vegetation, native fauna and fauna habitats of further road widening along the Great Western Highway, Linden.
Prepared for the Roads & Traffic Authority, NSW.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of road widening at Picton, NSW.
Prepared for RA Young & Assocs and the Roads & Traffic Authority, NSW.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of a realignment of the New England Highway near Murrurundi.
Prepared for GHD and the Roads & Traffic Authority, NSW.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats and heritage values of a proposed rail deviation at Banyabba.
Prepared for CMPS&F Ltd, and the State Rail Authority NSW.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats for the proposed expansion of a piggery near Scone, NSW.
Prepared for CMPS&F Ltd, Sydney.

Fauna survey and assessment of a proposed dwelling on land near Wyong, NSW.
Prepared for Unisearch, Sydney.
Expert witness in the NSW Land & Environment Court.

Review of Environmental Factors for vegetation disturbance in the eastern portion of the St Mary's site.
In preparation for Australian Defence Industries.

1993 continued

Assessment of the potential impacts of a proposed walking track on Dobroyd Head, Sydney Harbour National Park, NSW.
Prepared for the NSW National Parks & Wildlife Service.

1994

Ongoing:

Monitoring of Queensland Blossom Bat at Saltwater (Mineral Deposits Ltd).

Monitoring of Eastern Chestnut Mouse at Viney Creek (Mineral Deposits Ltd).

Monitoring of Platypus around Pindari Dam (DWR).

Monitoring rainforest rehabilitation at Crescent Head (Debrincat).

Management of wildlife and vegetation issues at St Marys (ADI).

Assessment of the potential impacts on fauna and flora of a proposed urban development at Pennant Hills, including a Bushland Management Plan.
Prepared for Masterplan Consultants.

Environmental assessment of a water supply augmentation scheme at Tumbarumba in southern NSW.
In preparation for the Public Works Department.

Fauna surveys on a potential coal mine extension in the Hunter Valley.
Prepared for Exxon and Sinclair Knight Partners.

Fauna surveys and impact assessment on a proposed quarry at Hartley, NSW.
Prepared for Hartley Pastoral Co and Sinclair Knight Merz.

Review of Fauna Impact Statement - Crown Land, Pambula.
Prepared for the National Parks & Wildlife Service.

Review of Fauna Impact Statement - development at Taree.
Prepared for the National Parks & Wildlife Service.

Fauna surveys and impact assessment on a proposed residential subdivision site at Byron Bay, NSW.
Prepared for Sinclair Knight Merz and Detala P/L.

Assessment of impact on fauna and fauna habitats of a proposed mining operation near Mt Isa, western Queensland.
Prepared for Placer Explorations Ltd, Sydney.

Impact assessment on native fauna for a proposed helipad at Arcadia, NSW.
Report preparation and expert witness in the Land & Environment Court.
Prepared for Emil Ford & Co, Sydney.

Assessment of significance for native fauna of a proposed development at City Hill, Coffs Harbour.
Prepared for Coffs Harbour City Council, NSW.

Survey of native fauna and flora and assessment of potential impacts of a housing development at Stonequarry Creek, Picton.
Prepared for J&N Davies, NSW.

1994 continued

Development of a Management Plan for a population of Green & Golden Bell Frogs at Rosebery, NSW.
Prepared for Meriton Apartments, Sydney.

Assessment of the potential impacts on vegetation, native fauna and fauna habitats of the Albury-Wodonga bypass along the Hume Highway.
Prepared for GHD and the Roads & Traffic Authority, NSW.

Urban development design to accomodate fauna issues, and preparation of a Fauna Impact Statement - North Bonville, NSW.
In preparation for KPMG Peat Marwick and BBH.

Impact assessment on native fauna and flora of proposed road widening, Eternity Corner, the Putty Road.
Prepared for the RTA and Rust PPK.

Impact assessment on native fauna and flora of proposed road widening and safety ramp on the Putty Road.
Prepared for the RTA and Rust PPK.

Fauna and flora surveys and impact assessment on 2 proposed residential subdivision sites at Blaxland, NSW.
Report preparation and expert witness in the Land & Environment Court.
Prepared for Michell Sillar, Sydney.

Survey of native fauna and flora and assessment of potential impacts of expansion of the Mount Thorley Coal Loader, NSW.
In preparation for Sinclair Knight Merz, Sydney.

Assessment of potential impacts on fauna and flora of proposed additional extraction at a limestone mine at Marulan, NSW.
Prepared for Sinclair Knight Merz, Sydney.

Fauna and flora surveys and impact assessment on a proposed residential subdivision sites at Blaxland, NSW.
Report preparation and expert witness in the Land & Environment Court.
In preparation for Michell Sillar, Sydney.

Fauna and flora surveys and impact assessment on a proposed tourist and golf course development at Cattai, NSW.
Prepared for Masterplan P/L and Elmsworth Australia Ltd.

Assessment of impacts on fauna and on flooding of quarrying operations and horse training facilities at Muskoka Farm, Gunderman, NSW.
Prepared for P J Donnellan & Associates, Sydney.
Statement of Evidence for the NSW Land & Environment Court.

Assessment of the potential impacts on native fauna and fauna habitats for a proposed Gold Mine Prospect at Lake Cowal, NSW.
Prepared for NSR Consultants and PEKO Ltd.

Environmental Impact Statement of a proposed Titanium-mining operation near Stockton, NSW.
In preparation for Mineral Deposits Ltd.

Fauna and flora assessment for a proposed Grafton water supply pipeline.
Prepared for Sinclair Knight Merz and Grafton City Council.

Fauna and flora surveys and assessment of a proposed quarry at Jugiong, NSW.
In preparation for Sinclair Knight Merz and Don Reed & Associates P/L.

1994 continued

Impact assessment on native fauna and flora of a proposed quarry at Windellama, NSW.
Prepared for Hirst Consulting P/L and Hallinan's Haulage.

Fauna Impact Statement for a proposed Golf Course at Pambula - Merimbula.
Prepared for Pambula - Merimbula Golf Club Limited.

Assessment of potential impacts on fauna and flora of continuing operations at the limestone mine at Marulan, NSW.
In preparation for Southern Blue Circle Cement and International Environmental Consultants Pty Ltd, Sydney.

Assessment of potential impacts on fauna and fauna habitats of the construction of a transmission line between Lismore and Mullumbimby, NSW.
Independent report and input into Environmental Impact Statement.
Prepared for Sinclair Knight Merz and Pacific Power.

Preparation of the Fauna Impact Statement for a transmission line between Lismore and Mullumbimby, NSW.
Prepared for Sinclair Knight Merz and Pacific Power.

Monitoring of the effects of discharges from Windamere Dam on Platypus populations in the Cudgegong River and the storage.
In preparation for the Department of Water Resources.

Consideration of the fauna and flora issues, and assessment of the potential impacts, for a proposed urban development at South Dural, Sydney.
Prepared for Masterplan Consultants and Cloudgard 135.

Management of disturbance to vegetation for site investigation and decontamination at the St Mary's facility.
Proceeding, for Australian Defence Industries.

Survey and assessment of vegetation at the St Mary's facility.
In preparation for Australian Defence Industries.

Assessment of potential impacts on fauna and fauna habitats of a proposed deviation of the Pacific Highway north of Raleigh near Coffs Harbour.
Prepared for Sinclair Knight Merz and the NSW Roads & Traffic Authority.

Fauna and flora surveys, and preparation of an Environmental Audit and Environmental Management Plan at the Myambat Logistics Co, Denman, NSW.
In preparation for Sinclair Knight Merz and the Department of Defence.

Assessment of the potential impacts on flora and fauna of a mining operation at Hillgrove, NSW.
Prepared for New England Antimony Mines.

1995

Ongoing:

Monitoring of Queensland Blossom Bat at Saltwater (Mineral Deposits Ltd).

Monitoring of Eastern Chestnut Mouse at Viney Creek (Mineral Deposits Ltd).

Monitoring of Platypus around Pindari Dam (DWR).

Monitoring of Platypus around Windamere Dam (DWR).

Monitoring rainforest rehabilitation at Crescent Head (Debrincat).

Management of wildlife and vegetation issues at St Marys (ADI).

Fauna and flora surveys and reports for a horse and pony trail in Ku-ring-gai Chase National Park, Sydney.
Prepared for the North Shore Horse & Pony Association.

Fauna monitoring for the construction of the M2 Motorway in Sydney.
In preparation for Abigroup/Obayashi.

Survey and tracking of the Squirrel Glider at Lake Macquarie (Caves Beach), and preparation of a Fauna Impact Statement.
In preparation for McCloy Developments P/L and Integrated Site Planning & Management.

Impacts of a proposed development at Byron Bay on endangered fauna: preparation of Statement of Evidence and appearance as an expert witness in the Land & Environment Court.
For Detala Pty Ltd.

Management Plan for fauna and flora - North Boambee valley urban release project.
In preparation for Coffs Harbour City Council.

Assessment of the potential impacts on flora and fauna of a proposed reconstruction of Delhi Road, between the Crematorium and the CSIRO Riverside Park.
Prepared for the NSW Roads & Traffic Authority.

Review of environmental factors and potential fauna impacts of proposed reservoir and aqueduct re-painting in Northern Sydney.
Prepared for Sinclair Knight Merz and the Sydney Water Corporation.

Preparation of the Fauna Impact Statement for existing and future operations of two Sand Mining Plants in the Tomago Sandbeds.
In preparation for RZM Pty Ltd.

Fauna Impact Statement for a proposed deviation of the Pacific Highway north of Raleigh near Coffs Harbour.
Prepared for Sinclair Knight Merz and the Roads & Traffic Authority.

Preparation of the Fauna Impact Statement for existing and future operations of a Sand Mining Plants at Hawks Nest.
In preparation for Mineral Deposits Ltd.

Assessment of the flora and fauna issues for an extraction site, Canoelands, including assessment of SEPP 44.
Prepared for Dames & Moore, Sydney.

1995 continued

Preparation of the Fauna Impact Statement for a residential development, Salamander Way.
In preparation for Salamander Projects Pty Ltd.

Preparation of the Fauna Impact Statement for a proposed Gold Mine Prospect at Lake Cowal, NSW.
In preparation for NSR Consultants and PEKO Ltd.

Assessment of the fauna issues for a proposed dam on the Perry River.
In preparation for Placer Pacific, Sydney and Environmental Management & Monitoring, Brookside.

Fauna and flora investigations for the upgrading of Elizabeth Drive (access to Badgerys Creek Airport). Input into Elizabeth Drive Environmental Impact Statement.
In preparation for Rust PPK Pty Ltd, Sydney.

Fauna and flora investigations for the Western Sydney Orbital - Prestons to Cecil Park. Input into Environmental Impact Statement for National Highway - Western Sydney Orbital.
In preparation for Rust PPK Pty Ltd, Sydney.

Fauna survey and impact assessment for a residential subdivision at Waterfall, including assessment of Sepp 44.
Prepared for Lean, Lackenby and Hayward, Sydney.

Assessment of the flora and fauna issues for a proposed development site, Padstow.
Prepared for Nuestein & Associates, Sydney and the Valuer General of NSW.

Fauna and flora investigations for a residential subdivision, Menai.
In preparation for Tivoli Developments, Sydney.

Assessment of the flora and fauna issues for a residential subdivision, Kellyville.
Prepared for Landcom, Sydney.

Fauna and flora investigations for a proposed coal washery waste emplacement site, Maddens Plains.
Prepared for Sinclair Knight Merz, Sydney and Metropolitan Colliery.

Fauna and flora investigations for the upgrade of the Federal Highway between Sutton, NSW and North Canberra, ACT.
Prepared for Ove Arup & Partners, Canberra and the Roads & Traffic Authority.

Fauna and flora investigations for the upgrade of a sewerage treatment plant, Morpeth.
Prepared for CMPS&F Environmental, Sydney.

Fauna investigations for a proposed deviation of Main Road #84, Binalong NSW.
Prepared for International Environmental Consultants Pty Ltd, Sydney.

Fauna investigations for a proposed golf course re-development, Katoomba, icluding assessment of SEPP 44.
Prepared for Masterplan Consultants and Noroton Holdings.

Fauna investigations for a proposed residential subdivision, Yarramundi, Coffs Harbour, including assessment of SEPP 44.
Prepared for Gutteridge, Haskins & Davey, Coffs Harbour.

1995 continued

Assessment of fauna issues for the Newington RANAD site, Sydney.
Prepared for NECS and the Department of Defence.

SEPP 44 Assessment Report for proposed residential development sites and associated drainage lines, Casula.
Prepared for Landcom, Sydney.

SEPP 44 Assessment Report for proposed residential development sites, Dural.
Prepared for Australian Housing & Land.

SEPP 44 Assessment Report for a proposed golf course extention, Pambula-Merimbula.
Prepared for Pambula-Merimbula Golf Club Limited.

SEPP 44 Assessment Report for a proposed subdivision, Cawdor.
Prepared for Dennis Smith.

SEPP 44 Assessment Report for a proposed residential development, Hoxton Park.
Prepared for Bellevale Homes.

SEPP 44 Assessment Report for a proposed residential development, Carnes Hill.
Prepared for Landcom.

Fauna and flora investigations for the Holsworthy Sewerage Scheme Transfer Environmental Impact Statement.
Prepared for Sinclair Knight Merz, Sydney.

Flora and fauna assessment for a Development Control Plan, Kings Beach, Tweed Shire.
Prepared for Sinclair Knight Merz, Sydney.

Flora and fauna assessment for the proposed Queanbeyan Bypass, ACT.
In preparation for Ove Arup & Partners, Canberra.

Lake Cowal Gold Project

Appendix B

WATERBIRD USAGE OF TAILINGS IMPOUNDMENTS

by

ERA Environmental Services
482 Stuart Highway, Winnellie NT 0821
Australia

for

NSR Environmental Consultants Pty Ltd
25 Burwood Road, Hawthorn 3122
Australia

August 1995

WATERBIRD USAGE OF TAILINGS IMPOUNDMENTS

LAKE COWAL

Prepared for: North Ltd
By: ERA Environmental Services Pty Ltd aryan:jd:0079 8/8/95

WATERBIRD USAGE OF TAILINGS IMPOUNDMENTS

1 BACKGROUND

The Lake Cowal Gold mine is a proposed gold mining and ore extraction project on the western shoreline of Lake Cowal. Lake Cowal is an ephemeral waterbody that serves as an important refuge for a number of birds including terrestrial and aquatic species.

The region is predominantly pastoral in a semi-arid climate. The Lachlan River is approximately 30 km to the north east and there are several intermittent creeks and channels running to and from the Lake.

Lake Cowal, on average, is dry three years out of ten and can be an area of high waterbird activity when sufficient water is present. The Lake Cowal Gold Project will have up to four tailings impoundments. These tailings impoundments will be 750 m x 750 m, although the actual surface area of exposed water will be considerably smaller. Tailings will be deposited by beaching and draining. Pond size (free water surface area) will be minimised to enable maximum recycle of water.

There is a paucity of relevant literature about the interaction of Australian waterbirds and mine tailings impoundments. As a consequence this preliminary survey was initiated. Information was collected via telephone conversations with relevant personnel at each mine and is based on their personal experience.

Norths' personnel approached several mines in New South Wales to document their experiences regarding waterbird usage of tailings impoundments. These mines are not dissimilar in location and climate to the proposed Lake Cowal Gold Mine.

In addition, ERA Environmental Services Pty Ltd was commissioned to survey mines in the Top End of the Northern Territory for observations of tailings impoundment usage by waterbirds. This region of Australia is renowned for its high levels of waterbird activity and in the "dry season " (April - November) can experience extended periods, usually six months, with no rainfall. Late in this season many natural waterbodies dry out resulting in deteriorating water quality and habitat. These conditions are considered to be similar to the likely situation at Lake Cowal during prolonged (aseasonal) dry conditions.

2 RESPONSES TO THE SURVEY

2.1 Northern Territory Mines

Six mines were contacted. Five gold mines and one uranium mine. The information was obtained by telephone from current senior environmental officer at each mine.

Zapopan NL Mt Todd

The contact was Thomas Morris who is the Environmental Superintendent at Mount Todd Gold Mine. This mine uses a heap leach extraction process and does not have a tailings impoundment dam. The Mount Todd Gold Mine has a leach pad which contains approximately 100 ppm cyanide and is devoid of vegetation. The leach pad does not usually attract birds.

However, during and after heavy rainfall events, frogs appear in the leach pad. Cormorants and small birds are attracted to the vulnerable frogs. Kites and other predatory birds wheel above the leach pad preying on the smaller birds. This situation led to 22 observed bird mortalities in 1993.

Streamers have been installed to scare the birds away. They were effective against most species with the exception of cormorants.

Pine Creek Goldfields

The contact was Mike Fawcett who is their Environmental Superintendent. Pine Creek Goldfields has a 45 hectare dam that for half the year is covered by cyanide decant. The cyanide concentration is typically less than 10 ppm. During its first year of operation, 50 to 60 bird deaths were recorded. These birds were all Black (Fork-tailed) Kites.

There no longer seems to be many birds attracted to the mine site and very few recent mortalities. Birds deaths are limited to one or two ducks or terns per year. The low number of bird kills is most likely due to a lower cyanide concentration in the water. Periodically a small flock of pelicans lands on the water. The pelicans are effectively hazed, within 16 hours of sighting, using gunshot noise.

The dam has large beaches that would probably appear as tidal flats to the birds and be particularly attractive to migratory wading species The nearby Process Water Dam has no beaches and does not attract birds and consequently has no observed bird deaths.

Union Reefs Gold Mine

The contact was Paul Tett who is their Environmental Officer. Union Reefs Gold Mine has been operating for 12 months. Bird activity is minimal and restricted to waterhens and ducks on the tailings dam. Cyanide concentrations (as predicted by laboratory trials) are typically less than 30 ppm.. There is a decant pond (0.5 ppm cyanide) with no noted bird activity. No bird kills have been recorded. Official records are kept and it is unnecessary to actively discourage birds from using the mine waterbodies. There is no cyanide destruction or detoxification process in place, however the cyanide wash circuit reduces the cyanide concentration of water to the tailings dam.

Rustlers Roost Gold Mine

The contact was Merrilyn Tinsley who is their Occupational Health and Environmental Officer. Rustlers Roost Gold Mine uses a heap leach process and is in its first year of operation. There is a pregnant liquor pond (200 ppm CN), a barren liquor pond (~10 ppm CN), a storm pond (~30 ppm CN) and an intermediate pond.

Bird mortality on site has been four unidentified raptors found on the heap leach stockpiles and one cormorant in the pregnant liquor pond. Two kingfishers were recovered from the plastic lined storm pond launder channel (cyanide concentration approximately 30 ppm). The kingfishers although distressed when retrieved from the water recovered within 15 minutes and were released.

There is an artificial waterbody (the Back Hoe Pit) on site and a large pastoral dam 500 m east of the mine site that is well colonised by vegetation, fish and insects.

Toms Gully Gold Mine

The contact was David Danato who is their Environment Officer. Tom's Gully Gold Mine has several large evaporation ponds, decant ponds and other cyanide bearing waterbodies on the minesite.

Cyanide concentrations are variable (30 - 100 ppm CN) being dependent upon process condition, natural decomposition and dilution.

The mine dewaters approximately six megalitres of water per day to a pond which superficially resembles a natural billabong. The minesite is two kilometres from the Mary River Floodplain.

The tailings dam contents are dark in colour, the free water has a high suspended solid content (to the consistency of sludge) and contains in the vicinity of 25 ppm cyanide. Observations of bird activity around the tailings dam has been restricted to small wader footprints along the edges of the tailings dam.

Bird activity consists of an itinerant bird population on the ore heaps and shorebirds searching for invertebrates around ponds. Waterbirds roost on sparsely vegetated ponds and seek food from well vegetated ponds on the minesite.

Hazing techniques have not been necessary on the mine site as the birds are easily spooked by any disturbance, such as an approaching vehicle. The observed bird deaths over the previous twelve months have been a Whistling Kite and a Black Kite.

ERA Ranger Mine

The contact was Peter Reid who is their Environment Superintendent. Although not a gold mine ERA Ranger mine has been included in this review because it is in the same region as the other surveyed mines and has kept detailed records of bird activity on its site for several years.

Appendix 1 is a table of waterbird abundance and richness at two of the mine's waterbodies during times of both abundance and lack of water in the region. Retention Pond Number 1 with a surface area of approximately 13 hectares, is a relatively clean waterbody with abundant riparian and aquatic plants and aquatic wildlife. Ecologically, this waterbody closely mimics the large, natural billabongs in the area. Ranger mine's tailings dam (surface area approximately 110 hectares is a sterile environment with no riparian or aquatic macrophytic vegetation and no aquatic wildlife.

By carefully examining waterbird richness and abundance data under varying seasonal conditions, the preference and distribution of waterbirds between the two distinct types of waterbodies can be demonstrated.

At Ranger Mine when water is widespread (ie January to July), waterbirds are dispersed and their abundance and richness is at its lowest on any given waterbody. During the late dry/early wet season (August to December) however, when regional surface water is scarce, the waterbirds congregate where water is available, resulting in large numbers of individuals and species in a limited area.

These data show that waterbirds strongly prefer Retention Pond 1 to the Tailings Dam, despite the difference in surface area.

2.2 New South Wales Mines

Three operating mines, situated in similar environments to Lake Cowal were contacted to ascertain the degree of waterbird usage associated with tailings dam operations. The comments from the operations are as follows. Note that all comments were verbal as none of the operations had any formal paperwork available.

In Summary the response from the New South Wales regional mines was:

Northparkes

The contact was Anna McMullen who is the Environmental Advisor for the operation. Anna stated that there have been some odd instances of birds, mainly swans, who get caught in the mud on the dam. An incident form is to be lodged by staff at each occurrence of observed wildlife mortality.

Sheahan Grants

The contact was Heath Sandercock who is the former Operations Manager at the mine site. Heath advised that they had problems with swans who appeared to be determined to settle on the tailings dam. Attempts to reduce the amount of waterbirds attracted to the dam by site personnel were helped by Corkery, an environmental consultant company based in Orange. Several methods, including shotgun noise, fake birds of prey and decoys were tried, with little success. The most successful method of discouraging birds from landing on the dam was gleaned by Corkery from Alcoa, WA. This system involves floating old chemical containers which are connected by rope on the dam's surface. The presence of ropes on the water's surface discourages the swans from landing. This method has succeeded in greatly reducing the incidence of bird mortality although rarely an incident still occurs.

London Victoria

The contact was Rod Chittenden who is the former Mill Superintendent. Rod commented that the birdlife seemed to realise that the water was unsafe when the cyanide levels were in the 80-100 ppm range and would not settle on it. When there was significant rainfall diluting cyanide levels in the tails runoff down to approximately 20 ppm, the birdlife would then settle on the dam with no apparent ill effect. Bird mortality was a rare occurrence and was not considered a problem. Two plovers made the tailings dam their home.

3 CONCLUSIONS

The usage of tailings impoundments by waterbirds at the mines contacted is not considered to be a significant problem. Waterbirds appear to select the more natural waterbodies over artificial and sterile waterbodies. From the observations and data presented it appears that waterbirds are not simply attracted to water surface area but are strongly influenced by other factors such as habitat (beaches, flats, open water and plants), and food sources (plants, invertebrates and fishes). As a result bird mortality on tailings impoundments appears incidental and consequently has not been a problem either on NSW tailings impoundments with climatically similar conditions to those experienced at Lake Cowal, or on NT tailings impoundments located near natural wetlands with high levels of waterbird usage, similar to the situation at Lake Cowal. Therefore bird mortality on the Lake Cowal tailings impoundment is not likely to be a problem. If under some climatic conditions bird usage of the impoundment increases then hazing techniques to discourage them from the artificial waterbodies can be effective.

Appendix 1

Abundance and Richness at ERA Ranger Mine's waterbodies

Period	RP1	RP1	TD	TD Richness
Wet 1980	20	6	40	7
Dry 1980	106	15	50	10
Wet 1981	24	10	7	5
Dry 1981	71	14	29	7
Wet 1982	12	5	24	3
Dry 1982	264	24	22	5
Wet 1983	16	6	14	4
Dry 1983	119	20	26	3
Wet 1984	36	7	5	2
Dry 1984	202	24	15	2

RP1 = Retention Pond No 1
TD = Tailings Dam

Note: Abundance = number of individuals
Richness = number of species
Numbers are averages per visit over a six month period

Lake Cowal Gold Project

Appendix C

WATERBIRD MONITORING ON LAKE COWAL

by

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August 1995

Contents

Executive Summary

1. In order to establish whether the mine site was of special importance and whether it might be useful to monitor waterbirds, regular systematic counts and breeding surveys have been carried out on the lake since 1989.
2. These counts were done on a Mine Transect at the site and three transects elsewhere. The transects were parallel to the shore, 300m wide and between 2.5 and 3.5 k long. They were counted in August, October and January each season, except in the 1990/91 season.
3. Waterbirds were classified into 10 ecological groups according to their feeding behaviour and habitat requirements - Deep Water Generalists, Deep Water Fishers, Filterers/Dabblers near Mud, Specialised Filterers, Shallow Water Hunters, Omnivorous Searchers, Mud Probers, Surface Hunters, Terrestrial Species and Vegetarians.
4. They were also classified as being infrequent (occurring 6 times or less in the data set) or frequent. The infrequent species could not be analysed formally. The frequent species and the ecological groups were analysed by generalised linear modeling with transect location and months as fixed effects.
5. There was no evidence that the Mine Transect was of particular significance to the infrequent species, although one of the other transects was. Four Schedule 12 vulnerable and rare species occurred on the counts but in numbers too low for analysis.
6. The linear modeling showed very few significant effects of transect and month. A contrast on transect and an analysis of confidence intervals of the point estimate from this contrast showed that only Purple Swamphen, Silver Gull, Whiskered Tern, Surface Hunters and Mud Probers were more abundant on the Mine Transect than on the other transects. These are either very common species or waders whose major habitats are coastal and estuarine.
7. A review of the breeding surveys demonstrates that the area around the mine site is insignificant for waterbird breeding. The major areas are the wooded and vegetated parts of the lake to the north.
8. An examination of the data demonstrated the obvious: i.e., that waterbirds are extremely dynamic and are unsuitable as monitoring organisms. Only gross and prolonged changes to their populations would be regarded as cause for concern.
9. It is suggested that monitoring be reduced to simple demonstrations of the continuing use of the lake and the mine area by waterbirds. However, their breeding activities should be continued to be surveyed.

Introduction

Two important questions in relation to the development of the mine in Lake Cowal are (i) how significant is the proposed mine site itself to waterbirds? and (ii) is it useful to monitor waterbird populations in view of the highly dynamic nature of their populations? This can be elaborated into the following four specific questions:

1. **Is the mine site located in a part of the lake that has particular significance to waterbird occurrence (feeding, resting areas)?**
2. **Is the mine site located in a part of the lake that has particular significance to waterbird breeding?**
3. **Are waterbird populations too dynamic to use these species as monitoring organisms?**
4. **If the answer to question 3 is "yes", then how should the utility of the lake to waterbirds be monitored?**

In order to answer these questions counts of waterbirds and surveys of breeding activity have been carried out since August 1989 (Lane 1989a, b, 1990, 1991a, b, c; E.E.S. 1992a, b, c, 1993a, b, c, 1994a, b, c, 1995a).

This Appendix presents a final analysis of these waterbird survey results. Results of the breeding surveys are well presented by E.E.S. (1995b) (Appendix D of this EIS) and will only be discussed here briefly.

Data Collection Methods

Waterbird counts

In 1989, a transect that encompassed the proposed mine site was established along the shore of the lake. This **Mine Transect** was a section of shoreline 3.5 km long and extended from a few metres above the waterline to 300m out into the lake. Seven other transects of the same width, three along the shoreline and four in the lake proper, were established elsewhere in the lake to act as a comparison with the Mine Transect. Their positions in relation to the Mine Transect are given on Figure 2 in Lane (1990). The three shoreline transects differed in length as follows:

- Transect 2 (T2), further southeast along the shoreline from the Mine Transect near the mouth of Bland Creek, was 3.5 km long;
- Transect 7 (T7), northeast of the Mine Transect on the eastern shore, was 2.5 km long; and
- Transect 8 (T8), directly opposite the Mine Transect on the eastern shore, was also 2.5 km long.

The four lake transects were 2.0 to 2.5 km long but were excluded after preliminary counts because the habitat was not directly comparable with that of the Mine Transect.

It must be recognised that these transects were not fixed absolutely. As the shoreline advanced and receded with changes in lake levels their absolute positions changed; but their radial positions in relation to the Lake's centroid and, therefore, their relative positions along the shore were fixed. Changes in shoreline also meant that the vegetation could change from count to count. However, the transects were in very similar habitats overall - open grassland with scattered redgums above the shore and open water or cane grass in the lake. On any one sampling date, the vegetation the transects covered was very similar. Transect 7 differed somewhat in that it had more relief and therefore more open pools than the other three.

Waterbirds were counted on these transects by walking slowly along the shoreline recording all birds within the transects. Transects were counted in August, October and January in the seasons of 1989/90 to 1994/95. Each transect was counted once in each month within a one or two day period. Table 1 gives the dates of each count, any modifications and the water levels at the time. No counts were done in the season of 1990/91, and the very dry conditions in 1992/93 meant that T7 could not be counted and T2 had to be shortened by 250m. More details on water level fluctuations are given in the main report.

Originally it was hoped that the transect counts could be used to estimate total bird numbers on the lake (Lane 1989a). In October 1989 an aerial reconnaissance was made of the entire lake to estimate total bird numbers in the southern part of Lake Cowal and test this idea, but it was concluded that the transect counts could not be used to estimate total numbers (Lane 1989b). They could only be used to index bird use of the lake.

Table 1. Timing of counts and lake conditions.

Season	Dates of Counts	Transect Modifications	Lake Levels and Conditions
1989/90	9-11/Aug 21-24/Oct early Jan	None	Lake very low early in 1989 but filled to near full by local rains at time of surveys. Much local flooding.
1990/91	No Counts		Flood on Lachlan R. put more water in the lake in mid 1990. Lake levels falling by the latter half of the year.
1991/92	24/Aug 18/Oct 25-26/Jan	None	Lake levels still falling. No heavy local rain.
1992/93	28-29/Aug 27-28/Oct 25-26/Jan	T7 now in lignum area and not counted; T2 reduced to 3.25 km	Lake levels lowest of entire study at the start of the season and rising slightly towards the end. District very dry.
1993/94	30-31/Aug 20-21/Oct 17-18/Jan	None	Lake levels very high after local rains in mid - late 1989. Levels reached peak in about October, then began to fall.
1994/95	20-21/Aug 9-10/Oct 15-16/Jan	None	Water levels declining throughout the season.

Breeding data

Breeding surveys were done every season by examining all areas of the lake from canoe or boat and by occasional aerial reconnaissance (October 1989, January 1990 and January 1993). All visible nests and rafts of young were identified, counted and mapped. However, holes in trees were not checked for duck nests.

Analytical Approach to Waterbird Counts

What is being counted?

Birds that are counted include birds feeding in the area and those that are just loafing. In general, the cormorants, herons and similar species are diurnal feeders, and the ducks and rails are more nocturnal. These latter species disperse at night to feed: either moving in to the shore; going to other parts of the lake; or leaving the lake to feed elsewhere locally. Similarly, birds from elsewhere can move into the transect. The fishing species may be feeding on the transect or may be simply resting and then feeding elsewhere at some other time of the day. However, this phenomenon is common to all transects and all waterbird surveys. What is being counted therefore are the birds occurring in the transect area at the time and an index of the birds that feed in the area.

Determination of species groups for analysis

The surveys recorded a total of 57 species. The full data set arranged by transect and overall transects is given in Addendum I (the species sequence used follows Christidis and Boles (1994) and differs from that in the individual survey reports of Lane and E.E.S).

Analyses of bird counts often involve analysis of the total numbers of species and total numbers of birds as indicators of the bird community overall. This is unsuitable. The total number of species cannot be analysed formally in this situation since the transects differ in length - the longer the transect the more likelihood there is of getting extra species. The total numbers of birds give little information since one or two species can dominate counts and different species can have opposite responses. One species could decline and another simultaneously increase, and this may not affect the total count.

A more appropriate approach is to analyse ecological groups of waterbirds and individually analyse those species for which there is sufficient data. Ecological groups were defined on the basis of what water conditions a species forages in and the type of prey it takes. Species in the same group would tend to feed in the same or similar parts of the lake. It must be stressed that waterbirds in general can be very catholic in their feeding habits and habitats, so there is a reasonable amount of subjectivity in defining groups and assigning birds to them. Information was obtained from personal knowledge, Marchant and Higgins (1990 and 1993) and references therein, Cramp and Simmons (1977-1985) and Frith (1977). Definitions of the 10 groups are given in Table 2, and their members are listed in Table 3. Virtually all these species have been recorded breeding on Lake Cowal, the major exception being species of the PM (Probers in Mud) Group. These are mostly migratory waders; only the Red-capped Plover, Black-fronted Dotterel and Red-kneed Dotterel are Australian residents.

Infrequent and frequent species

As well as defining ecological groups, species were classified as being infrequent or frequent in the data set. Frequent species can be analysed individually; infrequent species cannot. A species was classified as infrequent if it occurred on six or less of the 15 sampling occasions (lumping all transect data together). This classification is only relevant to the Lake Cowal data set. It does not mean that an infrequent species is rare or otherwise, regionally or nationally.

Twenty-eight of the 57 species were classified as infrequent (Table 3) and are considered separately in relation to question 1. No formal analysis of the infrequent species was attempted.

Table 2. Ecological groupings of waterbirds

Deep Water Generalists (DW) This group consists of divers that take a wide range of prey in the water column, including insects and plant material. They operate in deep and shallow water and will also forage on the surface.
Deep Water Fishers (DF) Species in this group dive for fish and crustacea usually in deep water although they will forage in shallow waters (< 1.0m deep). It includes the cormorants, Australian Pelican and Caspian Tern.
Filterers/Dabblers near Mud (FM) These are mostly generalised dabbling ducks. They forage in the shallows (usually < 20cm deep) and mud, sifting the water and the first few centimeters of mud for invertebrates and plant material. They cannot dig deeply into mud. They will also pick items from the surface. The Black-winged Stilt and Red-necked Avocet are included here as they are generalist feeders that collect items from these very shallow waters: they probe into mud much less than the PM species (see below).
Specialised Filterers (FS) These three species are more specialised at filtering than the previous group, and small plankton makes up a large part of the diet (Crome 1985). The Pink-eared Duck and Australasian Shoveler can forage in deeper waters than the FM group, and they can filter plankton from open water. The Freckled Duck tends to be more associated with shallow waters, where it filters mud as well as water.
Hunters in Shallow Water (HS) These species take a range of vertebrate (fish and frogs) and large invertebrate prey in shallow water. They actively hunt prey by lying in wait, or stalking and pouncing. Small invertebrates are rarely taken.
Omnivorous Searchers (OS) These tend to have a more catholic diet than the previous group and forage in a wider range of substrates. The spoonbills can harvest small as well as large invertebrates, fish and frogs, whereas the ibises can hunt and probe in mud.
Probers in Mud (PM) These are the waders. They mostly forage on exposed mud or in wet meadows rather than in water and get their prey from the surface or within the mud.
Surface Hunters (SH) These are the smaller terns. They will dive for small fish and invertebrates but are mostly invertebrate feeders and gather a lot of prey from the water surface or just beneath it.
Terrestrial Feeders (T) These species basically feed on dry land. The Australian Wood Duck is a grazer, and the lapwings are generalist foragers. The Straw-necked Ibis is included here as it forages in a range of generally drier habitats than the Australian White Ibis. These two ibises could be included here or in the OS Group.
Vegetarians (V) These species forage on vegetation in shallow water. All will take invertebrates, but various water plants form the bulk of the diet.
Unclassified These species are not readily classifiable. The Black Swan is vegetarian but usually feeds in deeper water (up to 1.5 m) than the Vegetarian Group. The Blue-billed Duck is a diver but takes a lot of plant material and feeds extensively in the substrate. The Silver Gull forages on anything and anywhere.

Table 3. Ecological groups of waterbirds used in analyses.

Ecological Group	Species	Status[1]
Deep Water Generalists (DW)	Musk Duck	I
	Australasian Grebe	I
	Hoary-headed Grebe	F
	Great Crested Grebe	I
Deep Water Fishers (DF)	Darter	F
	Great Cormorant	F
	Pied Cormorant	F
	Little Black Cormorant	F
	Little Pied Cormorant	F
	Australian Pelican	F
	Caspian Tern	I
Filterers/Dabblers near Mud (FM)	Australian Shelduck	F
	Pacific Black Duck	F
	Grey Teal	F
	Chestnut Teal	I
	Hardhead	F
	Black-winged Stilt	F
	Red-necked Avocet	I
Specialised Filterers (FS)	Freckled Duck	I
	Australasian Shoveler	F
	Pink-eared Duck	F
Hunters in Shallow Water (HS)	White-faced Heron	F
	Little Egret	I
	White-necked Heron	F
	Great Egret	F
	Intermediate Egret	I
	Cattle Egret	I
	Nankeen Night Heron	I
	Australasian Bittern	I
Omnivorous Searchers (OS)	Glossy Ibis	I
	Australian White Ibis	F
	Royal Spoonbill	F
	Yellow-billed Spoonbill	F
Probers in Mud (PM)	Latham's Snipe	I
	Marsh Sandpiper	I
	Common Greenshank	I
	Red-necked Stint	I
	Pectoral Sandpiper	I
	Sharp-tailed Sandpiper	I
	Red-capped Plover	I
	Black-fronted Dotterel	F
	Red-kneed Dotterel	I
Surface Hunters (SH)	Franklin's Gull	I
	Whiskered Tern	F
	Gull-billed Tern	I
Terrestrial Feeders (T)	Australian Wood Duck	F
	Straw-necked Ibis	F
	Banded Lapwing	I
	Masked Lapwing	F
Vegetarians (V)	Purple Swamphen	F
	Dusky Moorhen	I
	Black-tailed Native-hen	I
	Eurasian Coot	F
	Brolga	I
Unclassified	Blue-billed Duck	I
	Black Swan	F
	Silver Gull	F

1 I - infrequent; F - frequent.

Statistical Approach

Question 1

Question 1 was approached using generalised linear models with the data from the frequent species and the groups. A generalised model for the count data simply says that count is linearly related to transect identity, the month of the count and the interaction between transect and month. In its simplest form the relationship is

$$\log (E\{Count\}) = a + \log(l) + b_i + c_j = bc_{ij}$$

where b_i is the effect of the ith transect, c_j is the effect of the jth month, and bc_{ij} is the month by transect interaction. l is a term to account for differing transect lengths and a is a constant. $E\{Count\}$ represents the expected value (or population average) of the count.

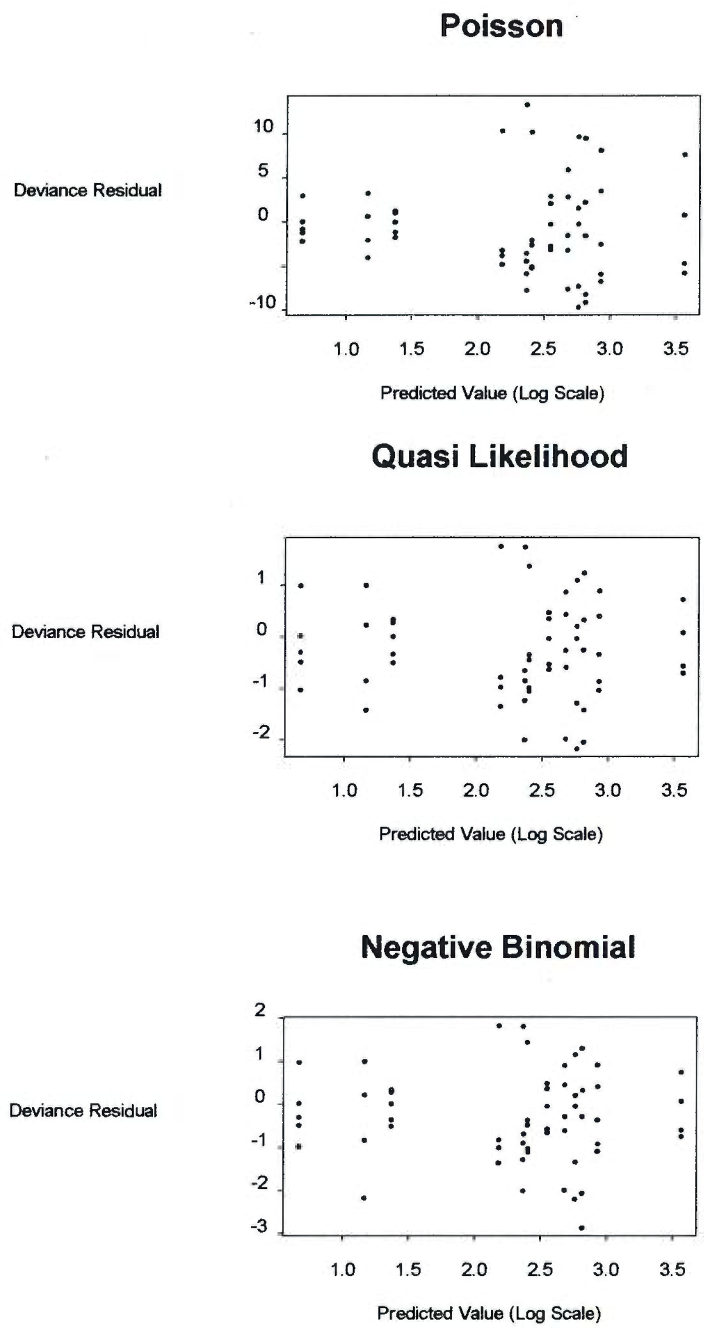
The term for transect has 3 degrees of freedom, and month has 2 degrees of freedom. Transect and Month are fixed effects, but Year of the count was considered to represent random effects and was not explicitly modeled. However, such random effects were allowed for by inflating the variance function (see Addendum II).

As in all statistical procedures it is necessary to determine what distribution best fits the count data. Counts ideally follow a Poisson distribution and are then more readily amenable to the general range of statistical tests familiar to ecologists. However, the bird counts in this study are extremely variable; and, as is usually the case with animal censuses, the variances of most of the counts exceeded the means. The data are too overdispersed, and it was decided that a Poisson distribution would provide too poor a description of the distribution of species counts. Accordingly, a quasi likelihood approach was adopted (McCullagh and Nelder 1983). Several relationships between the mean and the variance of the data set were explored: variance proportional to the mean; variance proportional to the mean squared; and a variance function based on the Negative Binomial distribution. Although rarely used, the Negative Binomial distribution has a long history in the ecological applications of statistics. Ecological data that is not Normal can often be fitted by this distribution. A Negative Binomial distribution can be generated in a variety of ways, including data that consists of a random distribution of clumps - a common ecological phenomenon.

To see which variance/mean relationship fitted best, diagnostic plots of deviance residuals versus fitted values were examined. In general, residual plots were better behaved for the Negative Binomial variance function than for the other variance functions, so this relationship was used in the analyses. The residual plots for Group T are shown in Figure 1. There are no marked problems for any of the variances functions with this group, although the very broad spread of the residuals (-10 to +10) at higher predicted values in the Poisson model shows some suggestion of heteroscedasticity for this model. For an appropriate variance function, the deviance residual should not show such marked heteroscedasticity. The Negative Binomial model and the squared variance function (quasi likelihood) models show very similar standardised residuals. Note the much narrower spread of the deviances for these models - the scales have had to be expanded on the graphs.

Log Likelihood ratio χ^2 tests were developed for the Transect main effect and the Transect x Month interaction. In order to examine the Mine Transect specifically, a contrast was developed which compared the mean response for the Mine Transect with the mean of the other transects combined. This contrast was approached in two ways.

1. A **t** test was performed comparing the mean of the Mine Transect with the mean of the others. It must be remembered that a non-significant result from such a test cannot be interpreted readily and certainly cannot be interpreted as no difference between the Mine Transect and the others.



Francis Crome Pty. Ltd. for NSR Environmental Consultants Pty. Ltd.	**Diagnostic Plots for Variance Functions for the Terrestrial Group (T)**
North Mining	
Lake Cowal Gold Project	**Figure 1**

2. A point estimate and a 95% confidence interval for the contrast was calculated. The point estimate (δ) can be interpreted as a measure of the difference between the Mine Transect and the others. It is the ratio of numbers of birds on transect 1 to the mean number on the other transects i.e. MT = δ OT (MT and OT = Mine and Other transects respectively). A value of $\delta = 1.0$ indicates they are identical, 0.8 indicates 20% less on the Mine Transect, 1.5 indicates 50% more on the Mine Transect. Confidence intervals are more informative than significance tests. They are interpreted as meaning that the real value of δ lies between these two extremes. They do not mean that there is a 95% chance that it lies between these extremes.

See Addendum II for a technical description of these statistical procedures.

Question 2

Breeding has been adequately dealt with in the reports of Lane and E.E.S. (See Appendix D of this EIS.)

Questions 3 and 4

No formal statistical procedure was used to explore these questions.

The Significance of the Mine Site

Question 1 - Is the mine site located in a part of the lake that has particular significance to waterbird occurrence (waterbird counts)?

Infrequent Species

Table 4 gives the number of times each of the 28 infrequent species occurred on each transect and overall on the lake. Six species - Blue-billed Duck, Cattle Egret, Red-necked Stint, Pectoral Sandpiper, Banded Lapwing and Franklin's Gull only occurred once during the entire study period. Three others, Australasian Bittern, Brolga and Red-necked Avocet, never occurred more than once on any transect. Franklin's Gull is a rare vagrant to Australia, and the Sandpiper is an uncommon migrant. The Stint is more a coastal species, and Avocets are much more common further inland. The Bittern is a rarely seen, secretive species.

Examination of the total number of infrequent species seen on each transect suggests that most species were recorded on T7 and least on T8. Considering that T7 was only sampled 12 times compared with the 15 times of the others and that it is shorter than the Mine Transect, it must be concluded that overall it was the most attractive to the infrequent species.

Table 4. Number of times each infrequent species occurred on the transects and overall on Lake Cowal. Shaded cells are transects with the highest number of occurrences of the species.

Species	Mine Transect	T2	T7	T8	Overall
Blue-billed Duck	0	0	1	0	1
Musk Duck	2	4	1	2	4
Freckled Duck	1	1	3	1	3
Chestnut Teal	0	1	3	3	5
Australasian Grebe	4	6	2	2	6
Great Crested Grebe	1	3	0	2	4
Little Egret	0	1	2	1	4
Intermediate Egret	2	3	2	1	5
Cattle Egret	0	0	1	0	1
Rufous Night Heron	2	2	2	0	5
Australasian Bittern	0	1	1	0	2
Glossy Ibis	2	4	3	2	5
Dusky Moorhen	0	0	2	0	2
Black-tailed Native-hen	2	0	6	0	6
Brolga	0	1	1	0	2
Latham's Snipe	0	4	0	0	4
Marsh Sandpiper	2	4	0	0	4
Common Greenshank	4	2	2	1	5
Red-necked Stint	0	0	1	0	1
Pectoral Sandpiper	1	0	0	0	1
Sharp-tailed Sandpiper	3	0	1	0	3
Red-necked Avocet	1	1	1	0	3
Red-capped Plover	2	1	1	0	3
Red-kneed Plover	0	0	2	1	3
Banded Lapwing	1	1	0	0	1
Franklin's Gull	1	0	0	0	1
Gull-billed Tern	2	0	2	3	4
Caspian Tern	3	0	0	0	3
Total Species	18	17	21	11	28

If a species consistently prefers a transect, it is reasonable to assume that it would occur on that transect more often than on the others. This can be approximately explored by ranking the transects for each infrequent species: a transect ranked as first for a species had that species on more sampling occasions than the others. Summing the number of species that ranked a transect as first gives a very approximate idea of whether a transect ranks more highly overall. T2 and T7 had the most species that ranked them first, and T8 had the least. The Mine Transect ranked highest for four species, three of them waders.

It must be emphasised again that these infrequent species are not necessarily rare regionally or nationally. Musk Duck, the two grebes, the egrets, the Nankeen Night Heron, Dusky Moorhen, Black-tailed Native-hen and the two terns are extremely common regionally and nationally. The majority of the waders are common migrants that prefer coastal regions, and the bulk of their populations are located there; they rarely occur in large numbers on inland lakes. Only the Pectoral Sandpiper and the vagrant Franklin's Gull are nationally rare.

Four of these infrequent species are Schedule 12 species: Blue-billed Duck, Freckled Duck, Brolga and Australasian Bittern. Of these, only the Freckled Duck, which is much commoner further inland, is likely to ever occur on the lake in moderate numbers; the others will only occur sporadically and in low numbers. In northern Australia where the Brolga is common, it uses coastal floodplains and inland habitats. Large flocks occur in the Gulf country. In New South Wales, it is commonest in inland areas (NPWS, pers. comm. to NSR). The Australasian Bittern is naturally rare and secretive, preferring dense reed and cumbungi beds to the open areas around the Mine Transect. The Blue-billed Duck can occur in small numbers at any time on deeper lakes. The other four schedule 12 species that have been recorded as occurring at Lake Cowal (Magpie Goose, Osprey, Painted Snipe and Black-tailed Godwit) were not recorded on the transects. The Black-tailed Godwit, although it occurs regularly on inland NSW wetlands, is fundamentally a tropical coastal species, and flocks of several hundred are commonplace in such habitat. It is most likely that it would only ever be a vagrant at Lake Cowal. Similarly, the Magpie Goose is now mostly distributed in the tropics, where it is expanding in coastal north Queensland. It likes agricultural areas there and may continue to occur as a vagrant at Lake Cowal. Lake Cowal is of no significance to its populations. Only the Osprey and Painted Snipe are uncommon; the latter is very rare. If the latter occurs regularly at Lake Cowal, it is likely to be in the more heavily vegetated northern parts of the lake.

Thus, there is not a lot of evidence to suggest that the Mine Transect especially attracts the infrequent species except possibly for some waders. Transect 7 with its shallow pools appears to be the most attractive.

More Frequent Species and Groups

The results of the linear modeling are shown in Table 5. The left half of the Table gives the χ^2 tests for Transect main effect and Transect x Month interaction, and the **t** tests for the contrast (no difference) between the means of the Mine Transect and the other transects. The right half of the table gives the estimated effect size and its 95% confidence interval. The iteratively reweighted least squares algorithm used to fit the generalised linear model failed to converge for some species. This occurred when total counts for some Transect-Month combinations were zero. For these species, the Transect x Month interaction was dropped from the model, and the model was re-fitted. These species are indicated in the table by missing values in the column of results for the Interaction test.

Table 5. Results of generalised linear modeling of transect counts. P values ≤0.05 in bold. Species for which the Mine Transect differs significantly from the other 3 transects in bold.

Species	Test Procedures			Effect Size and Confidence Interval		
	Transect P value[1]	Interaction P value[2]	Contrast P Value[3]	Estimated Effect	Lower Limit	Upper Limit
Black Swan	0.377	0.135	0.378	0.911	0.739	1.124
Australian Shelduck	**<0.001**	0.386	0.591	0.937	0.735	1.194
Australian Wood Duck	0.784	**0.013**	**0.028**	0.798	0.653	0.975
Pacific Black Duck	0.500	0.574	0.408	0.947	0.829	1.080
Australasian Shoveler	**0.028**	-------[4]	0.909	0.984	0.746	1.299
Grey Teal	0.288	0.062	0.878	1.013	0.854	1.201
Pink-eared Duck	0.616	-------	0.894	1.028	0.678	1.558
Hardhead	0.947	-------	0.567	0.911	0.658	1.261
Hoary-headed Grebe	0.686	0.782	0.926	0.988	0.764	1.278
Darter	0.292	0.877	0.780	1.027	0.849	1.242
Little Pied Cormorant	0.700	0.062	0.510	0.918	0.708	1.190
Pied Cormorant	0.173	-------	0.771	1.041	0.788	1.376
Little Black Cormorant	0.122	0.222	0.326	1.115	0.894	1.390
Great Cormorant	**0.002**	-------	0.721	0.946	0.691	1.294
Australian Pelican	0.905	0.239	0.252	1.109	0.927	1.329
White-faced Heron	0.197	0.818	0.568	1.052	0.880	1.258
White-necked Heron	**<0.001**	-------	0.501	0.899	0.656	1.233
Great Egret	0.600	0.609	0.897	1.014	0.822	1.249
Australian White Ibis	**0.006**	0.254	0.306	0.895	0.722	1.110
Straw-necked Ibis	0.302	0.200	0.291	0.859	0.644	1.144
Royal Spoonbill	0.748	0.703	0.339	0.913	0.756	1.103
Yellow-billed Spoonbill	**0.046**	0.607	0.443	0.917	0.733	1.148
Purple Swamphen	**0.016**	-------	**0.001**	1.711	1.263	2.318
Eurasian Coot	0.803	0.985	0.655	1.052	0.839	1.318
Black-winged Stilt	0.333	-------	0.745	0.958	0.735	1.249
Black-fronted Dotterel	**<0.001**	-------	0.543	1.127	0.761	1.668
Masked Lapwing	0.110	0.991	0.886	0.989	0.844	1.159
Silver Gull	**0.019**	0.104	**0.001**	1.359	1.132	1.632
Whiskered Tern	**0.050**	-------	**0.001**	1.541	1.192	1.992
DW Group	0.615	0.836	0.925	0.989	0.781	1.252
DF Group	0.666	0.189	0.447	1.060	0.909	1.236
FM Group	0.181	**0.027**	0.978	1.002	0.858	1.170
FS Group	0.173	**0.031**	0.284	0.872	0.677	1.124
HS Group	0.964	0.099	0.900	0.991	0.854	1.150
OS Group	**0.048**	0.256	0.194	0.905	0.776	1.054
PM Group	0.103	-------	**0.028**	1.562	1.051	2.322
SH Group	0.070	0.226	**<0.001**	1.498	1.206	1.860
T Group	0.444	**0.013**	0.177	0.899	0.770	1.051
V Group	0.642	0.973	0.369	1.094	0.896	1.337

1 P value for a Transect effect.
2 P value for a Transect x Month interaction effect.
3 P value for mean of Mine Transect equaling overall mean of the other 3 transects.
4 Zero values preclude inclusion of interaction term. Model fitted without it.

Despite the large number of significance tests conducted, there was little evidence of statistically significant differences. Only 15 of the 67 Transect and Interaction tests were significant at 5% and only five at 1%. Of the 39 contrasts, only six were significant at 5% and only four at 1%. Given the large number of tests performed, the results should be interpreted with caution. Of the 106 tests performed at the 5% significance level, five will be significant by chance alone; and it is impossible to know which, if any, of the significance tests are the chance ones.

There was a significant Transect effect for ten species:

- Australian Shelduck
- Australasian Shoveler
- Great Cormorant
- White-necked Heron
- Australian White Ibis
- Yellow-billed Spoonbill
- Purple Swamphen
- Black-fronted Dotterel
- Silver Gull
- Whiskered Tern

None of these showed a Transect x Month interaction, which means that the position of the transect affected the counts irrespective of the month of the count. One species and three groups did show a significant Transect x Month interaction: Australian Wood Duck and the FM, FS and T Groups.

Examination of the contrasts (column three in Table 5) indicates that Australian Wood Duck, Purple Swamphen, Silver Gull, and Whiskered Tern showed a significant contrast between the Mine Transect and the others. Thus, for 70% of the species whose counts are affected by Transect position, it was not the Mine Transect producing the effect.

Mean counts for each species are given in Table 6, and this illustrates the substantially larger numbers of Purple Swamphens, Silver Gulls and Whiskered Terns found on the Mine Transect.

Examination of Addendum I demonstrates that Silver Gulls and Whiskered Terns tended to be consistently abundant on the Mine Transect, whereas the Purple Swamphen was usually rare. The Swamphen's abundance was due to occasional rafts of several hundred birds that occurred in August 1993 and in the 1994/95 season.

The mean abundance of the Australian Wood Duck (Table 6) on the Mine Transect was similar to that on Transects 2 and 8 but less than on Transect 7. It was the abundance of this species on Transect 7 that produced the significant contrast between the Mine Transect and the others. Transect 7 increased the mean of the non-mine transects to a level at which it was significantly higher than the Mine Transect mean.

Table 6. Mean counts (birds/km of transect) of the more frequent species and the groups on each transect and the overall mean (4 transects)

Species	Mine Transect	Transect 2	Transect 7	Transect 8	Mean*
Black Swan	7.68	6.68	18.83	9.36	10.21
Australian Shelduck	0.78	0.08	3.73	1.79	1.48
Australian Wood Duck	7.05	7.84	13.03	7.47	8.63
Pacific Black Duck	8.00	9.02	15.43	9.33	10.18
Australasian Shoveler	1.37	0.59	10.10	0.61	2.80
Grey Teal	68.59	71.22	215.67	45.63	94.20
Pink-eared Duck	4.63	2.96	4.73	1.47	3.38
Hardhead	0.50	0.97	1.03	1.07	0.88
Hoary-headed Grebe	1.71	2.44	6.17	1.71	2.84
Darter	1.64	1.46	0.87	2.37	1.62
Little Pied Cormorant	1.18	2.13	1.10	3.39	2.00
Pied Cormorant	0.23	0.34	0.13	0.16	0.22
Little Black Cormorant	9.81	12.55	1.20	12.93	9.54
Great Cormorant	1.77	3.13	0.20	10.99	4.22
Australian Pelican	27.83	25.55	27.67	20.00	25.14
White-faced Heron	1.20	1.09	1.37	0.45	1.01
White-necked Heron	0.21	0.30	0.80	0.13	0.34
Great Egret	2.95	2.82	1.73	4.83	3.15
Australian White Ibis	0.53	0.87	2.53	0.24	0.97
Straw-necked Ibis	0.44	0.34	2.00	2.11	1.18
Royal Spoonbill	0.84	0.92	1.27	1.65	1.17
Yellow-billed Spoonbill	0.99	1.30	3.87	0.77	1.62
Purple Swamphen	17.75	6.01	0.67	7.76	8.44
Eurasian Coot	41.10	24.96	29.27	47.25	35.98
Black-winged Stilt	5.16	3.84	18.97	1.76	6.83
Black-fronted Dotterel	0.34	0.67	0.13	0.11	0.32
Masked Lapwing	2.99	2.00	4.80	2.64	3.02
Silver Gull	9.10	2.01	3.30	2.64	4.31
Whiskered Tern	8.10	5.50	2.33	1.97	4.59
DW Group	2.59	4.43	6.77	2.16	3.84
DF Group	42.51	45.18	31.17	49.84	42.75
FM Group	83.10	85.24	256.17	59.92	114.00
FS Group	6.02	3.74	15.77	2.13	6.45
HS Group	4.59	4.55	4.93	5.47	4.88
OS Group	3.71	4.79	10.33	2.80	5.15
PM Group	4.51	2.26	1.03	0.51	2.13
SH Group	8.19	5.50	2.40	2.19	4.68
T Group	10.51	10.24	19.83	12.21	12.85
V Group	58.93	31.03	33.80	55.01	45.27

* The figure in this column is the mean birds/km and is not readily derivable from the figures in the four previous columns.

Only one group—the OS Group—showed a significant transect effect, but there was no significant contrast, which means that, although the transects as a whole were different, the Mine Transect did not stand out as particularly different from the others. The PM and SH Groups were more abundant on the Mine Transect, but this difference by itself was not great enough to produce a significant transect effect in the Log Likelihood tests. It might be expected that the PM Group (mostly waders) would be more abundant on the Mine Transect since there is exposed mud there. However, an examination of Addendum I and Table 7 demonstrates that, overall, waders are very rare at Lake Cowal, as would be expected with these species. Except for the Red-capped Plover and the two dotterels, which occur commonly on inland lakes and wetlands, all are basically migratory, coastal species. The significant contrast was produced by a small flock of Common Greenshanks that stayed on the Mine Transect throughout the 1992/93 season when the lake was very low and by twelve Common Greenshanks on other transects in January 1995. Like most of the migratory waders, the Common Greenshank prefers coastal areas.

Table 7. Totals of groups on each sampling occasion (summed across transects).

Group	8/89	10/89	1/90	8/91	10/91	1/92	8/92	10/92	1/93	8/93	10/93	1/94	8/94	10/94	1/95
DW Group	35	25	375	15	5	0	24	1	0	59	0	0	86	27	0
DF Group	76	288	672	227	321	2194	579	372	258	202	75	79	245	391	1400
FM Group	560	1524	5690	183	129	2199	2484	778	580	380	139	294	769	725	2264
FS Group	21	46	181	2	4	55	281	2	2	30	3	11	83	93	251
HS Group	7	88	62	127	47	164	61	70	25	16	14	61	23	30	34
OS Group	8	82	32	26	93	58	75	82	2	20	1	96	15	187	76
PM Group	0	0	0	3	5	98	61	143	50	3	4	2	6	9	20
SH Group	0	67	239	49	4	24	7	112	93	14	0	41	0	19	200
T Group	56	335	452	128	78	224	30	100	37	34	21	212	121	122	190
V Group	0	31	586	1141	331	133	215	402	341	1165	20	229	1167	1218	801

The importance of such sporadically occurring flocks of birds cannot be overestimated in waterbird censuses. It is notable that, in January 1992, only 59 Australian Shelducks and one Pink-eared Duck were counted on the transects, yet there was a flock of more than 800 Australian Shelducks and another of 120 Pink-eared Ducks in the northern part of the lake (Table 5 in E.E.S. 1992a). For the Australian Shelduck, the sighting in the northern part of the lake is higher than ever recorded on the transects; and for the Pink-eared Duck, only one transect count has been higher. Sharp-tailed Sandpipers in that same month were recorded as "relatively common" and Whiskered Terns as in "large numbers" in these northern waters. Similarly, in October 1989, over 400 Nankeen Night Herons were recorded away from the transects, while none were recorded on them (Table 4 in Lane 1990).

As indicated above, non-significant results cannot be readily interpreted. However, an examination of effect size and its confidence interval is more meaningful. The species and groups showing a significant contrast for the Mine Transect have effect sizes and confidence intervals demonstrating that the Mine Transect is different. For example, the effect size for Purple Swamphen is 1.711; i.e. a 71% increase on the Mine Transect compared to the mean of the other three. Although the confidence intervals are wide (26% to 132% increase), they still show an increase.

For the species and groups with non-significant contrasts, effect sizes are all fairly close to or less than 1.0; i.e., no effect or a slight increase or decrease. However, the width of the confidence intervals indicates that, for many species, a moderate decrease or increase on the Mine Transect is as likely as there being no effect. For example, the effect size for Hoary-headed Grebe is 0.988, but the confidence interval indicates there could be a 24% decrease or a 28% increase on the Mine Transect relative to the other transects.

Considering the behaviour of these species and their mobility, however, the confidence intervals are surprisingly narrow. The confidence intervals of all but two of the non-significant species and groups range between 0.3 and 0.6; i.e., 15 to 30% either side of the effect. The widest confidence intervals are shown by the species and groups that demonstrated a significant contrast; e.g., the effect size for the PM Group is between a 5% and a 132% increase.

Overall, considering the nature of these waterbirds, the effect sizes and confidence intervals can be interpreted as suggesting little difference between the Mine Transect and the other three transects, except for those species and groups showing a significant contrast; i.e., Australian Wood Duck, Purple Swamphen, Silver Gull, Whiskered Tern and the PM and SH groups.

Question 2 - Is the mine site located in a part of the lake that has particular significance to waterbird breeding?

The reports of Lane and E.E.S. demonstrate convincingly that the major breeding areas for waterbirds are in the northern vegetated parts of the lake. Throughout the study only 'some broods of grey teal' were recorded at the mine site (Lane 1990). The mine site is in habitat B, 'shore areas intermittently flooded', as defined by Vestjens (1977). Although he recorded 56 nests in this habitat type, almost all were in lignum or red gum. The low breeding activity at the mine site is due to the lack of trees and bushes in the shore habitat. There are only a few scattered red gums to support hole and tree nesters, such as ducks, cormorants and herons. Similarly, the lignum is very sparse, and there are no dense lignum clumps for the rails and other bush nesting species. The area around the mine site is an insignificant area for waterbird nesting. (See also Appendix D of this EIS.)

Conclusions

The analyses indicate that the Mine Transect is not special for the bulk of the waterbirds that occur on Lake Cowal. Transect 7 appears to be the most attractive to the infrequent species, and only the Silver Gull, Whiskered Tern, Purple Swamphen and waders are found more abundantly on the Mine Transect. Silver Gulls and Whiskered Terns are very common and highly mobile, following food wherever it occurs. They are of no special concern, especially as neither breed near the Mine Transect. The waders tend to prefer the Mine Transect, but most of these species are migratory with the bulk of their populations located in coastal and estuarine environments. Waders are infrequent at Lake Cowal, and the lake is not significant habitat for this group of species. For the few that do occur, engineering of the bund wall to generate exposed muddy areas will compensate for any loss of habitat.

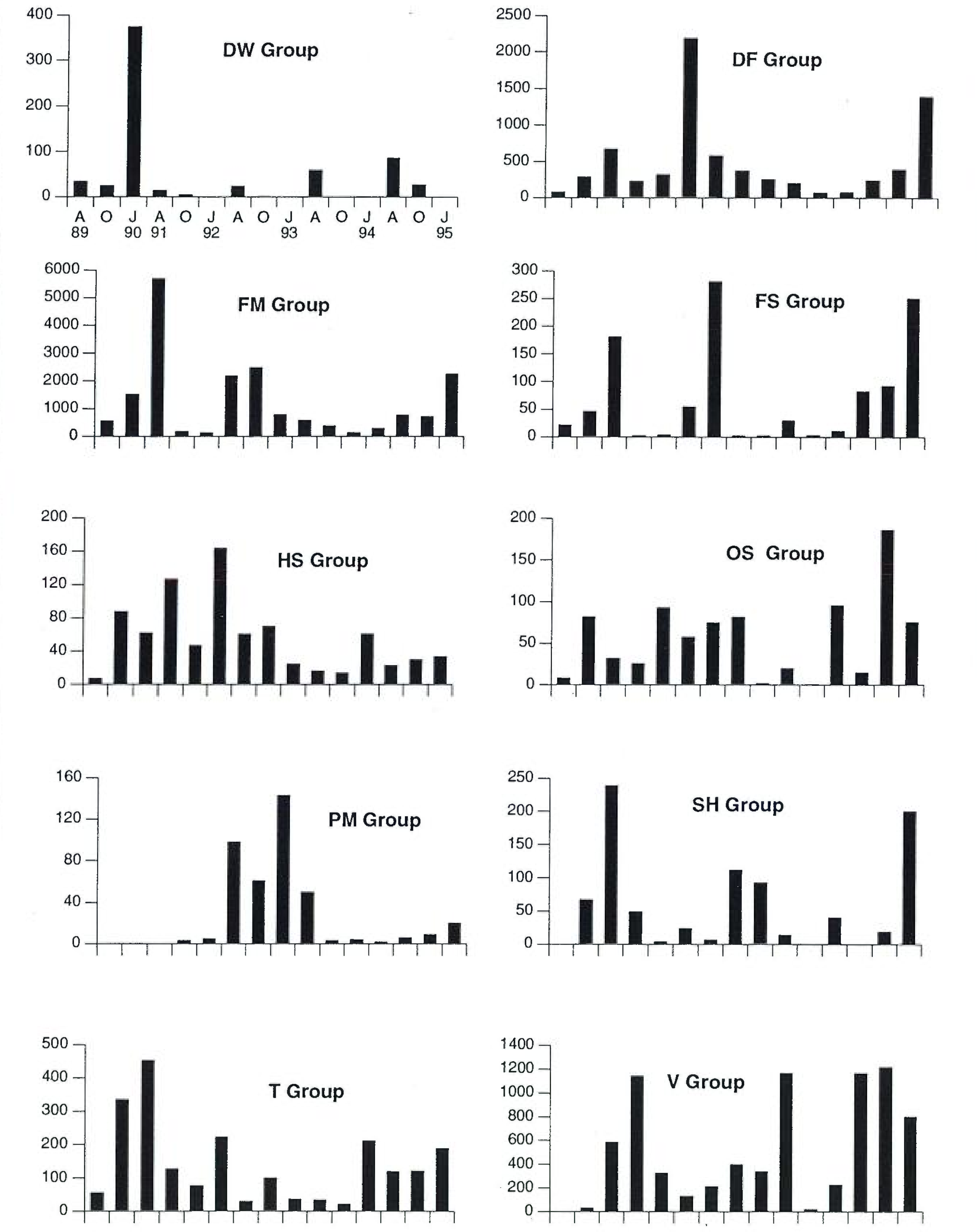
Within Lake Cowal, I consider the vegetated northern parts that support breeding colonies and large numbers of birds and that input quantities of litter and organic material into the lake to be most significant. Vegetated, particularly wooded, wetland habitat is much harder, and takes much longer, to replace than open water edges.

Waterbird Dynamics, Mine Impacts and Monitoring (Questions 3 and 4)

Waterbirds are notoriously dynamic, and Humphries *et al.* (1991) have already indicated that they are too dynamic for monitoring purposes. All the reports by Lane and E.E.S. stress the huge year-to-year variation in counts and its dominance in the data set. It is well known that waterbird presence and abundance is influenced not only by the conditions within a wetland but also by the conditions and the amount of rainfall and habitat within the district and by regional and national vagaries in weather and wetland availability. On any particular wetland, a species may be abundant for several weeks then disappear overnight. The patterns shown by individual species on the different transects (Addendum I) illustrates this.

Counts of species and groups have been summed over all transects to index the bird numbers on the lake. It is not a strong index, as large numbers of birds can be missed in the northern part of the lake and it would underestimate the temporal variability on the lake overall. Table 7 gives results for the groups, and Addendum I gives the results for species. To illustrate this variability, the total counts for the groups have been graphed in Figure 2. The variation over any of these groups and species over the sample period as a whole is several hundred percent.

It is obvious that bird counts are of little value for monitoring.



Francis Crome Pty. Ltd. for
NSR Environmental Consultants Pty. Ltd.

North Gold (WA) Ltd.

Lake Cowal Gold Project

Temporal sequence of total counts of each Ecological Group

Figure 2

The variability of waterbirds not only excludes them as monitoring organisms but also indicates that only the grossest impacts on them would be detectable. Such an event would be massive pollution that persisted in the lake sediments over successive drying and filling cycles and that reduced diversity and productivity of habitats and/or produced large toxic effects on birds. Even this would only be signaled by sustained declines and absences of species and groups over long periods of time. Such an event would be far easier detected using chemical sampling of the substrate, water and biota described in NSR (1995) (Appendix T of this EIS). It is possible that, on a small scale, noise and dust around the mine site may drive birds away. E.E.S. (1994a, b) suggested that low counts on the Mine Transect in January 1994 were due to drilling activities. This is a reasonable general conclusion. Birds will withdraw from any strange intrusion, including drilling rigs, boats and fishermen; but they adapt to continuing, predictable disturbances that aren't aimed at them directly[1]. It is quite likely that noise from the site will soon be ignored by birds. The main problem they face is crashing into the roofs of the buildings at night.[2]

Conclusions

The transect counts have served their purpose well in investigating the characteristics of the mine site. They also provide a good baseline description of waterbird dynamics. They have also demonstrated that waterbirds are unsuitable as monitoring organisms for the lake. In view of this, the present intensive system of transect counts should be discontinued. However, some continuing system of maintaining awareness of the waterbirds on the lake needs to be maintained in order to demonstrate that there have not been gross changes to the waterbird use of the lake. Lake Cowal is being included in the R.A.O.U. waterbird survey program (R.A.O.U. undated), so there will be ongoing yearly counts. It would be very useful to survey breeding birds every year to ensure breeding is being maintained.

At the mine site itself, it would be useful to keep records of the birds using the immediate vicinity and the tailing ponds and to collect any fatalities. This would be most appropriately incorporated into the duties of someone based at the site.

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1 In this particular situation, the evidence is lacking. At that particular sampling time, the greatest decline was on Transect 8, not on the Mine Transect. Nonetheless, the general case of birds avoiding "intruders" is true.

2 Waterbirds, especially ducks, have been known to crash onto shiny steel roofs at night, presumably because a roof reflects the moonlight and looks like a water body. Colorbond roofing will probably circumvent this.

References

Christidis, L. and Boles, W. E. (1994). The taxonomy and species of birds of Australia and its territories. RAOU Monograph No. 2. RAOU, Melbourne.

Crome, F.H.J. (1985). An experimental investigation of filter feeding on zooplankton by some specialised waterfowl. *Australian Journal of Zoology* **33**:849-862.

Cramp, S. and Simmons, K. E. L. (eds.) (1977 - 1985). *Handbook of the birds of Europe, the Middle East and North Africa*. Volumes I - IV. Oxford University Press, Oxford.

E.E.S. (1992a). Lake Cowal waterbird monitoring survey progress report, January 1992. Report to Geopeko Operations and NSR.

E.E.S. (1992b). Lake Cowal waterbird monitoring survey progress report, August 1992. Report to Geopeko Operations and NSR.

E.E.S. (1992c). Lake Cowal waterbird monitoring survey progress report, October 1992. Report to Geopeko Operations and NSR.

E.E.S. (1993a). Lake Cowal waterbird monitoring survey progress report, January 1993. Report to Geopeko Operations and NSR.

E.E.S. (1993b). Lake Cowal waterbird monitoring survey progress report, August 1993. Report to Geopeko Operations and NSR.

E.E.S. (1993c). Lake Cowal waterbird monitoring survey progress report, October 1993. Report to Geopeko Operations and NSR.

E.E.S. (1994a). Lake Cowal waterbird monitoring survey progress report, January 1994. Report to Geopeko Operations and NSR.

E.E.S. (1994b). Lake Cowal waterbird monitoring survey progress report, August 1994. Report to Geopeko Operations and NSR.

E.E.S. (1994c). Lake Cowal waterbird monitoring survey progress report, October 1994. Report to Geopeko Operations and NSR.

E.E.S. (1995a). Lake Cowal waterbird monitoring survey progress report, January 1995. Report to North Ltd and NSR.

E.E.S. (1995b). Lake Cowal waterbird monitoring interim breeding report, January 1995. Report to North Ltd and NSR.

Frith, H. J. (1977). *Waterfowl in Australia*. Reed Publishing, Melbourne

Humphries, S., Crome, F. H. J. and Faith, D. (1991). Principles and guidelines for a biological monitoring program in Lake Cowal. Report to NSR Environmental Consultants and Geopeko.

Lane, B. A. (1989a). Waterbird survey at Lake Cowal, August 1989. Report to Geopeko and NSR.

Lane, B. A. (1989b). Waterbird investigation. Breeding survey report, October 1989. Report to NSR.

Lane, B. A. (1990). Waterbird investigation data report (September 1990). Report to NSR.

Lane, B. A. (1991a). Report on Lake Cowal waterbird breeding activity January 1991. Report to Geopeko Operations and NSR.

Lane, B. A. (1991b). Lake Cowal waterbird monitoring survey progress report, August 1991. Report to Geopeko Operations and NSR.

Lane, B. A. (1991c). Lake Cowal waterbird monitoring survey progress report, 17th-19th October 1991. Report to Geopeko Operations and NSR.

McCullagh, O., and Nelder, J. A. (1983). *Generalised linear models*. Chapman and Hall, London and New York.

Marchant, S. and Higgins, P. J. (coordinators). (1990 and 1993). *Handbook of Australian, New Zealand and Antarctic birds*. Volumes I and II. Oxford University Press, Melbourne.

NSR (1995). Lake Cowal Gold Project Environmental Baseline Data Review. Internal report. NSR.

R.A.O.U. (undated). Report of RAOU Lake Cowal bird survey. Internal report to NSR.

Venables, W. N. and Ripley, B. D. (1994). *Modern applied statistics with S Plus*. Springer-Verlag, New York, Berlin, Heidelberg.

Vestjens, W. J. M. (1977). Status, habitats and food of vertebrates at Lake Cowal. CSIRO Technical Memorandum No. 12.

Addendum I Data

Counts on Mine Transect

Species	Year and month of survey														
	1989	1989	1990	1991	1991	1992	1992	1992	1993	1993	1993	1994	1994	1994	1995
	A	O	J	A	O	J	A	O	J	A	O	J	A	O	J
Blue-billed Duck															
Musk Duck			1							1					
Freckled Duck															1
Black Swan	57	9	70			2	216	8	1				10	28	2
Australian Shelduck		20	1				1	2	2	1			10	4	
Australian Wood Duck		129	60	1	2	111					8	41	3	11	4
Pacific Black Duck	7	33	1	11	20	58	60	26	50	16		3	51	43	41
Australasian Shoveler	3	14		2			51						2		
Grey Teal	94	375	258	46	57	322	1284	315	360	38	10	10	134	221	77
Chestnut Teal															
Pink-eared Duck		2	4				211						22	2	2
Hardhead	13	3	2					4	4						
Australasian Grebe	6		15				13			4					
Hoary-headed Grebe	4	6	36	6	4					7			14	13	
Great Crested Grebe			6												
Darter		2	3	2	18	8	1	2	1	4			11	24	10
Little Pied Cormorant	16		13	16	2	10	2	1		1					1
Pied Cormorant				1	3			1	3				2		2
Little Black Cormorant	17	5	15	88	2	223	130	15	7		2			3	8
Great Cormorant		1	1	15	3	10	20	1	1					2	39
Australian Pelican		58	5		33	608	136	135	128	48	6	7	28	63	206
White-faced Heron	2	8	21	4	2	7	1		13		1	2		2	
Little Egret															
White-necked Heron		2	4						2		1	2			
Great Egret		1	6	41	10	41	32	14				5	1	1	3
Intermediate Egret							4			3					
Cattle Egret															
Nankeen Night Heron												4		1	
Australasian Bittern															
Glossy Ibis					42									29	
Australian White Ibis	1	15	1		2	3				2		3			1
Straw-necked Ibis	9	4							2	7		1			
Royal Spoonbill			4	1	5		1	8		3		13			9
Yellow-billed Spoonbill			3		3	9	9	14		4		2		3	5
Purple Swamphen			5				1	4		155		2	406	284	75
Dusky Moorhen															
Black-tailed Native-hen												1		3	
Eurasian Coot		7	77	974	31	96		66	173	16			152	404	162
Brolga															
Latham's Snipe															
Marsh Sandpiper								32	1						
Common Greenshank						1	37	82	42						
Red-necked Stint															
Pectoral Sandpiper								2							
Sharp-tailed Sandpiper						1	5	6							
Black-winged Stilt		4	92	4	2	83	18		28						40
Red-necked Avocet						4									
Red-capped Plover							2	8							
Black-fronted Dotterel				2	2	7		1				2	2	1	1
Red-kneed Dotterel															
Banded Lapwing			2												
Masked Lapwing	7	12	34	4	4	31	2	14	17			4	1	7	20
Silver Gull	63	36	1	10	3	256	16	24	29	6			14	4	16
Franklin's Gull						1									
Gull-billed Tern						1	3								
Caspian Tern						1		1	1						
Whiskered Tern		53	103	31				100	35	14				2	87
Totals	299	799	844	1259	250	1894	2256	886	900	330	28	102	863	1155	812

Counts on Transect 2

Species	Year and month of survey														
	1989	1989	1990	1991	1991	1992	1992	1992	1993	1993	1993	1994	1994	1994	1995
	A	O	J	A	O	J	A	O	J	A	O	J	A	O	J
Blue-billed Duck															
Musk Duck		2	6							2				1	
Freckled Duck															10
Black Swan	3	2	169		1		100	24		4		6	6	13	13
Australian Shelduck		1					2					1			
Australian Wood Duck	2	4	118	118	14		23				9	48	27	15	32
Pacific Black Duck	8	48	2	10	9	19	8	35	15	15	13	55	57	68	107
Australasian Shoveler	6	6									1		1	3	14
Grey Teal	85	278	1056	58	2	291	594	239	24	21	29	119	432	256	189
Chestnut Teal	5														
Pink-eared Duck						1	2		2				58	86	6
Hardhead	8	31											2	10	
Australasian Grebe	10	8	30				6			2			1		
Hoary-headed Grebe		2	52	4	1					24			36	9	
Great Crested Grebe	12	1	23												
Darter	1		4	1	8	2	3	6	1	3	3	3	14	21	6
Little Pied Cormorant	34	3	61	5	5		1			1					2
Pied Cormorant					12								1	5	
Little Black Cormorant		10	6	28	96	418	2	11		44	11	1	4	3	24
Great Cormorant		2	8		5	3	67	4		1	1	2	42	3	21
Australian Pelican			10		37	137	120	105	55	79	3	57	48	90	579
White-faced Heron	1	18	11	2	1	3		2	4			13	1		1
Little Egret								3							
White-necked Heron		7	2									7			
Great Egret			5	28	10	28	5	35		6	2	6	7	1	12
Intermediate Egret		4												1	1
Cattle Egret															
Nankeen Night Heron										2	5				
Australasian Bittern									1						
Glossy Ibis						1		46						33	5
Australian White Ibis	3	9	7	5	1		11		1			2		2	4
Straw-necked Ibis	4	3	1							10					
Royal Spoonbill		15		2	1	6	3	3	1			10	4		3
Yellow-billed Spoonbill	3	10		1		1	42					7		1	
Purple Swamphen		1	44					4	5	129	17	26	46	34	9
Dusky Moorhen															
Black-tailed Native-hen															
Eurasian Coot		2	165	108	2	17	210	41				100	376	270	
Brolga			3												
Latham's Snipe									5	2	4				4
Marsh Sandpiper						39		9	2						3
Common Greenshank						4									8
Red-necked Stint															
Pectoral Sandpiper															
Sharp-tailed Sandpiper															
Black-winged Stilt		12	48	9		43	19	3							66
Red-necked Avocet															1
Red-capped Plover								2							
Black-fronted Dotterel					1	22		1		1			2	8	
Red-kneed Dotterel															
Banded Lapwing			3												
Masked Lapwing	6	11	20	1	2	11	1	8	2			2		4	36
Silver Gull	20	1		4		10	2	2	3	10		4	4	4	41
Franklin's Gull															
Gull-billed Tern															
Caspian Tern															
Whiskered Tern		10	59	2	4	15		12	40			31			112
Totals	211	501	1913	386	212	1071	1221	595	161	356	98	500	1169	941	1309

Counts on Transect 7

Species	Year and month of survey														
	1989	1989	1990	1991	1991	1992	1992	1992	1993	1993	1993	1994	1994	1994	1995
	A	O	J	A	O	J	A	O	J	A	O	J	A	O	J
Blue-billed Duck			13				.	.	.						
Musk Duck							.	.	.					1	
Freckled Duck		4	23				.	.	.						1
Black Swan	24	4	27	8	10	68	.	.	.	41	7	15	24	12	325
Australian Shelduck	6	2	17	3	7	35	.	.	.	5			12	4	21
Australian Wood Duck	10	55	123		32		.	.	.	1	2	90	2	54	22
Pacific Black Duck	14	54	225	24	9	59	.	.	.	27	14	8	4	11	14
Australasian Shoveler	8	12	53			54	.	.	.	27		11			138
Grey Teal	154	277	3605		9	934	.	.	.	124	43	62		27	1235
Chestnut Teal	4		25				.	.	.					2	
Pink-eared Duck		6	84		4		.	.	.		2			2	44
Hardhead	8	15	1			5	.	.	.	2					
Australasian Grebe		1	16				.	.	.						
Hoary-headed Grebe	1	5	154	5			.	.	.	1			18	1	
Great Crested Grebe							.	.	.						
Darter				3			.	.	.	4	1	6		12	
Little Pied Cormorant		23		2	3		.	.	.					2	3
Pied Cormorant		1			2		.	.	.		1				
Little Black Cormorant		4		5	17	1	.	.	.	4			1	1	3
Great Cormorant		1			4		.	.	.					1	
Australian Pelican		175	500	3	16	32	.	.	.	1	6	3	2	38	54
White-faced Heron	1	15	7	1		3	.	.	.				3	5	6
Little Egret							.	.	.				1	3	
White-necked Heron	1	18			1		.	.	.				1	3	
Great Egret			1	11	18	1	.	.	.	4		5	5	6	1
Intermediate Egret		1					.	.	.					6	
Cattle Egret		12													
Nankeen Night Heron					2		.	.	.			5			
Australasian Bittern							.	.	.			1			
Glossy Ibis						5	.	.	.					72	3
Australian White Ibis		17	7		11	9	.	.	.	3				19	10
Straw-necked Ibis	2	17	4			32	.	.	.	3		2			
Royal Spoonbill		6		5	4		.	.	.	4		14		1	4
Yellow-billed Spoonbill		4		12	23	20	.	.	.	3		10	9	22	13
Purple Swamphen				17			.	.	.	3					
Dusky Moorhen							.	.	.	1	2				
Black-tailed Native-hen			4	19			.	.	.	2		5	29	52	
Eurasian Coot		5	84	23	260		.	.	.	180		65		6	255
Brolga							.	.	.						2
Latham's Snipe							.	.	.						
Marsh Sandpiper							.	.	.						
Common Greenshank						1	.	.	.						4
Red-necked Stint						2	.	.	.						
Pectoral Sandpiper							.	.	.						
Sharp-tailed Sandpiper						13	.	.	.						
Black-winged Stilt		18	178			183	.	.	.						190
Red-necked Avocet			9				.	.	.						
Red-capped Plover						5	.	.	.						
Black-fronted Dotterel					2	1	.	.	.				1		
Red-kneed Dotterel				1			.	.	.				1		
Banded Lapwing							.	.	.						
Masked Lapwing	7	45	42		2	8	.	.	.	6		4	1	3	26
Silver Gull		44	21	7		6	.	.	.	4	1	5	7	2	2
Franklin's Gull							.	.	.						
Gull-billed Tern				1		1	.	.	.						
Caspian Tern							.	.	.						
Whiskered Tern		2	31	10			.	.	.			10		17	
Totals	240	843	5254	160	436	1478	.	.	.	450	79	321	121	385	2376

Counts on Transect 8

Species	Year and month of survey														
	1989	1989	1990	1991	1991	1992	1992	1992	1993	1993	1993	1994	1994	1994	1995
	A	O	J	A	O	J	A	O	J	A	O	J	A	O	J
Blue-billed Duck															
Musk Duck			6							1					
Freckled Duck															2
Black Swan		9	25	12	32		25	68	12	45	8	21	44	46	4
Australian Shelduck	2	3			8	24	11						9	10	
Australian Wood Duck	3	35	31	3	19	8	1	11		7	2	18	84	23	35
Pacific Black Duck	7	25	17	11	6	11	48	20	37	19	14	10	24	30	71
Australasian Shoveler	4	2	2				4	2		2					7
Grey Teal	139	297	137	7		102	423	133	60	110	16	26	34	39	188
Chestnut Teal	6						5			2					
Pink-eared Duck			15				13			1					26
Hardhead		28	2			10									
Australasian Grebe							5			3					
Hoary-headed Grebe	2		29							14			17	2	
Great Crested Grebe			1					1							
Darter			2	4	10	12		5		2	1		12	10	31
Little Pied Cormorant			35	1		38	37	2					2		12
Pied Cormorant					1	1	1						1	2	
Little Black Cormorant			1	39	39	190	30	14	3	2				1	166
Great Cormorant			5	6	3	288	16	24			2			59	9
Australian Pelican	8	3	3	8	2	212	13	45	58	8	38		77	51	224
White-faced Heron	2	1	2					2	1		4	3	1		1
Little Egret															1
White-necked Heron		1	1								1	1		1	
Great Egret			2	40	3	81	19	14	4			7	3		8
Intermediate Egret										1					
Cattle Egret															
Nankeen Night Heron															
Australasian Bittern															
Glossy Ibis						2									3
Australian White Ibis		1	4		1		1					1	1		
Straw-necked Ibis	1		1					65	12						
Royal Spoonbill		2	1			1	1	3		1	1	33	1	3	15
Yellow-billed Spoonbill	1	3	5			1	7	8				1		2	1
Purple Swamphen							1	1	5	121	1		110	20	32
Dusky Moorhen															
Black-tailed Native-hen															
Eurasian Coot		16	204		38	20	3	286	158	558		30	48	145	266
Brolga															
Latham's Snipe															
Marsh Sandpiper															
Common Greenshank						2									
Red-necked Stint															
Pectoral Sandpiper															
Sharp-tailed Sandpiper															
Black-winged Stilt			14			16	11	1							24
Red-necked Avocet															
Red-capped Plover															
Black-fronted Dotterel							4								
Red-kneed Dotterel							13								
Banded Lapwing															
Masked Lapwing	5	20	13	1	3	23	3	2	4			2	3	5	15
Silver Gull	1	17	1	1		8	17	6	4	13	5	1	22	2	1
Franklin's Gull															
Gull-billed Tern		2		2			4								
Caspian Tern															
Whiskered Tern			46	3		6			18						1
Totals	181	465	605	138	165	1056	716	713	376	910	93	154	493	451	1143

Sum of Counts on All Transects

Species	Year and month of survey														
	1989 A	1989 O	1990 J	1991 A	1991 O	1992 J	1992 A	1992 O	1993 J	1993 A	1993 O	1994 J	1994 A	1994 O	1995 J
Blue-billed Duck			13												
Musk Duck		2	13							4				2	
Freckled Duck		4	23												14
Black Swan	84	24	291	20	43	70	341	100	13	90	15	42	84	99	344
Australian Shelduck	8	26	18	3	15	59	14	2	2	6		1	31	18	21
Australian Wood Duck	15	223	332	122	67	119	24	11		8	21	197	116	103	93
Pacific Black Duck	36	160	245	56	44	147	116	81	102	77	41	76	136	152	233
Australasian Shoveler	21	34	55	2		54	55	2		29	1	11	3	3	159
Grey Teal	472	1227	5056	111	68	1649	2301	687	444	293	98	217	600	543	1689
Chestnut Teal	15		25				5			2				2	
Pink-eared Duck		8	103		4	1	226		2	1	2		80	90	78
Hardhead	29	77	5			15		4	4	2			2	10	
Australasian Grebe	16	9	61				24			9			1		
Hoary-headed Grebe	7	13	271	15	5					46			85	25	
Great Crested Grebe	12	1	30					1							
Darter	1	2	9	10	36	22	4	13	2	13	5	9	37	67	47
Little Pied Cormorant	50	26	109	24	10	48	40	3		2			2	2	18
Pied Cormorant		1		1	18	1	1	1	3		1		4	7	2
Little Black Cormorant	17	19	22	160	154	832	162	40	10	50	13	1	5	8	201
Great Cormorant		4	14	21	15	301	103	29	1	1	3	2	42	65	69
Australian Pelican	8	236	518	11	88	989	269	285	241	136	53	67	155	242	1063
White-faced Heron	6	42	41	7	3	13	1	4	18		5	18	5	7	8
Little Egret								3					1	3	1
White-necked Heron	1	28	7		1				2		2	10	1	4	
Great Egret		1	14	120	41	151	56	63	4	10	2	23	16	8	24
Intermediate Egret		5					4			4				7	1
Cattle Egret		12													
Nankeen Night Heron					2					2	5	9		1	
Australasian Bittern									1			1			
Glossy Ibis					42	8		46						134	11
Australian White Ibis	4	42	19	5	15	12	12		1	5		6	1	21	15
Straw-necked Ibis	16	24	6			32		65	14	20		3			
Royal Spoonbill		23	5	8	10	7	5	14	1	8	1	70	5	4	31
Yellow-billed Spoonbill	4	17	8	13	26	31	58	22		7		20	9	28	19
Purple Swamphen		1	49	17			2	9	10	408	18	28	562	338	116
Dusky Moorhen										1	2				
Black-tailed Native-hen			4	19						2		6	29	55	
Eurasian Coot		30	530	1105	331	133	213	393	331	754		195	576	825	683
Brolga			3												2
Latham's Snipe									5	2	4				4
Marsh Sandpiper						39		41	3						3
Common Greenshank						8	37	82	42						12
Red-necked Stint						2									
Pectoral Sandpiper								2							
Sharp-tailed Sandpiper						14	5	6							
Black-winged Stilt		34	332	13	2	325	48	4	28						320
Red-necked Avocet			9			4									1
Red-capped Plover						5	2	10							
Black-fronted Dotterel				2	5	30	4	2		1		2	5	9	1
Red-kneed Dotterel				1			13						1		
Banded Lapwing			5												
Masked Lapwing	25	88	109	6	11	73	6	24	23	6		12	5	19	97
Silver Gull	84	98	23	22	3	280	35	32	36	33	6	10	47	12	60
Franklin's Gull						1									
Gull-billed Tern		2		3		2	7								
Caspian Tern						1		1	1						
Whiskered Tern		65	239	46	4	21		112	93	14		41		19	200
Number of Species	**22**	**35**	**37**	**28**	**27**	**36**	**32**	**34**	**28**	**33**	**20**	**26**	**30**	**34**	**34**
Totals	**931**	**2608**	**8616**	**1943**	**1063**	**5499**	**4193**	**2194**	**1437**	**2046**	**298**	**1077**	**2646**	**2932**	**5640**

Addendum II Description of Analytical Methods

This addendum describes the statistical procedures used to analyse bird counts.

Bird counts were investigated using generalised linear models. The models included terms for Transect (3 degrees of freedom), Month (2 degrees of freedom) and Month x Transect interaction. Other terms were considered to represent random effects and were not explicitly modeled (though such random effects are allowed for by inflating the variance function - see below). A log link function was used to avoid problems with negative counts. The effect of variable transect length was modelled by using log transect length as an offset. Using log transect length as an offset is equivalent to assuming expected counts to be proportional to transect length.

Bird counts in this study are extremely variable. The variance of observed counts usually exceeds the mean. This overdispersion indicates that a Poisson distribution will provide a poor description of the distribution of species counts. Accordingly, a quasi likelihood approach was adopted (McCullagh and Nelder, 1983). Several variance functions were explored (with variance proportional to the mean and to the mean squared and with a variance function based on the Negative Binomial distribution). Diagnostic plots of deviance residuals versus fitted values were produced. In general, residual plots were better behaved for the Negative Binomial variance function than for the other variance functions. Results are presented for this variance function

The Negative Binomial variance function has the form: $\sigma^2 = \alpha\mu\ (1+\mu/\theta)$, where σ^2 is the variance, μ is the mean and θ is a constant which must be estimated. θ was estimated using a Fisher scoring technique, alternating with the iteratively reweighted least squares iterations used to fit the generalised linear model. The approach is described by Venables and Ripley (1994), and calculations were performed in **Splus**, using the Venables and Ripley function "glm.nb".

Log Likelihood ratio $\chi 2$ square tests were developed for the Transect main effect and the Transect x Month interaction. In addition, a specific contrast was developed, comparing the mean response for the Mine Transect with the mean of the other transects. This contrast was tested with a **t** test. A point estimate and 95% confidence interval for the contrast was calculated. The point estimate can be interpreted as a measure of effect size - the ratio of numbers of birds on the Mine Transect to the mean number on the other transects.

The iteratively reweighted least squares algorithm used to fit the generalised linear model failed to converge for some species. This occurred when total counts for some transect-month combinations were zero. This is a well-known phenomenon. For these species, the transect by month interaction was dropped from the model, and the model was refitted.

Lake Cowal Gold Project

Appendix D

LAKE COWAL WATERBIRD MONITORING SURVEY
INTERIM BREEDING REPORT

by

Environmental & Educational Services
37 Graduate Cres., Mulgrave, Vic 3170
Australia

for

NSR Environmental Consultants Pty Ltd
25 Burwood Road, Hawthorn, Vic 3122
Australia

January 1995

LAKE COWAL WATERBIRD MONITORING SURVEY

INTERIM BREEDING REPORT

January 1995

Prepared by: Environmental & Educational Services
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Fax: 905-2948

For: NSR Environmental Consultants Pty Ltd
North Gold Mining (WA) Limited

Date: January 1995

1. INTRODUCTION

This report presents the results of the monitoring survey of waterbird breeding activity on Lake Cowal undertaken between August 1989 and January 1995 inclusive. The study includes data from sixteen surveys (see Lane, 1990, 1991a, b, c; Environmental & Educational Services, 1992a, b, c, 1993a, b, c, 1994a, b, c, 1995) over six breeding seasons.

2. METHODS

The methods employed comprised:

(1) surveys of areas of inundated living Lignum, Cane Grass and River Red Gum stands for breeding waterbirds

(2) incidental observations of breeding activity or young birds, particularly along the four shore-based transects (T1, T2, T7 and T8) used for monitoring waterbird numbers, and

(3) survey from the air when low breeding activity was suspected.

3. RESULTS

The data set of breeding birds from Lake Cowal shows variation in breeding bird numbers over time as well as spatially around the lake.

3.1 Seasonality

A record of bird breeding activity since the commencement of the survey is presented in Figure 1. These data are assembled from observations of nests, adult birds with young and clutches of young and are standardised to a unit equating to the number of nests. Some observations of large numbers of immatures are included as total number of young (e.g., Whiskered Terns).

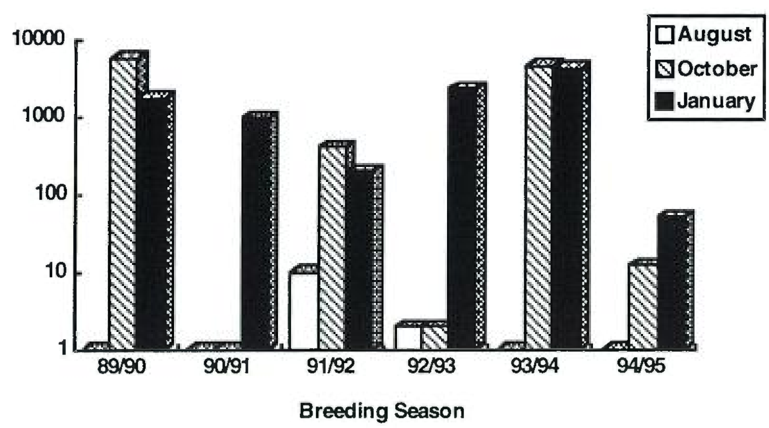

Figure 1. The seasonality of breeding bird numbers observed at Lake Cowal since August 1989.

Since mid-1989, the greatest breeding activity has been in October and January. While several species were observed by Lane to be breeding in August 1989 (Lane, 1990), these were not quantified. Very few or no nests have been recorded in the four other surveys undertaken in August (1991, 1992, 1993 and 1994).

These data are presented by species in Table 1. The only species recorded breeding in August are:

White-faced Heron	Black Swan
Australian Shelduck	Pacific Black Duck
Grey Teal	Pink-eared Duck
Hardhead	Australian Wood Duck
Eurasian Coot	Silver Gull

None of the colonially nesting species (e.g., ibis, cormorants, spoonbills or egrets) have been recorded breeding in August, with the exception of a small number of Silver Gulls at two places in the northern end of the lake in August 1991. The rest of the colonial nesting activity appears to have commenced mostly in September, as breeding was well established by the October

Table 1. Record of breeding activity at Lake Cowal since August 1989 (*denotes breeding record; # denotes colonial breeding species detailed in Table 2; other species detailed in Table 3; ? denotes possible nest; numbers are standardised to number of nests).

Species	Aug 89	Oct 89	Jan 90	Jan 91	Aug 91	Oct 91	Jan 92	Aug 92	Oct 92	Jan 93	Aug 93	Oct 93	Jan 94	Aug 94	Oct 94	Jan 95
Great Crested Grebe			*													
Hoary-headed Grebe		*	*													
Australasian Grebe			*													
Darter #		30	49	162		133	21			3		10	90		7	50
Great Cormorant #			3	40		1							6			
Pied Cormorant #			*	15		8	1						7			
Little Black Cormorant #		150	295	474		214	164			8		55	1000			
Little Pied Cormorant #		100	337			3						6				
White-necked (Pacific) Heron		*	*	1								1				
White-faced Heron	*		*									1				
Great Egret #			*	120		2?										
Intermediate Egret #			7	1												
Nankeen (Rufous) Night Heron #			210	28												
Glossy Ibis #			10							100						
Australian White (Sacred) Ibis #		120	113	24		5	3			500+		191	50			
Straw-necked Ibis #		4000	3545							1500+		3734	2500			
Royal Spoonbill #		15	42	35		1				30		14	100			
Yellow-billed Spoonbill #		*	*	12		1							20			
Black Swan	*	*	*					2	2	7		3	1			
Australian (Chestnut-breasted) Shelduck	*														1	
Pacific Black Duck	*	*										1				
Grey Teal	*	*	*									2	5			
Pink-eared Duck	*	*	*													
Hardhead (White-eyed Duck)	*	*	*													
Australian Wood (Maned) Duck	*							1					5			
Blue-billed Duck		*	*													
Musk Duck			*													
Eurasian (Australian) Coot	*	*	*													
Purple (Eastern) Swamphen													1			
Masked Lapwing (Plover)		*														
Red-kneed Dotterel			*													
Black-winged (Pied) Stilt		*	*													
Silver Gull #					*	10						6				
Whiskered Tern		1000	900				*			*			6			
Gull-billed Tern			3													
TOTAL	*	5415+	5514+	912	*	378	189+	3	2	2148+	0	4024	3791	0	8	50
N. Spp.	9	19	29	11	1	10	5	2	1	8	0	12	13	0	2	1

Table 2. Summary of Colonial Breeding Birds - Lake Cowal (August 1989 - January 1995)

		Number of Nests per Species* (Species Preferred Habitat†)														
Survey Dates	Breeding Area** (Habitat Type†)	Darter (A, C, D)	Great Cormorant (A, C, D)	Pied Cormorant (A, D)	Little Black Cormorant (A)	Little Pied Cormorant (D)	Great Egret (D)	Intermediate Egret (D)	Rufous Night Heron (C, D)	Glossy Ibis (B)	Sacred Ibis (B)	Straw-necked Ibis (B)	Royal Spoonbill (B)	Yellow-billed Spoonbill (A, D)	Silver Gull (E)	Total
9-11/8/89	Unspecified			NC								4,000				4,000+
21-24/10/89	1 (A, D)															0
early 1/90	2 (B, C, D)		3		45	35	1	7	200	10	25		20	4		350
	3 (A)	4				22								6		32
	4 (B, C, D)	15				30					10		2			57
	5 (B, C, D)	30			250	250			10		18		20			578
	6 (B, C, D)										60					60
	8 (E)															0
	Total	49	3	NC	295	337	1	7	210	10	113	4,000	42	10	0	5,077+
24-26/1/91	1 (A, D)	37	19											11		67
	2 (B, C, D)	35					120	1	28		10					194
	3 (A)	65	21	11									2	1?		100
	4 (B, C, D)															0
	5 (B, C, D)	25		4	474						11		33			547
	6 (B, C, D)										3					3
	8 (E)															0
	Total	162	40	15	474	0	120	1	28	0	24		35	12	0	911
24-26/8/91	1 (A, D)															0
17-19/10/91	2 (B, C, D)	28					2?									30
24-26/1/92	3 (A)	92	1	8	40	3								1	3	148
	4 (B, C, D)															0
	5 (B, C, D)	13			174								1			188
	6 (B, C, D)										5					5
	8 (E)														7	7
	Total	133	1	8	214	3	2	0	0	0	5	0	1	1	10	378
28-29/8/92	1 (A, D)															0
27-28/10/92	2 (B, C, D)															0
25-26/1/93	3 (A)	3			8											11
	4 (B, C, D)									100	500	1,500	30			2,130
	5 (B, C, D)															0
	6 (B, C, D)															0
	8 (E)															0
	Total	3	0	0	8	0	0	0	0	100	500	1,500	30	0	0	2,141
30-31/8/93	1 (A, D)	10	1											20		31
20-21/10/93	2 (B, C, D)											400				400
17-18/1/94	3 (A)	20	5													25
	4 (B, C, D)															0
	5 (B, C, D)	60		7	1,000	3						3,500	50			4,620
	6 (B, C, D)										191	234	50			475
	8 (E)														6	6
	Total	90	6	7	1,000	3	0	0	0	0	191	4,134	100	20	6	5,557
20-21/8/94	Unspecified				A											A
9-10/10/94	1 (A, D)															0
15-16/1/95	2 (B, C, D)															0
	3 (A)	50														50
	4 (B, C, D)															0
	5 (B, C, D)															0
	6 (B, C, D)															0
	8 (E)															0
	Total	50	0	0	A	0	0	0	0	0	0	0	0	0	0	50

*To avoid double counting, nest number for each site is the highest number of nests counted for that site in any one survey during the breeding season. When adult breeding birds or recently fledged birds (juveniles) have been counted rather than nests, the bird counts have been converted to nest counts at a ratio of 2 birds (adult or juvenile) = 1 nest, unless otherwise recommended in the survey report.
†Habitat: A—Open water with River Red Gum; B—Lignum; C—River Red Gum with Lignum; D—River Red Gum; E—Open water; F—Cane Grass. **See Figure 2 for locations of breeding areas. ?— Possible nest. NC—Breeding recorded but no count recorded of nests, breeding birds or juveniles. A—Numerous nests, presumed to be Little Black Cormorant nests, were recorded as abandoned in the October survey. They were in good repair and were not noted in the August survey.
Sources: Lane (1989a, b; 1990; 1991a, b, c) and EES (1992a, b, c; 1993a, b, c; 1994a, b, c; 1995).

Table 3. Summary of Incidental Breeding Records - Lake Cowal (August 1989-January 1995)

Survey Dates	Transect or Breeding Area**	Great-crested Grebe (CG, L)	Hoary-headed Grebe (CG, L)	Australasian Grebe (CG, L)	Pacific Heron (B, L)	White-faced Heron (B)	Black Swan (CG, L)	Australian Shelduck (H)	Pacific Black Duck (H, L)	Grey Teal (H)	Pink-eared Duck (H)	Hardhead (H, L)	Maned Duck (H)	Blue-billed Duck (L)	Musk Duck (L)	Eurasian Coot (CG, L)	Purple Swamphen (L)	Masked Lapwing (T)	Red-kneed Dotterel (T)	Black-winged Stilt (T)	Whiskered Tern (CG)	Gull-billed Tern (CG)	Total
		Number of Nests per Species* (Species Preferred Habitat†)																					
9-11/8/89	Unspecified	NC		NC		NC	NC	NC	NC			NC	NC	NC	NC			NC	NC	NC			NC
21-24/10/89	T1									NC													NC
early 1/90	BA2		1		2						2					5							10
	BA3				3																900		903
	BA4															1							1
	BA7																				500	3	503
	Total	NC	1	NC	5	NC	NC	NC	NC	NC	2	NC	NC	NC	NC	6	0	NC	NC	NC	1,400	3	1,417+
24-26/1/91	BA1				1																		1
	Total	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
24-26/8/91																							
17-19/10/91	BA6																				NC		NC
24-26/1/92	Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NC	0	NC
28-29/8/92	Unspecified						7														NC		7+
27-28/10/92	T2												1										1
25-26/1/93	T8						2																2
	BA2						1																1
	Total	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0	0	NC	0	11+
30-31/8/93	Unspecified									5			5				1						11
20-21/10/93	T2								1												6		7
17-18/1/94	T7									2													2
	BA5						1																1
	BA6						2																2
	BA7						1																1
	BA8				1	1																	2
	Total	0	0	0	1	1	4	0	1	7	0	0	5	0	0	0	1	0	0	0	6	0	26
20-21/8/94																							
9-10/10/94	T8							1															1
15-16/1/95	Total	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

*To avoid double counting, nest number for each site is the highest number of nests counted for that site in any one survey during the breeding season. When adult breeding birds or recently fledged birds (juveniles) have been counted rather than nests, the bird counts have been converted to nest counts at a ratio of 2 birds (adult or juvenile) = 1 nest. †Habitat: CG–Cane Grass, L–Lignum, H–hollows, B–tree branches, T–terrestrial habitat. **See Figure 2 for locations of transects and breeding areas. NC Breeding recorded but no count recorded of nests, breeding birds or juveniles.

Sources: Lane (1989a, b; 1990; 1991a, b, c) and EES (1992a, b, c; 1993a, b, c; 1994a, b, c; 1995).

surveys. Large numbers of nests were recorded in October 1989, January 1990, January 1993 and October 1993. The main species were Little Black and Little Pied Cormorants, Straw-necked and Sacred Ibis and Rufous Night Heron. The number of nests recorded in October and January declined after the 1989/90 breeding season, with the gradual decline in water levels, through to late 1992. A small increase in water level (~20 cm) between October 1992 and January 1993 correlates with an increase in the number of nests, principally of the three ibis species.

Although this water level rise was short-lived, it was followed, from July 1993, by a flooding phase that raised lake water levels by over 2.1 m by October 1993. These high levels, which were maintained through most of the 1993/94 breeding season, correlated with high numbers of breeding birds of 18 species. The most active species were Little Black Cormorant and Straw-necked and Sacred Ibis. Over one hundred Royal Spoonbills were also observed breeding.

The lake level has steadily declined since with the onset of an El Ninõ event in March 1994. No evidence of breeding was observed in August of that year, and while many nests of Little Black Cormorant had been constructed by October, they appeared to have all been abandoned. Other than incidental observations of a pair of Australian Shelducks with ducklings, the only species recorded breeding in October 1994 were Darters. They continued breeding through to January 1995 in trees amongst shallow water (~10 to 20 cm). Generally, the more recent nests, those without young, appeared to be furthest from the lake edge.

3.2 Breeding Locations

The breeding activity recorded on Lake Cowal has been divided into that of colonially breeding species (Table 2) and that for which evidence of breeding has been derived from mainly incidental observations (Table 3). The numbers of nests given for each breeding season and site is the largest number returned for any one survey during the breeding season.

The colonially breeding species, in particular, appear to adopt set locations for breeding. The localities referred to in Tables 2 and 3 are those identified on Figure 2. Breeding areas are numbered 1 to 8; and T1, T2, T7 and T8 refer to the main survey transects on the project area and on the southwest, northeast and southeast of the lake's shoreline respectively.

Table 2 demonstrates that very little colonial breeding activity took place during the surveys since August 1989 in areas 1 and 8 and that none occurred in area 7. Area 1, which is in Nerang Cowal, is probably used only when Nerang Cowal contains sufficient water. At area 8, that closest to the prospective mine site, a few Silver Gull nests have been recorded. Effectively no colonial breeding activity of any conservation significance has been recorded within 2.5 kilometres of the proposed mine site during the surveys over six breeding seasons.

The main part of the breeding activity of ibis and Royal Spoonbill takes place in the large stands of Lignum in areas 2, 4, 5 and 6. Darter and Yellow-billed Spoonbill breed in stands of River Red Gum (and isolated trees) in open water. The cormorants breed in River Red Gum, either in individual trees in the case of Pied Cormorant or, in the case of Little Black Cormorants, generally in denser stands.

Little further conservation significance for waterbird breeding is afforded by the few records of breeding from incidental observations (Table 3). Most of these records are of clutches of young or immature birds and so reflect little of potentially sensitive breeding sites. The only breeding record from the mine site transect is of some broods of Grey Teal, recorded in the

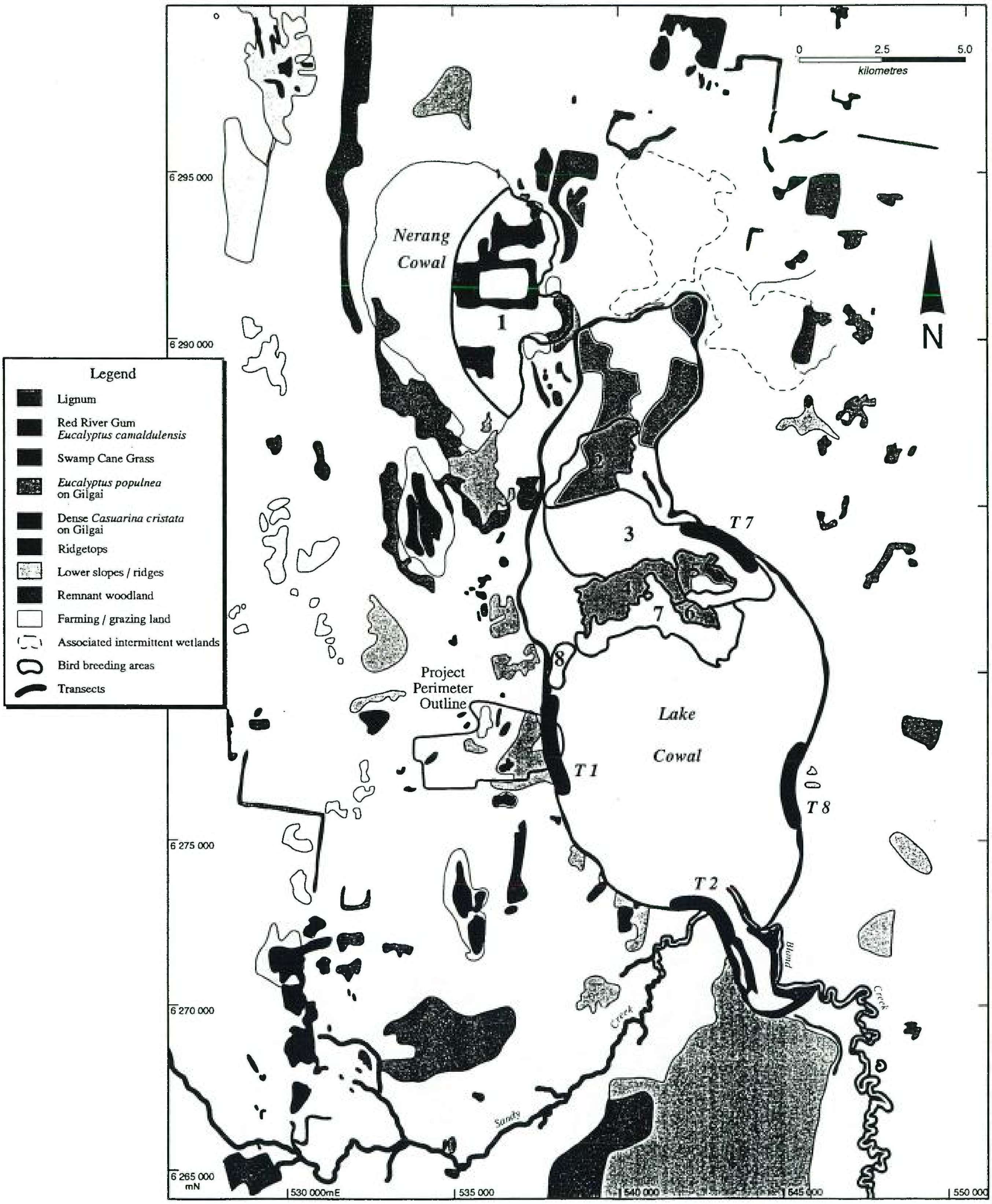

Figure 2. Location of breeding areas and survey transects at Lake Cowal.

1989/90 breeding season. At the nearest breeding localities, numbers 7 and 8, apart from a large number of immature Whiskered Terns recorded in area 7 in the 1989/90 breeding season, the only incidental breeding records for these two areas are of a few Pacific Herons, White-faced Herons, Black Swans or Gull-billed Terns.

4. DISCUSSION

Several other species have been recorded breeding at Lake Cowal in the recent past. These include the Pelican, Freckled Duck, Wandering Whistling Duck, Magpie Goose (Lawler, 1989), Dusky Moorhen and Spotted Crake (Vestjens, 1977). This would raise the list of 35 breeding water birds recorded in this study (Table 1) to 41. There have been, no doubt, even more records taken by others in the past, so this list represents a minimum tally.

The lake is clearly an important breeding site for about ten species of waterbird. In January 1994, the Royal Australasian Ornithologists Union (RAOU) launched a Murray-Darling basinwide survey of the abundance and breeding activity of bird species (Hutchison, 1994). Until that data set is better established, no useful evaluation can be made regarding the importance of Lake Cowal for these birds relative to other sites in the Murray-Darling Basin.

While the RAOU data set is not comprehensive, it provides an insight into the extent of breeding across the region since the study's inception. Across 200 or more sites, as few as 15 species have been recorded breeding. The RAOU's volunteers have not recorded Darter breeding at any site during this period. While its breeding may have been overlooked at some sites and it may breed at sites yet to be visited, the available data suggest that Lake Cowal may represent a favoured breeding site in the Basin during drought conditions. The Darter's continued breeding well into the falling limb of the lake's cycle attests to its greater persistence relative to the cormorants and other colonial breeding species.

5. REFERENCES

E.E.S. 1992a. Lake Cowal Waterbird Monitoring Survey. Progress Report - January 1992. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1992b. Lake Cowal Waterbird Monitoring Survey. Progress Report - August 1992. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1992c. Lake Cowal Waterbird Monitoring Survey. Progress Report - October 1992. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1993a. Lake Cowal Waterbird Monitoring Survey. Progress Report - January 1993. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1993b. Lake Cowal Waterbird Monitoring Survey. Progress Report - August 1993. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1993c. Lake Cowal Waterbird Monitoring Survey. Progress Report - October 1993. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1994a. Lake Cowal Waterbird Monitoring Survey. Progress Report - January 1994. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1994b. Lake Cowal Waterbird Monitoring Survey. Progress Report - August 1994. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1994c. Lake Cowal Waterbird Monitoring Survey. Progress Report - October 1994. Prepared for NSR Environmental Consultants Pty Ltd.

E.E.S. 1995. Lake Cowal Waterbird Monitoring Survey. Progress Report - January 1995. Prepared for NSR Environmental Consultants Pty Ltd.

Hutchison, M. 1994. Drought in the Murray-Darling Basin. *Wingspan*, **16**:10-11.

Lane, B.A. (1989a). Waterbird Investigation, Winter 1989 Survey Report. Report prepared for NSR Environmental Consultants Pty Ltd. September.

Lane, B.A. (1989b). West Wyalong Prospect Waterbird Investigation: Breeding Survey Report, October 1989. Report prepared for NSR Environmental Consultants Pty. Ltd. November.

Lane, B.A. 1990. West Wyalong Prospect - Waterbird Investigation Final Report. Prepared for NSR Environmental Consultants Pty Ltd.

Lane, B.A. 1991a. Report on Lake Cowal Waterbird Breeding Activity - January 1991. Prepared for NSR Environmental Consultants Pty Ltd.

Lane, B.A. 1991b. Lake Cowal Waterbird Monitoring Survey - Progress Report August 1991. Prepared for NSR Environmental Consultants Pty Ltd.

Lane, B.A. 1991c. Progress Report - Lake Cowal Waterbird Monitoring Survey, 17th-19th October 1991. Prepared for NSR Environmental Consultants Pty Ltd.

Lawler, W. 1989. Waterbird breeding at Lake Cowal, N.S.W. *Australian Birds*, **23**:32-35.

Vestjens, W.J.M. 1977. Wetlands water management strategy for the Lachlan River Valley. Progress report. Water Resources Commission of N.S.W.

Lake Cowal Gold Project

Appendix E

LAKE COWAL BASELINE MONITORING PROGRAM: SUPPLEMENTARY INVERTEBRATE SAMPLING

by

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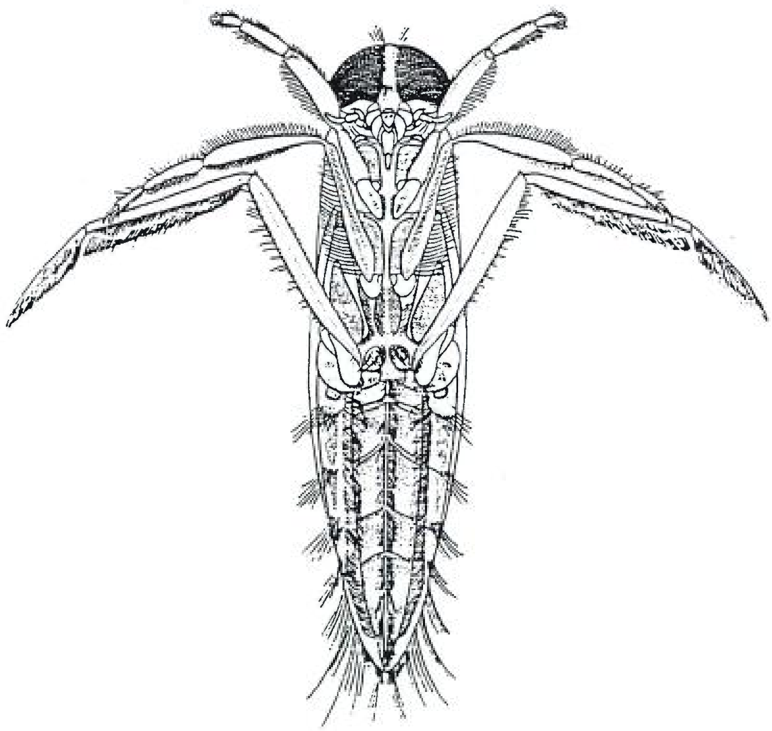
March 1995

LAKE COWAL BASELINE MONITORING PROGRAM: SUPPLEMENTARY INVERTEBRATE SAMPLING

A Report to N. S. R. Environmental Consultants Pty Ltd



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March 1995

INTRODUCTION

The Lake Cowal Baseline Monitoring program was initiated by NSR Environmental Consultants Pty Ltd and have sub-contracted sections of the "In fauna" Survey (as per Humphries *et al.* (1991)) to the Murray-Darling Freshwater Research Centre and the first results were reported earlier (Hawking 1991). This "supplementary invertebrate sampling program" was proposed by F Dominic Fanning of Gunninah Consultants for NSR Consultants.

PROJECT OUTLINE

As per F. Dominic Fanning's facsimile transmission 14th January 1995 (Appendix 1).

LAKE COWAL PROPOSED GOLD MINE
for GEOPEKO LTD
SUPPLEMENTARY INVERTEBRATE SAMPLING PROGRAM
January 1995

This supplementary invertebrate sampling and identification program is required to provide a baseline of invertebrates (diversity and densities) in the area to be disturbed by the proposed pit and comparative data from sites along the previous survey lines (Hawking 1991).

Features of the invertebrate survey should include:

- the use of sediment core and sweep net sampling procedures (as per the original studies - Hawking 1991);
- survey sites should include both of the main aquatic habitats present within the pit area (open water and cane grass) and representative samples distant from the pit site. Suggested locations include B1, P2, E2, C2, B5, L1, L7, as well as two samples of each habitat within the pit;
- if lignum is present within the pit area, additional samples should be taken at these locations and at "control" sites elsewhere in the lake (eg L4 and L9);
- species identification should be to the level detailed in Hawking (1991);
- calculation of species densities for each site, to provide comparative base-line data for future monitoring of any changes in species composition and to enable monitoring of recolonisation of the disturbed sites.

STUDY AND SAMPLE SITES

Lake Cowal, is a large freshwater lake in the Lachlan Region of New South Wales, approximately 50 km north-east of West Wyalong (Vestjens 1977). Humphries *et al.* 1991)(Appendix 2) identified thirty four sample sites on four transects; the Bland transect (six sites), East transect (11 sites, including 3 project & 3 control sites), Irrigation (4 sites) and Lachlan transect (13 sites). Seven of these sites, Bland 1, Bland 5, Project 2, East 2, Control 2, Lachlan 1 and Lachlan 7 were sampled as per the brief. Four addition sites as suggested were chosen. Two sites within the pit area (Pit 1 (cane grass) and Pit 2 (open water) and two sites between the pit area and the bund wall; Bund Wall 1 (open water) and Bund Wall 2 (cane grass). The location (grid co-ordinates) of the sites sampled and their aquatic habitats are presented in Table 1.

Table 1. The location (grid references used by GeoPeko) of the study sites and the major aquatic habitat at each site, during the initial survey (4 March 1991) and the present survey (24 January 1995) .

Sample Site	Location Grid reference	Habitat type 4 Mar 91	 24 Jan 95
Bland 1	539250E, 6277260N	Cane grass	Mud bottom
Bland 5	542350E, 6274720N	Mud bottom	Mud bottom
Project 2	539050E, 6277820N	Cane grass	Cane grass
East 2	541710E, 6278600N	Cane grass	Mud bottom
Control 2	543725E, 6278125N	Cane grass	Cane grass
Lachlan 1	538010E, 6279475N	Mud bottom	Mud bottom
Lachlan 7	539450E, 6284470N	Mud bottom	Mud bottom
Pit 1	547670E, 6277502N	Cane grass	Cane grass
Pit 2	547600E, 6277502	Mud bottom	Mud bottom
Bund Wall 1	548174E, 6277650N	Mud bottom	Mud bottom
Bund Wall 2	547899E, 6278040N	Cane grass	Cane grass

METHODS

Benthic Fauna Collection

Five sediment core were taken at each site. The cores were taken using a 100mm diameter standard hand operated soil corer. The contents of the corer were emptied into a 10 litre bucket, broken up by hand and then washed through a set of Toni Technik E11-70 standard sieves, mesh sizes of 10mm, 2mm and 500um. The samples were preserved in 70% alcohol.

Pelagic Macroinvertebrate Collection

A sweep net collection, consisting of 10 sweeps, each sweep sampling an area approximately 3m in length, were taken from the side of the boat at each site. An "A" framed F.B.A. style hand net, 300um mesh netting, was used. Sweep net collections were performed immediately prior to the core sampling. The samples were preserved in 70% alcohol.

Plankton Collection

Plankton (micro-crustacea) were collected by a horizontal haul just under the water surface. A 300m diameter circular opening, 49 micron mesh plankton tow net was hauled over a measured three metre distance. The samples were transferred into 60 ml pomade jars and preserved in 70% alcohol. The samples are stored at the Murray-Darling Freshwater Research Centre and will be identified when requested by NSR.

Physical Parameters

The water temperature and water depth at each site were recorded. The water temperature was measured using a general purpose white-back Mercury thermometer (-10 to 110°C), taken 300mm below the water surface ,and water depth was measured using a graduated two-meter pole.

Macroinvertebrate Identifications

The faunal identifications have been taken to species level where possible and in the case of damaged or immature specimens the identifications have been taken to the lowest taxonomic level. Voucher specimens were checked by renown experts. The taxonomic identifications followed the keys listed in Hawking (1994). The major keys used were: **General keys**, Williams 1980; **Oligochaeta**, Pinder & Brinkhurst 1994; **Crustacea**, Horwitz *et al.* 1995, Horwitz 1995; **Ephemeroptera**, Alba-Tercedor and Suter 1990; **Odonata**, Hawking 1986; **Hemiptera**, Lansbury 1969, 1975; **Diptera**, Cranston 1994, 1995; **Trichoptera**, Cartwright 1991.

RESULTS

Physical Parameters

The samples were collected from the eleven site during the period 24th to 25th January 1995. At each site the date, time of sampling, water temperature and water depth were recorded (Table 2).

Table 2. Table of sample dates, collection times, water temperature and water depth for each site sampled.

Sample Site	Date	Time	Water Temp.	Water Depth
Bland 1	24 Jan 95	1200 hrs	26.0°C	1.12 m
Bland 5	24 Jan 95	1300 hrs	24.8°C	1.45 m
Project 2	24 Jan 95	1400 hrs	25.6°C	1.15 m
East 2	24 Jan 95	1600 hrs	29.3°C	1.37 m
Control 2	24 Jan 95	1500 hrs	26.6°C	1.2 m
Lachlan 1	25 Jan 95	0930 hrs	24.2°C	0.78 m
Lachlan 7	25 Jan 95	0845 hrs	24.0°C	0.48 m
Pit 1	25 Jan 95	1150 hrs	28.1°C	0.52 m
Pit 2	24 Jan 95	1815 hrs	30.0°C	0.4 m
Bund Wall 1	24 Jan 95	1730 hrs	27.0°C	0.9 m
Bund Wall 2	25 Jan 95	1100 hrs	25.8°C	0.72 m

Macroinvertebrate Fauna

Twenty five different species of macroinvertebrates were collected from the core and sweep net samples (Table 3). The faunal results from these sample are presented as follows: Lachlan 1 (Table 4); Lachlan 7 (Table 5); Control 2 (Table 6); Project 2 (Table 7); East 2 (Table 8); Bland 1 (Table 9); Bland 5 (Table 10); Pit 1 (Table 11); Pit 2 (Table 12); Bund Wall 1 (Table 13); Bund Wall 2 (Table 14).

The immature *Anisops* larvae can not be positively identified, and are recorded as immatures. *Anisops gratus* is the dominant species, with *A. thienemanni* only occurring in low numbers at two sites. It can probably be assumed that most of the immatures belong to *A. gratus*. The ceratopogonid has temporally been recorded as a species of *Stillobezzia* and its identification is presently being confirmed by Leon Metzeling (Ceratopogonidae expert). Another unknown dipteran larva's identification (collected from Bund Wall site 2 (Table 14)) is being confirmed by Dr Peter Cranston (Australian National Insect Collection).

Table 3. Species list of macroinvertebrates recorded from core and sweep net from Lake Cowal, during supplementary sampling 24-25 January 1995.

SPECIES\METHOD	CORE	SWEEP NET
Cnidaria		
Family Hydridae		
Hydra sp.	*	-
Nematoda		
Nematoda sp.	*	-
Oligochaeta		
Tubificidae		
Branchiura sowerbyi	*	-
Dero nivea	*	-
Aulodrilus pigueti	*	-
Limnodrilus hoffmeisteri	*	-
Tubificid sp.	*	-
Naididae		
Nais bretscheri	*	-
Megadrile sp.	*	-
Crustacea		
Family Cyprididae		
Cypridid sp.	-	*
Family Atyidae		
Paratya australiensis	*	*
Family Palaemonidae		
Macrobrachium australiense	-	*
Insecta		
Ephemeroptera		
Family Caenidae		
Tasmanocoenis tillyardi	*	*
Hemiptera		
Family Notonectidae		
Anisops gratus	-	*
Anisops thienemanni	-	*
Anisops immatures	-	*
Family Corixidae		
Micronecta annae	-	*
Diptera		
Family Chironomidae		
Subfamily Chironominae		
Cladotanytarsus sp.	*	-
Cryptochironomus sp.	*	*
Parachironomus sp.	*	-
Subfamily Orthocladiinae		
Cricotopus sp.	*	*
Nanocladius sp.	-	*
Subfamily Tanypodinae		
Coelopynia sp.	*	*
Procladius sp.	*	-
Family Ceratopogonidae		
Stillobezzia sp.	*	-
Unknown Diptera (larva)	-	*
Trichoptera		
Family Ecnomidae		
Ecnomus pansus	*	-
Family Leptoceridae		
Oecetis sp.	*	-

Table 4. Numbers of invertebrates recorded in the sweep net (SN) and the five core (C) samples from Lachlan Site 1.

Species\Sample	SN	C1	C2	C3	C4	C5	$\# m^{-2}$
Branchiura sowerbyi	-	3	-	3	-	2	202.6
Tubificid sp.	-	1	1	-	-	-	50.6
Limnodrilus hoffmeisteri	-	-	-	1	-	-	25.3
Macrobrachium australiense	1	-	-	-	-	-	-
Paratya australiensis	12	-	-	-	-	-	-
Tasmanocoenis tillyardi	-	-	-	-	-	1	25.3
Anisops gratus	36	-	-	-	-	-	-
Anisops immature	88	-	-	-	-	-	-
Coelopynia sp.	-	2	-	-	3	5	253.2

Table 5. Numbers of invertebrates recorded in the sweep net and the five core samples from Lachlan Site 7.

Species\Sample	SN	C1	C2	C3	C4	C5	$\# m^{-2}$
Hydra sp.	-	-	-	4	-	-	101.3
Nematoda sp.	-	1	-	-	-	-	25.3
Branchiura sowerbyi	-	1	2	-	-	1	101.3
Limnodrilus hoffmeisteri	-	2	-	-	-	-	126.6
Nais bretscheri	-	-	-	5	-	-	126.6
Tubificid sp.	-	-	2	-	-	-	50.6
Megadrile	-	-	-	-	-	1	25.3
Paratya australiensis	16	-	-	-	-	-	-
Cyprididae sp.	4	-	-	-	-	-	-
Tasmanocoenis tillyardi	4	-	1	5	1	-	177.2
Stillobezzia sp.	-	-	-	1	-	-	25.3
Cladotanytarsus	-	-	1	1	1	-	76.0
Crytochironomus	1	-	-	2	-	1	76.0
Coelopynia sp.	1	1	2	-	-	1	101.3
Procladius sp.	-	-	-	2	2	-	101.3
Anisops gratus	24	-	-	-	-	-	-
Anisops immature	1764	-	-	-	-	-	-
Ecnomus pansus	-	-	-	4	-	-	101.3
Oecetis sp.	-	-	-	3	-	-	76.0

Table 6. Numbers of invertebrates recorded in the sweep net and the five core samples from Control Site 2.

Species\Sample	SN	C1	C2	C3	C4	C5	# m^{-2}
Branchiura sowerbyi	-	2	1	1	-	-	101.3
Oligochaeta sp.	1	-	-	-	-	-	-
Paratya australiensis	5	-	-	-	-	-	-
Anisops immature	4	-	-	-	-	-	-

Table 7. Numbers of invertebrates recorded in the sweep net and the five core samples from Project Site 2.

Species\Sample	SN	C1	C2	C3	C4	C5	# m^{-2}
Branchiura sowerbyi	-	2	6	-	1	-	227.9
Tubificid sp.	-	-	-	-	-	2	50.6
Paratya australiensis	3	-	-	-	-	-	-
Anisops gratus	1	-	-	-	-	-	-
Anisops immature	18	-	-	-	-	-	-
Coelopynia sp.	-	-	1	-	-	-	25.3
Cricotopus sp.	2	-	1	-	-	-	25.3

Table 8. Numbers of invertebrates recorded in the sweep net and the five core samples from East Site 2.

Species\Sample	SN	C1	C2	C3	C4	C5
Anisops gratus	9	-	-	-	-	-

Table 9. Numbers of invertebrates recorded in the sweep net and the five core samples from Bland Site 1.

Species\Sample	SN	C1	C2	C3	C4	C5
Tasmanocoenis tillyardi	1	-	-	-	-	-
Anisops gratus	4	-	-	-	-	-
Anisops immature	20	-	-	-	-	-

Table 10. Numbers of invertebrates recorded in the sweep net and the five core samples from Bland Site 5.

Species\Sample	SN	C1	C2	C3	C4	C5	# m^{-2}
Paratya australiensis	1	-	-	-	-	-	-
Coelopynia sp.	-	-	-	-	-	1	25.3
Anisops immature	51	-	-	-	-	-	-

Table 11. Numbers of invertebrates recorded in the sweep net and the five core samples from Pit Site 1.

Species\Sample	SN	C1	C2	C3	C4	C5	# m^{-2}
Branchiura sowerbyi	-	9	2	17	3	5	911.5
Limnodrilus hoffmeisteri	-	-	-	-	-	1	25.3
Megadrile	-	1	-	-	1	-	50.6
Paratya australiensis	24	-	2	3	1	-	151.9
Macrobrachium australiense	15	-	-	-	-	-	-
Tasmanocoenis tillyardi	1	-	-	-	-	-	-
Stillobezzia sp.	-	-	-	-	1	-	25.3
Cladotanytarsus sp.	2	-	-	-	-	-	-
Crytochironomus sp.	-	-	-	-	1	-	25.3
Parachironomus sp.	-	-	1	1	-	-	50.6
Cricotopus sp.	10	1	-	-	1	-	50.6
Procladius sp.	-	-	-	-	1	1	50.6
Anisops gratus	25	-	-	-	-	-	-
Anisops thienemanni	10	-	-	-	-	-	-
Anisops immature	64	-	-	-	-	-	-
Micronecta annae	7	-	-	-	-	-	-

Table 12. Numbers of invertebrates recorded in the sweep net and the five core samples from Pit Site 2.

Species\Sample	SN	C1	C2	C3	C4	C5	# m^{-2}
Hydra sp.	-	-	-	1	-	-	25.3
Branchiura sowerbyi	-	5	-	-	1	1	177.2
Limnodrilus hoffmeisteri	-	-	2	5	-	2	227.9
Aulodrilus pigueti	-	-			-	1	25.3
Dero nivea	-	-			-	1	25.3
Oligochaeta sp.	-	-	-	1	-	-	25.3
Conchostraca sp.	-	1	-	-	-	-	25.3
Macrobrachium australiense	1	-	-	-	-	-	-
Paratya australiensis	1	-	-	-	-	-	-
Tasmanocoenis tillyardi	-	-	-	1	-	-	25.3
Stillobezzia sp.	-	-	1	1	1	1	101.3
Cladotanytarsus sp.	-	-	-	3	-	-	76.0
Crytochironomus sp.	-	1	-	-	1	-	50.6
Cricotopus sp.	2	-	1	-	-	-	25.3
Procladius sp.	-	2	-	-	-	1	76.0
Anisops gratus	10	-	-	-	-	-	-
Anisops thienemanni	2	-	-	-	-	-	-
Anisops immature	85	-	-	-	-	-	-

Table 13. Numbers of invertebrates recorded in the sweep net and the five core samples from Bund Wall Site 1.

Species\Sample	SN	C1	C2	C3	C4	C5	# m^{-2}
Limnodrilus hoffmeisteri	-	-	-	1	-	-	25.3
Megadrile	-	1	-	-	1	-	50.6
Coelopynia sp.	-	-	-	-	1	-	25.3
Anisops gratus	3	-	-	-	-	-	-
Anisops immature	2	-	-	-	-	-	-

Table 14. Numbers of invertebrates recorded in the sweep net and the five core samples from Bund Wall Site 2.

Species\Sample	SN	C1	C2	C3	C4	C5	# m^{-2}
Branchiura sowerbyi	-	-	-	2	4	3	227.9
Limnodrilus hoffmeisteri	-	-	-	2	-	6	126.6
Megadrile	-	-	-	-	-	1	25.3
Paratya australiensis	41	-	-	-	-	-	-
Macrobrachium australiense	1	-	-	-	-	-	-
Cyprididae sp.	23	-	-	-	-	-	-
Coelpynia sp.	-	-	-	-	1	1	50.6
Cricotopus sp.	20	3	-	-	-	2	126.6
Nanocladius sp.	1	-	-	-	-	-	-
Unknown dipteran	1	-	-	-	-	-	-
Anisops gratus	19	-	-	-	-	-	-
Anisops immature	61	-	-	-	-	-	-

Sweep Net Sampling

Twelve species were identified from the sweep net samples. The "backswimmer" *Anisops gratus* was the dominant species, being collected from all eleven sites. The greatest abundance of *Anisops* occurred at Lachlan 7, with 24 *A. gratus* and 1764 *Anisops* immatures. Crustaceans were common, with the prawn *Paratya australiensis* occurring at eight sites and the shrimp, *Macrobrachium australiense* occurring at 4 sites. Both species occurred together at four sites. The greatest abundances of the two Crustacea were recorded from Pit 1 and Bund Wall 2, both cane grass habitats. Only one small fish species, *Gambusia affinis* (Mosquito fish), was collected in the sweep net samples (Table 15). The fish were collected in low numbers from only three sites; Pit 1 and Bund Wall 2 (cane grass) and Bland 5 (open water) (Tables 1 and 15).

Table 15. Distribution and numbers of *Gambusia affinis* collected and its habitat type.

Site\Species	*Gambusia affinis*	Habitat
Pit 1	5	Cane grass
Bund Wall	3	Cane grass
Bland 5	5	Open water

Core Sampling

Twenty species were identified from the cores samples. The cores contained mainly species of Oligochaeta and Chironomidae, both being present at eight sites. (Appendix 2). Macroinvertebrates were absent from two sites (Bland 1 and East 2). The most diverse sites were Lachlan 7 (13 species), Pit 2 (10 species) and Pit 1 (9 species). These three sites also had the greatest abundances of animals; Pit 1 (52 animals), lachlan 7 (48 animals) and Pit 2 (33 animals).
The prawn *Paratya australiensis* was collected only from the sweep net samples, except at Pit site 1 where it was collected from cores 2,3 and 4.

DISCUSSION

Twenty five species of macroinvertebrate fauna were collected from Lake Cowal during the monitoring survey. The greatest species richness and abundance were at the two pit sites and the two Lachlan sites, based on results from both the core and sweep net collections (Table 16). These sites were all in shallow water (depth less than 0.8m). The habitat at each site was open water, except at Pit 1 where it was cane grass. Twelve species were collected in the sweep nets, twenty species the core samples and seven were common to both methods. The sweep net collections were dominated by the backswimmer *Anisops gratus* and the crustacean *Paratya australiensis*. The core samples contained a diverse assortment of predominantly oligochaete and chironomid species.

Table 16. Summary table: The number of species and the total number of animals from the core and sweep net samples from each study sites.

	Core		Sweep net	
Sample Site	No.of spp.	No.of animals	No. of spp.	No. of animals
Bland 1	0	0	2	25
Bland 5	1	1	2	52
Project 2	4	13	3	24
East 2	0	0	1	9
Control 2	1	4	3	10
Lachlan 1	4	22	3	137
Lachlan 7	13	48	6	1814
Pit 1	9	52	8	158
Pit 2	10	33	5	101
Bund Wall 1	3	4	1	5
Bund Wall 2	2	24	8	167

The habitats at several of the sites had changed from the previous samplings (Bland 1 and East 2), previously covered in cane grass, where now open water sites. The species compostion of both the core and sweep net collections were similar to the previous collections. A noted change was that *Paratya* was more common than *Macrobrachium*, and the "yabby" *Cherax destructor* was not collected.

The results show that the pit sites have the highest species richness and abundance. These are sites along the margin of the lake in shallow water. This suggests, as did the previous report (Hawking 1991) that the lake margins are the areas richest in species diversity and abundance.

REFERENCES

Alba-Tercedor, J. and Suter, P. J. (1990). A new species of Caenidae from Australia: *Tasmanocoenis arcuata* sp. n. (Insecta: Ephemeroptera). *Aquatic Insects* 12: 85-94.

Cartwright, D. I.(1991). Key to mature larvae of the families Ecnomidae, Philopotamidae and Polycentropidae of Australia. Presented at the Trichoptera Workshop, MDFRC, Albury, February 1991. Unpublished Keys.

Cranston, P. S. (1994). Keys to the Australian Chironomidae. Presented at the Chironomidae Workshop, MDFRC, Albury, February 1994. Unpublished Key.

Cranston, P.S. (1995). Key to aquatic Diptera families. Presented at the Monitoring River Health Initiative Workshop, MDFRC, Albury, February 1995. Unpublished Key.

Hawking, J. H. (1986). Dragonfly larvae of the River Murray System: A preliminary guide to the identification of known final instar odonate larvae of south-eastern Australia. Technical Report No. 6. (Albury-Wodonga Development Corporation: Wodonga.)

Hawking, J. H. (1991). Lake Cowal Baseline Monitoring Program: Macroinvertebrates, Initial Survey. A progress report to N.S.R. Environmental Consultants Pty Ltd. June 1991. Unpublished Report.

Hawking, J. H. (1994). A preliminary guide to keys and zoological information to identify invertebrates from Australian freshwaters. Identification Guide No. 2. Cooperative Research Centre Freshwater Ecology: Albury.pp. 36.

Horwitz, P. (1995). A preliminary key to the species of Decapoda (Crustacea: Malacostraca) found in Australian inland waters. Identification Guide No. 5. Cooperative Research Centre Freshwater Ecology: Albury.pp. 69.

Horwitz, P., Knott, B. and Williams, W.D. (1995). A preliminary key to the: malacostracan families (Crustacea) found in Australian inland waters. Identification Guide No. 4. Cooperative Research Centre Freshwater Ecology: Albury.pp. 31.

Humphries, S. E., Crome, H. J. and Faith, D. P. (1991). Principles and guidelines for a biological monitoring program in Lake Cowal. A report to N. S. R. Environmental Consultants Pty Ltd. CSIRO, Division of Wildlife and Ecology. Unpublished Report.

Lansbury, I. (1969). The genus *Anisops* in Australia (Hemiptera-Heteroptera: Notonectidae). *J. nat. Hist.* 3: 433-458.

Lansbury, I. (1975). Notes on additions, changes and the distribution of the Australian water-bug fauna (Hemiptera-Heteroptera). *Mem. natn. Mus. Vict.* 36: 17-23.

Pinder, A.M. and Brinkhurst, R. O. (1994). A preliminary guide to the identification of the microdrile Oligochaeta from Australian inland waters. Identification Guide No. 1. Cooperative Research Centre Freshwater Ecology: Albury.pp. 137.

Smith, B. J. and Kershaw, R. C. (1979). *Field guide to non-marine molluscs of south eastern Australia.* (Australian National University Press: Canberra.)

Vestjens, W. J. M. (1977). Status, habitat and food of vertebrates at Lake Cowal, N. S. W. Division of Wildlife Research Technical Memorandum No. 12. CSIRO, Canberra.

Williams, W. D. (1980). *Australian Freshwater Life.* 2nd Ed. (Macmillan: Melbourne.)

ACKNOWLEDGEMENTS

I would like to thank Adrian Pinder (University of New England) for confirming the Oligochaete identifications. Leon Metzeling and Peter Cranston are also thanked for offering to identify the unknown dipteran larvae.

APPENDIX I

F. Dominic Fanning's facsimile transmission 14th January 1995

gunninah consultants

environmental assessment and management

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FACSIMILE TRANSMISSION

attention : John Hawking
MDFRC
Ph: 060 - xxx xxx fax: 060 -431 626

from : Dominic Fanning fax: 02 - 906 7770

date : 14/01/95 total # pages : 2

URGENT

Dear John,

herewith my suggestions for the invertebrate survey at Lake Cowal. The intention is to obtain a comparative set of data on the invertebrates of the mine pit site, with repesentative samples from the body of the Lake. These data will provide us with a base-line for monitoring the impacts of the mine, and for monitoring the re-colonisation of disturbed areas and new substrate (eg outside the bund wall).

Please give me a call if you have any queries or comments, or wish to discuss/modify any of the proposed survey. I will be at a Land & Environment case in Murwillumbah from Sunday to Wednesday, but will be contactable on my mobile (018 - 020 429) except during Court hearings. Alternatively, you can leave a message with my assistant Jayne at the office.

Yours sincerely,

Dominic Fanning MAIBiol MEIA MESA
Director and Principal

GUNNINAH HOLDINGS PTY. LTD. A.C.N. 003 824 502

LAKE COWAL
PROPOSED GOLD MINE

for GEOPEKO LTD

SUPPLEMENTARY
INVERTEBRATE SAMPLING PROGRAM

January 1995

F DOMINIC FANNING

This supplementary invertebrate sampling and identificationprogram is required to provide a baseline of invertebrates (diversity and densities) in the area to be disturbed by the proposed pit and comparative data from sites along the previous survey lines (Hawking 1991).

Features of the invertebrate survey should include:

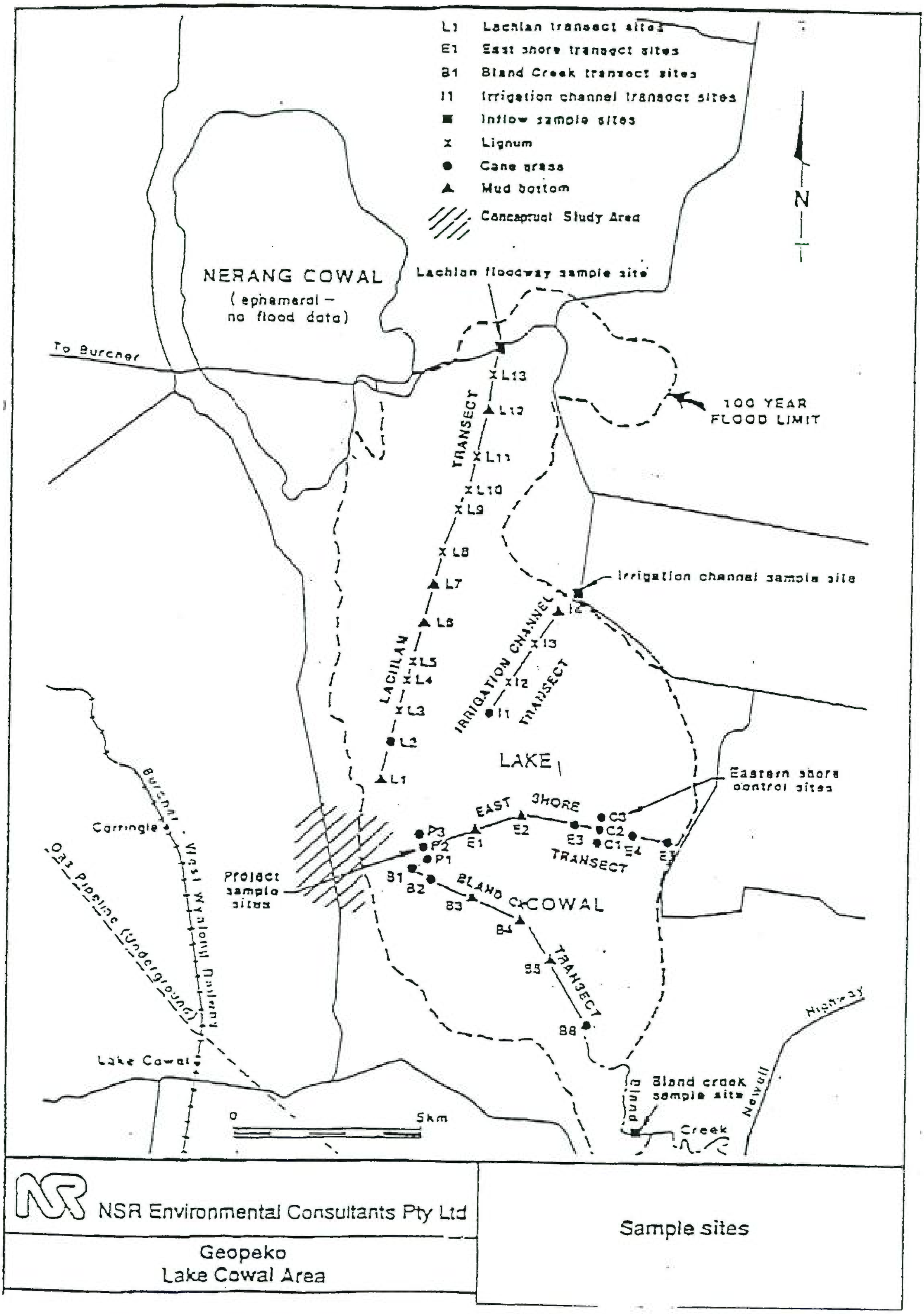
- the use of sediment core and sweep net sampling procedures (as per the original studies - Hawking 1991);
- survey sites should include both of the main aquatic habitats present within the pit area (open water, cane grass) and repesentative samples distant from the pit site. Suggested locations include B1, P2, E2, C2, B5, L1, L7. as well as two samples of each habitat within the pit;
- if lignum is present within the pit area, additional samples should be taken at these locations and at 'control' sites elsewhere in the Lake (eg L4 and L9);
- species identification should be to the level detailed in Hawking 1991;
- calculation of species densities for each site, to provide comparative base-line data for future monitoring of any changes in species composition and to enable monitoring of recolonisation of disturbed sites.

F Dominic Fanning BSc (Hons 1) MEIA MAIBiol MESA
and Principal

GUNNINAH CONSULTANTS
22 Clarke St Crows Nest NSW 2065
ph: 02 - 906 5436 fax: 02 - 906 7770

APPENDIX II

Map of Lake Cowal showing sample sites and the habitat present at each habitat.



Lake Cowal Gold Project

Appendix F

TERRESTRIAL FLORA REPORT: LAKE COWAL DISTRICT

by

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August 1995

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Terrestrial flora report:
Lake Cowal district

prepared by:
Dr AnneMarie Clements
A.N. Rodd

prepared for:

NSR

August 1995

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Map in rear pocket

1.0 Introduction

The study area is 740 km^2 in size (20 km east-west and 37 km north-south), extending from Bland Creek near Marsden in the south-eastern corner to Kerribrew Ridge in the north-western corner (Figure 1). It is part of the botanical sub-division of Central Western Slopes of New South Wales (Harden (1990-1993).

Lake Cowal in the centre of the study area is the largest lake in inland New South Wales. Lake Cowal is about 9 km from east to west and about 14 km from north to south. It is very shallow, reaching a depth of only 4.2 m at the deepest point when full (Rankine and Hill 1980). The water level is highly variable (Anderson *et al.* 1993, Bland Historical Society 1993).

The lake is filled by runoff from its local catchment and from the catchment of Bland Creek which enters the lake at the southern end. About 20 km north of the lake, the Lachlan River flows westward. When the Lachlan floods, water enters the lake from the north. The lake level varies widely. At the time of sampling the lake was full. At times of low lake level, the bottom of the lake is used for agriculture. The vegetation fringing the lake is dependent on the water level.

The vegetation of the study area has been extensively cleared for farming, with rocky outcrops, gilgai areas and creek lines retaining some native vegetation (Figure 2). There are some remnants of the original vegetation on the flat agricultural land on roadsides as well as scattered trees in paddocks. Local native grasses and shrubs are components of grazing paddocks and on fence lines of crop paddocks. Grass species used for pasture improvement, tend to die over the hot summer months and in times of low rainfall. These species are replaced in time by the climatically more suitable native species.

The flora was surveyed on 19-25 October and 1-7 December 1993 by Dr AnneMarie Clements and A.N. Rodd. As good rains fell over late winter and spring, vigorous growth and subsequent flowering of most herbaceous plants provided an ideal vegetation sampling period. Sampling in December enabled collections of grasses in full flower for identification.

2.0 Existing environment - the biological setting

2.1 Climate

The land surface of the Lake Cowal region has an altitude of 210-220 m AHD on the lake shore. This rises to 400 m AHD on the summit of Mount Wamboyne (Wamboyne 8330-I & IV CMA of NSW Topographic map 1:50 000). The nearest meteorological stations are:

- Forbes (station #065023, commenced operations in 1873, latitude 33°6'S, longitude 148°52'E, elevation 529 m), approximately 50 km NE

- Condobolin Post Office (station #050014, commenced operations in 1881, latitude 33°5'S, longitude 147°9'E, elevation 199 m), 60 km NNW

- Condobolin Agricultural Research Station (station #050052, commenced operations in 1954, latitude 33°4'S, longitude 147°14'E, elevation 195 m), 60 km NNW

- Quandialla (station #073032, commenced operations in 1925, latitude 34°1'S, longitude 147°48'E, elevation 250 m), 60 km SE

- Wyalong Post Office (station #073054, commenced operations in 1895, latitude 33°56'S, longitude 147°15'E, elevation 253 m), 40 km SSW

approximately 50 km NE, 60 km NNW, 60 km NNW, 60 km SE and 40 km SSW respectively of the proposed Lake Cowal mine site.

Highest mean maximum monthly temperatures are in January:

- Forbes 32°, 86 percentile 37° and 14 percentile 27° (29 years of records)

- Condobolin Post Office 33°, 86 percentile 38° and 14 percentile 27° (20 years of records)

- Condobolin Agricultural Research Station 33.5°, 86 percentile 39.4° and 14 percentile 28° (21 years of records)

- Quandialla 32.6°, 86 percentile 38.3° and 14 percentile 27.5° (18 years of records)

- Wyalong Post Office 32.2°, 86 percentile 37.9° and 14 percentile 27.1° (20 years of records)

and lowest mean minimum monthly temperatures are in July:

- Forbes 2.4°, 86 percentile 6.7° and 14 percentile -2.0°

- Condobolin Post Office 3.5°, 86 percentile 7.4° and 14 percentile 0° (20 years of records)

- Condobolin Agricultural Research Station 2.0°, 86 percentile 6.8° and 14 percentile -2.2° (21 years of records)

- Quandialla 2.2°, 86 percentile 6.5° and 14 percentile -1.7° (18 years of records)

- Wyalong Post Office 2.3°, 86 percentile 6.0° and 14 percentile -1.0° (20 years of records)

The mean annual rainfall ranges from 523 mm to 441 mm (Forbes 523 mm, Condobolin Post Office 441 mm, Condobolin Agricultural Research Station 468 mm, Quandialla 520 mm, Wyalong 482 mm (Bureau of Meteorology 1988)). The mean monthly rainfall varies from 25 mm to 57 mm (Forbes 39-50 mm, Condobolin Post Office 33-44 mm, Condobolin Agricultural Research Station 25-57 mm, Quandialla 37-53 mm, Wyalong 36-46 mm (Bureau of Meteorology 1988)). In terms of effective rainfall for cropping (rainfall minus pan evaporation), the frequency of exceedance is maximum in winter months, falling off sharply in August (Hounan 1947 cited Kelly 1971).

The rainfall between years is however variable. The levels of Lake Cowal and Nerang Cowal illustrate the long-term rainfall variability within the local catchment. The lakes vary from empty to covering a total area of 14 600 ha. The lake has been recorded as being inundated at least 13 times since 1930 (including 1990) and the water takes two to three years to dry out (WRCNSW 1986 cited Lane 1990).

Frosts occur in winter and a thin sheet of ice may cover stagnant pools among Lignum bushes at the edge of the lake (Vestjens 1977).

2.2 Geology and topography

The area is characterised by a series of resistant rock ridges having a north-south trend (Figure 1). The ridges consist mainly of conglomerate, sandstone and siltstone and remain today as the remnants of formerly higher mountain ranges. The ridges have been eroded to their present state by the ancient Lachlan River and Bland Creek system which have carved deep channels (palaeochannels) into the basement rock. The rock systems have then deposited thick sequences (up to 140 metres of sand, gravel, silt and clay) initially into these channels and then over more extensive flood plain area (Anderson *et al.* 1993).

2.3 Soils

Three main soil type in the proposed mine site area have been identified by Barker and Wild (1994), namely;

Map unit A hard pedal red duplex soils

Map unit B grey, brown and red cracking clays

Map unit C hill soils

Map units A and B occur on very gently inclined (about 1% slope) stagnant alluvial plains. Crabhole gilgai micro-relief occurs with variable frequency on map unit A, but not as well developed as in map unit B (Barker and Wild 1994).

Map unit C soils are shallow and uniformly coarse textured without gilgai formation (Barker and Wild 1994).

Gilgais are found in soils with a high clay content with regular or intermittent period of drought. Gilgais consist of undulations in the soil surface identified by hummocks and hollows. This phenomenon is a natural and permanent feature of certain soils which cannot be altered by cultivation or levelling (Jensen 1914 cited Beadle 1981). The presence of gilgais affects the micro-communities in plant associations. They appear to result from the differential movement of blocks, that is the upward movement of some blocks (which become mounds), and the downward movement of other blocks which become depressions. In some cases mounds and depressions are contiguous. In other cases, mounds and depressions are separated by a stretch of flat or concave surface (shelf), so that the sequence from high to low is mound, shelf, depression (= melon-hole or crab-hole). Within the depressions sink holes may occur, these being small, usually angular holes extending into the subsoil.

In many cases the A and B horizons remain intact, though the depth of the A on mounds may be reduced by washing into hollows. In some cases, the B horizon lies at the surface of the mound (usually readily identified by the presence of calcium carbonate) which has a granular surface.

The mechanism of gilgai formation is not precisely known. It is usually considered that the upward movement of the soil is due to differential swelling of the A and B horizons. The B horizon contains a higher proportion of sodium dominated clay with an expanding lattice, and is also more clayey than the A horizon. It swells more than the A horizon on wetting and rises towards the surface. Once the B horizon becomes elevated, it remains in this position as a mound. The soils crack on drying and soils move into these cracks adding to the volume of subsoil. The pressure of the soil is thereby increased on wetting and further upward movement of soil results. The early wetting of the subsoil by water-flow down the cracks may also be a factor contributing to upward movement with the B horizon swelling before the A horizon is fully wetted (Beadle 1981). Paton (1974 cited Beadle 1981) however attributes the upward movement to "differential loadings", namely the wet, plastic subsoil is pushed to the surface in compensation for the downward pressure exerted by the more solid and less plastic blocks of soils.

2.4 European exploration and settlement

Mount Blaxland in the Blue Mountain was first reached by Blaxland's party in 1813. From Mount Blaxland, the party saw "forest land all around them sufficient to feed the Stock of the colony" (Mr G. Blaxland's journal entry for 13 May 1813 cited Perry 1963).

The Assistant-Surveyor George Evans was sent to confirm the Blaxland report. He travelled further west to discover the Fish, Campbell and Macquarie Rivers and the grassy plains of Bathurst (Assistant-Surveyor Evans' Journal, 1813-14 cited Perry 1963). A road connecting Emu Plains (on Cumberland Plains in western Sydney) to the central part of Bathurst Plains was started in July 1814 and completed January 1815 (Perry 1963).

Evans was sent to explore the country to the south-west of Bathurst. In his journey he found the Lachlan River, returning with attractive descriptions of the country. Oxley and the botanist Alan Cunningham were sent to carry out a more detailed reconnaissance, in 1817 and 1818 following the course of the Lachlan and the Macquarie respectively. In his first expedition, Oxley followed the course of the Lachlan until it became a vast swamp and in the second, the Macquarie River, also found to spread into wide marshes. These expeditions convinced Oxley that "the interior of this vast country is a marsh and uninhabitable" (John Oxley, *Journals of two expeditions into the interior of New South Wales.* cited in Perry 1963). It was not until the drought of 1828-9 dried the marshes that it was possible for Charles Sturt to trace the lower courses of the Lachlan and Macquarie River (Perry 1963).

The Government in 1826 and 1829 set the limits of settlement with the western extreme at Mount Canobolas near the present town of Orange (Perry 1963). Between 1835 and 1839, pastoral runs as far west as Hay were being taken up (Semple 1990 cited Porteners 1993). In the Lake Cowal district, the first phase of settlement consisted of squatting. These first settlers took up pastoral runs about 1842, including the Billabong Pastoral Run. Apart from the pastoral stations, very little settlement took place in the district prior to 1885 (Bland Historical Society 1993).

By the Land Act of 1884 (the Subdivision of Runs Act), old runs were converted to Pastoral Holdings. A number of smaller holdings were taken up in the Lake Cowal area along the western perimeter extending from Wamboyne through Billys Lookout to Clear Ridge. In the Marsden district, the smaller holdings were mainly situated between the village and the Booberi Hills fronting the road to Wyalong. Hardly any other settlement in this locality occurred until 1889 with taking up of Conditional Leases or Conditional Purchases a few miles north and north west of the present township of West Wyalong (Bland Historical Society 1993).

The gold claim was pegged out in 1893. By 1899, the Wyalong goldfield was the most productive in the Colony. There were also discoveries in the surrounding area including Yalgogrin, Buddigower, Billys Lookout, Hiawatha and Clear Blow (Bland Historical Society 1993). Considerable amounts of alluvial gold were obtain from the eastern slope of Billys Lookout (S. Wilson copy taken from R.A.H.S. Journal and Proceedings volume VIII - 1923. page 373 & ff. cited Bland Historical Society 1993).

"The old mining camp at Billys Lookout ... seemed likely to become a permanent township. Two stores have been built and are in full swing and other business places are being erected." (The Town and Country Journal dated 2 June 1894 cited Bland Historical Society 1993). In 1896, the first teacher was appointed to the school at Billys Lookout (Bland Historical Society 1993).

In 1890, there was a drop in gold yield in the Wyalong goldfield accompanied by a drop the number of from 1600 in 1899 to 1200 in 1900. In 1907, the number of miners had fallen to 462 and by 1910 only 150 men were employed on the goldfield (Bland Historical Society 1993).

By 1900, wheat growing had become established in the Wyalong district with 11 900 acres (4 820 ha) and an average yield of 12 bushels to the acre which is 808 kg/ha (1 bushel/acre = 60 lb/acre (67.3 kg/ha)) (Bland Historical Society 1993).

In 1992-93 in Bland Shire, wheat production was 200 000 ha with a yield of 2.42 t/ha as well as:

40 000 ha of oats with a yield of 1.7 t/ha

36 000 ha of barley with a yield of 1.9 t/ha

8 400 ha of lupin with a yield of 1.7 t/ha

8 000 ha of canola with a yield of 1.8 t/ha

4 000 ha of fieldpea with a yield of 1.3 t/ha

2 000 ha of chickpea with a yield of 1.8 t/ha

(Bob Thompson, Department of Agriculture, West Wyalong, pers. comm., May 1995).

2.5 Past and present land use

For more than a century, the main land use of the Lake Cowal region has been agriculture and grazing. The lake bottom is used for sheep and cattle grazing and occasionally for cereal crops when the lake is dry (Australian Heritage Commission 1992). During one dry period in the 1920s, the whole area of the lake was subdivided for stock grazing, known as "lake blocks". The shores of the lake are used for wheat cropping and pastures, some irrigated, for sheep and cattle (Vestjens 1977).

A comparison of the aerial photographs of 22/5/1953 and 21/9/1989 shows that there has been little or no new clearing. This is consistent with the finding that virtually all major land use development had taken place prior to the 1940s (Jemalong-Wyldes Plain Community Steering Committee 1994).

To the early European settlers, the tree cover was an impediment to the pastoral and agricultural use of the land. The forest reserves are generally on rocky soils unsuitable for cropping and less desirable for grazing (Forestry Commission of NSW 1987). Within the study area, there are two forestry reserves, Nerang Cowal National Forest and Clear Ridge State Forest. These two areas are classified as 11T (no erosion, trees) on Soil Conservation erosion/land use maps. In the study area, the treed areas identified by the Soil Conservation study include Billys Lookout, Wamboyne Mountain, "Hillgrove" property ridge and the minor ridges.

On the 1983 Soil Conservation Service of NSW's land capacity 1:100 000 Wyalong map (Muddle 1983), the lake beds of Lake Cowal and Nerang Cowal were classified as class IV - suitable for grazing with occasional cultivation. The land immediately to the east, west and extensive areas to the south of the lake were classified as class II, suitable for regular cultivation. The ridges and slopes are classified as V (suitable for grazing with occasional cultivation), VI (suitable for grazing with no cultivation), VII (land best protected by green timber) and VIII (land unsuitable for agricultural pasture production). The remainder of the land was classified as III (suitable for regular cultivation) and IV.

In 1901/2, 56.6% of the total area of the central western slopes and plains of NSW had been sown, cropped, made ready for cultivation, partly cleared or ringbarked. By 1919/20, 80.2% had been modified and by 1981 84.8% consisted of areas other than forest/woodland (Goldney and Bowie 1990). One of the most dramatic of all man-induced changes to the environment, namely the change in the groundwater system, is most probably the result of this removal of tree cover (Jemalong-Wyldes Plains Community Steering Committee 1994).

Associated with agricultural land uses, changes in the understorey vegetation have occurred, one factor being the sowing of improved pastures. Increased use of improved pastures has led to greater stocking rates. Among the side effects of modern agricultural methods are contamination from the fuels and lubricants associated with farm machinery, as well as from agricultural chemicals such as herbicides and pesticides. These contaminants have probably had some serious effects on the remaining vestiges of natural environments (Goldney and Bowie 1990).

There are no National Parks or Nature Reserves in the study area. In 1925, Lake Cowal was proclaimed a Bird and Animal Sanctuary under the New South Wales Bird and Animal Protection Act 1918. This proclamation was revoked in 1967. The area is a popular site for duck shooting with some indiscriminate shooting of other waterbirds occurring. On 30 June 1992, it was gazetted as an entry in the Register of the National Estate under the Commonwealth of Australia's Australian Heritage Commission Act 1975.

Cardale (1987) reviews the known literature of the vegetation of central NSW. The extensive clearing of the central western slopes and plains, particularly those associated with the wheat belt, poses considerable problems in determining the distribution of vegetation types.

Based on observations of the Hay Plain (including stock exclosure paddocks over 25 years), the effects of grazing on native vegetation have been found to range from the disappearance of perennials and their replacement by other species, to minor defoliation of perennial shrubs, trees and grasses. Grazing of seedlings also directly prevents regeneration in many communities (Porteners 1993).

Nature conservation in the ephemeral swamps is a supplementary land use. These nationally significant plant communities are maintained by three factors - the flood cycle, the adequate water quality of the catchment runoff to the lake, and the retention of substantial waterbird habitat, especially breeding habitat (Australian Heritage Commission 1992). The ephemeral swamps include three major vegetation groups including:

1. Red Gum swamps (*Eucalyptus camaldulensis*),

2. Lignum swamps (*Muehlenbeckia cunninghamii* (now *M. florulenta*) and Black Box (*E. largiflorens*), and *E. populnea* swamps

3. Cane grass (*Eragrostis australasica*) and reed swamps (Schwinghamnier 1987).

3.0 Flora

The time of sampling for this survey was chosen to maximise the chance of finding flowering specimens, especially grasses for identification. This survey followed upon good spring rains.

The flora survey provides data of what does grow in the area, the species distribution, plant communities (species/species associations), species/soils relationships, densities of tree/shrub species at the time of the survey. The vegetation is likely to alter over time depending on climatic conditions, especially the regeneration of *Callitris glaucophylla* and *Eucalyptus camaldulensis*. The northern lease area of Girilambone Copper was surveyed in 1988 and repeated in December 1994. The rather striking differences in the results of the two surveys show the dynamics of plant species distributions over time (Rodd and Clements 1995).

The validity of mapping natural vegetation on evidence of what is growing in relatively undamaged areas, what has grown on cleared or altered areas (from relic fragments or old records), and what is believed would grow on radically altered areas if man and his biological accomplices (animal and plant) were removed depends on the existence of old records, plant specimens, extent of soil changes (mainly due to fertiliser, herbicide and pesticides), grazing regimes, seeding and plantings (Hayden 1971 cited Cardale 1987).

The original ranges of some native trees species in New South Wales have expanded by planting, especially tree and shrubs used for shade and fodder such as *Brachychiton populneus* (Kurrajong) (Cardale 1987). The farmers in the study area are likely to encourage the growth of local native trees with fodder potential in grazing paddocks, for example, Kurrajong, Wilga, White Cypress, Belah (Andrew Buttenshaw's growing suggestions, December 1994). The farmers of the district also actively remove tree/shrub species which have no fodder value such as *Hakea* sp., *Acacia* spp., *Eremophila* spp. and *Myoporum* spp. (Malcolm Carnegie, pers. comm., February 1995).

3.1 Previous botanical surveys

There were three major earlier studies, namely:

- 1817 prior to settlement (Cunningham' survey in 1817)
- 1901 prior to major clearing (Cambage 1901)
- 1940s prior to major use of fertilisers, improved pasture species, herbicides and pesticides (Beadle 1948)

3.1.1 Prior to settlement (1817)

On 6 April 1817 (during a drought period), the surveyor John Oxley's party, including the botanist Alan Cunningham, left Bathurst to trace the course of the Lachlan River. Neither Oxley nor Cunningham were impressed with what are now the prized river flats of the Lachlan. Cunningham wrote on the 15th May:

> "The soil of these flats is of a tenacious cold stiff clay quality. The *Cupressus glauca* (now *Callitris glaucophylla*) (White Cypress Pine) is frequent, forming small trees scarcely exceeding 25 feet (7.6 m), and many dead stems scattered amongst the common Eucalypt are sufficient demonstration of the coldness and sterility of the soil." (cited in Mitchell n.d).

During this exploration, Cunningham made extensive botanical collections, many of which were type specimen for the description of the species. A number of these specimens are held at John Ray Herbarium, University of Sydney.

3.1.2 Prior to major clearing (1901)

In 1901, Cambage published notes on the botany of the interior of New South Wales with part IV being from Mount Hope (about 140 km NNW of Lake Cargelligo) to Parkes. Travelling by road from Mount Hope to Condobolin (about 60 km north of the study area), Cambage (1901) noted the difference in vegetation on two hills approximately four miles apart namely Mount Allen, an igneous rock apparently porphyry, compared with Double Peak, also known as Dromedary, a Silurian slate with a few belts of porphyry. On Mount Allen, "there was considerable quantity of *Casuarina quadrivalvis* (She Oak)" (now *Allocasuarina verticillata*) but none on Double Peak. "*Sterculia diversifolia* (Currajong) (now *Brachychiton populneus* (Kurrajong)) was more plentiful on the former than the latter." *Acacia doratoxylon* (Currawong) was found covering the heights of Double Peak but was absent from Mount Allen.

Cambage (1901) lists the main shrub and tree species present between Mount Hope and Parkes. He noted 15 species of eucalypt, 17 species of Acacia and 3 species of Casuarinaceae. Of the eucalypt species, six species were not sighted in this current survey (Table 1). Of the *Acacia* sight by Cambage (1901) only five were recorded in this survey. All of the Casuarinaceae sighted were recorded (Table 1).

3.1.3 Prior to major use of fertilisers, improved pasture species, herbicides and pesticides applications (1940s)

Beadle (1948) mapped the vegetation and pastures of western New South Wales with part of his eastern limit following the western and northern shores of Lake Cowal. Beadle identified the following plant communities in the Lake Cowal region (Figure 3):

- *Eucalyptus populifolia* (now *E. populnea*) Association (Poplar Box, Bimble Box)
- *E. populifolia* (now *E. populnea*) - *Callitris glauca* (now *C. glaucophylla*) Association (Bimble Box and Pine)
- *E. Woollsiana* (now *E. microcarpa*) Association (Grey Box)
- *E. dealbata* - *E. sideroxylon* Association (Gum and Ironbark)

In Beadle's (1981) broad descriptions of the vegetation of Australia, the major vegetation alliances for the study area is described as *Stipa* spp. grassland and savanna and *Eucalyptus microcarpa*.

3.1.4 Vegetation classification based on bird habitat

From 1969 to 1976, Vestjens visited the lake monthly for one week with the exception of 1974 and 1975 when the area was visited three and five times respectively. His study area is shown on Figure 4. This survey concentrated on birds present and the vegetation survey was bird habitat based. The location of these habitats tends to depend on water depth.

Vestjens (1977) identified six habitats:

A. Open areas used for cereal cropping or for pastures for sheep and cattle; some part occasionally flooded. Excavation tanks and irrigation channels are present. The vegetation is a savanna eucalypt woodland with Poplar Box (*E. populnea*) and small stands or single trees of Myall or Boree (*Acacia pendula*), River Cooba (*A. stenophylla*) and Belah (*Casuarina cristata*). Close to the edge of the lake, *E. populnea* is replaced by River Gum (*E. camaldulensis*) and a few Lignum bushes (*Muehlenbeckia florulenta*) and Cane Grass (*Eragrostis australasica*). The zone of change from *E. populnea* to *E. camaldulensis* is narrow and marks the high water level of the lake.

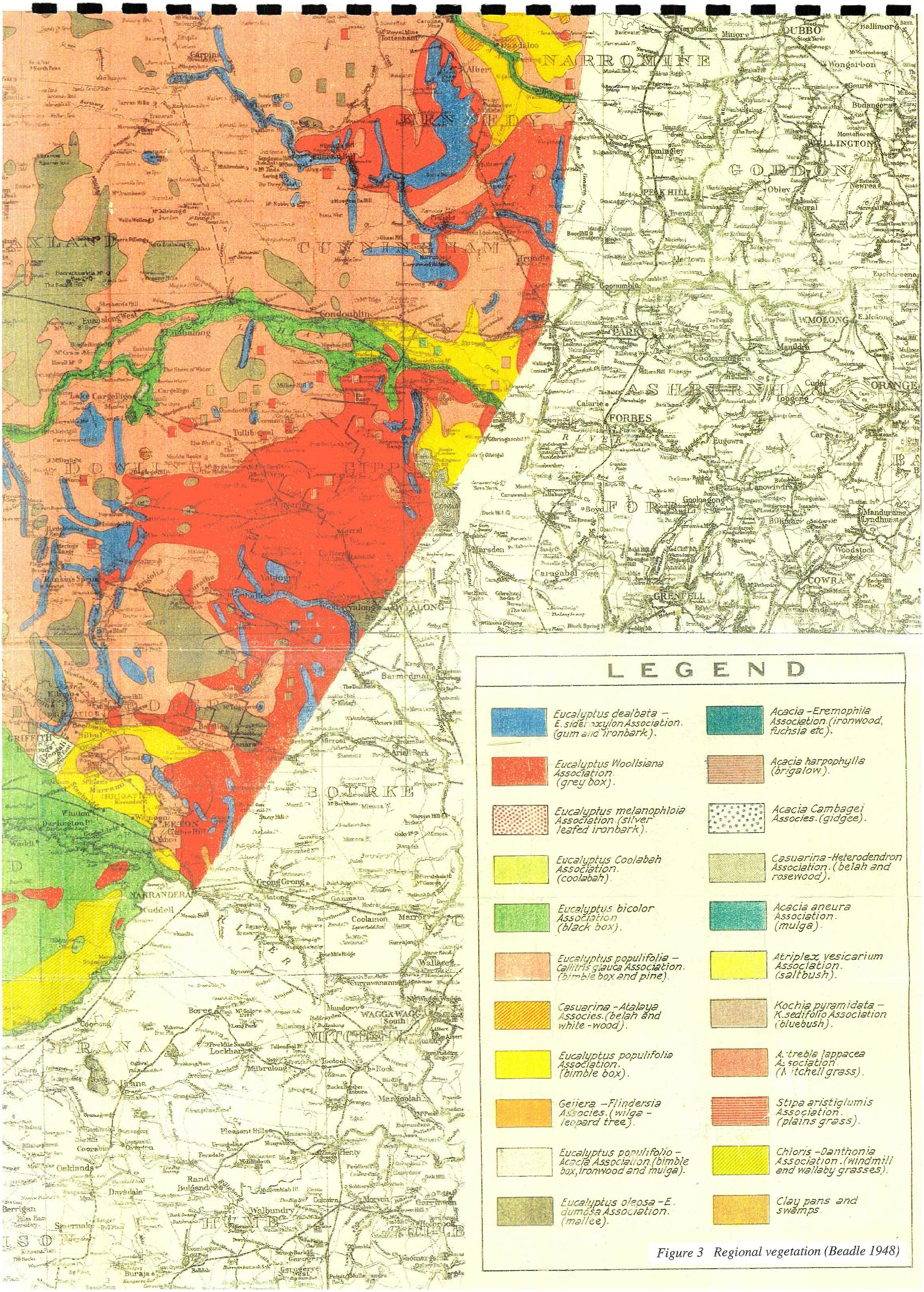
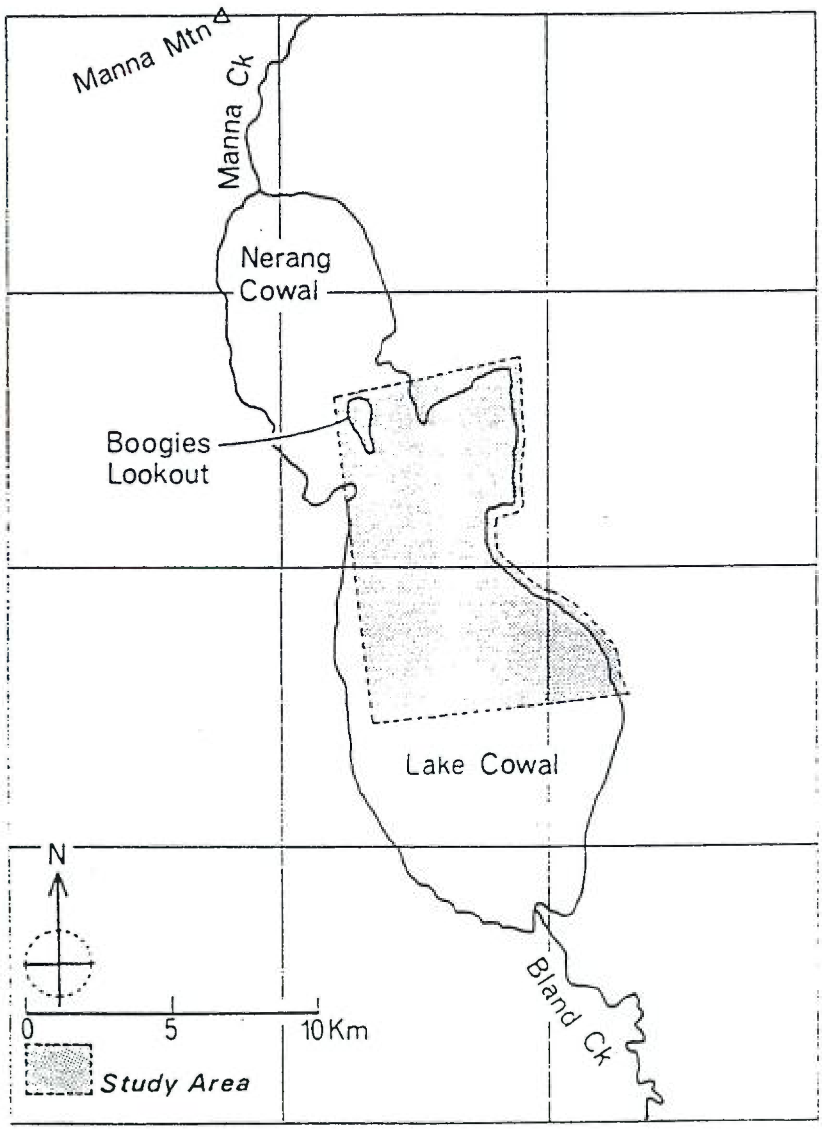


Figure 3 Regional vegetation (Beadle 1948)



Source : Vestsjeus 1977

Figure 4 : Lake Cowal, copied from map of Forbes, NSW 155/7 zone 7 Second edition 1942

Table 1
Major species sighted in Cambage's survey and records in this survey.

Eucalyptus species	**recorded in this survey**
E. conica (only in the eastern part)	yes
E. dumosa	no
E. hemiphloia var. albens (only close to Parkes) (now E. albens)	no
E. intertexta	no
E. largiflorens (on the Lachlan only)	yes
E. melliodora	yes
E. oleosa	no
E. populifolia (now E. populnea subsp. bimbil)	yes
E. rostrata (now E. camaldulensis) (only on creeks and the Lachlan)	yes
E. sideroxylon	yes
E. tereticornis (scarce in Cambage's survey)	no
E. tereticornis var. dealbata (now E. dealbata)	no
E. viridis	yes
E. Woollsiana (now E. microcarpa)	yes
Eucalyptus species not sighted by Cambage but found in this survey	
E. cladocalyx, planted	yes
E. dwyeri - perhaps under E. tetericornis subsp. dealbata	yes
Acacia species	
A. aneura (in western half)	no
A. Burkittii (in western half only)	no
A. calamifolia (in western half only)	no
A. colletioides	no
A. conferta	no
A. dealbata (green variety) - probably A. deanei	no
A. decora	yes
A. doxatoxylon	yes
A. excelsa (scarce)	no
A. hakeoides	no
A. homalophylla	yes
A. implexa	no
A. Oswaldii	yes
A. pendula (not plentifully)	yes
A. salicina (on the Lachlan only)	no
A. spectabilis (close to Parkes)	no
A. triptera	no
Acacia species not sighted by Cambage but found in this survey	
A. amblygona	yes
A. deanei subsp deanei	yes
A. difformis	yes
A. stenophylla	yes

Members of the Casuarinaceae family, sighted by Cambage, were all recorded in this survey, namely:

C. Cambagei (now Casuarina cristata).	yes
C. Luehmannii (now Allocasuaraina leuhmannii)	yes
C. quadrivalvis (now Allocasuarina verticillata)	yes

B. Shore areas intermittently covered with water, depending on the water level of the lake. Excavation tanks and irrigation channels are present. *E. camaldulensis* is the dominant tree, with a few *Acacia stenophylla*. *Muehlenbeckia florulenta* and *Eragrostis australasica* cover large areas. Open wet areas are cover with Nardoo (*Marsilea drummondii*) and Water Milfoil (*Myriophyllum verrucosum*).

C. Areas of very shallow water with small islets which are banks of earth along excavated tanks made during periods when lake level was low. *Muehlenbeckia florulenta* are the dominant plants with dead and living *E. camaldulensis* and *Acacia stenophylla*. Large areas of the water contain Ribbon Weed (*Vallisneria spiralis* (now *V. gigantea*).

D. Areas of shallow water with stands of *E. camaldulensis* and with small islets of soil alongside excavation tanks.

E. Areas of shallow water with large areas of *Muehlenbeckia florulenta*, very few *E. camaldulensis* and small islets formed from soil excavated from tanks.

F. Areas of open and deep water with a few *E. camaldulensis* on shallow edges.

During Vestjen's (1977) study, 162 plant species were recorded.

3.2 The current survey

In this survey, 411 species were recorded, including some undetermined species. There were 321 native and 90 exotic species recorded in the 240 sampling locations (115 transects and 126 spot locations).

By far the most diverse plant group occurring in the survey was the grasses, family Poaceae, with 62 native and 25 exotic species. Next in number were the composites, family Asteraceae, with 37 native and 18 exotic species. The saltbushes, family Chenopodiaceae, numbered 22 native and one exotic species; the peas, family Fabaceae subfamily Faboideae, comprised 9 native and 11 exotic species; the sedges, family Cyperaceae, comprised 17 native and one exotic species. No other plant family was represented by more than 10 species except the Myrtaceae, with 10 species of *Eucalyptus* (1 exotic to the region) and 1 of *Calytrix* (Table 2).

3.2.1 Sampling methods

This survey collected detailed vegetation data mainly from non-crop vegetation including roadsides, hills and creek banks, as well as recording tree and shrub species in paddocks.

This present study covers a greater area (740 km2) than that of Vestjens (1977)

TABLE 2 - Species recorded for site

Notes: 1. Bot. name code is used in Appendices 1 and 2.

2. Asterisk preceding Bot. name code signifies species is not indigenous to site.

Bot. name code	Botanical name	Common name
1. Pteridophytes		
Azollaceae		
AZOL FILI RUBR	Azolla filiculoides var. rubra	Pacific Azolla
Marsileaceae		
MARSI ANGU	Marsilea angustifolia	Narrow-leaved Nardoo
MARSI DRUM	Marsilea drummondii	Common Nardoo
MARSI HIRS	Marsilea hirsuta	Nardoo
PILU NOVA	Pilularia novae-hollandiae	Austral Pillwort
Ophioglossaceae		
OPHIOG LUSI CORI	Ophioglossum lusitanicum subsp. coriaceum	Adder's Tongue
Sinopteridaceae		
CHEILA AUST	Cheilanthes austrotenuifolia	Rock Fern
CHEILA DIST	Cheilanthes distans	Bristly Cloak-fern
CHEILA SIEB	Cheilanthes sieberi subsp. sieberi	Rock Fern
2. Gymnosperms		
Cupressaceae		
CALLIT ENDL	Callitris endlicheri	Black Cypress-pine
CALLIT GLAU	Callitris glaucophylla	White Cypress-pine
3. Dicotyledons		
Acanthaceae		
BRUNONIE AUST	Brunoniella australis	Blue Trumpet, Blue Yam
Amaranthaceae		
ALTE DENT	Alternanthera denticulata	Lesser Joyweed
ALTE SP.A	Alternanthera sp. A	Joyweed
PTILOTU SEMI	Ptilotus semilanatus	Lambs' Tails, Purple Tails
PTILOTU SPAT	Ptilotus spathulatus	Pussy Tails, Cat's Paw
Apiaceae		
DAUC GLOC	Daucus glochidiatus	Australian Carrot, Carrot Weed, Carrot-burrs
HYDROC LAXI	Hydrocotyle laxiflora	Stinking Pennywort
HYDROC SP.	Hydrocotyle sp.	
TRACHYM ORNA	Trachymene ornata	Sponge-fruit
Apocynaceae		
PARS EUCA	Parsonsia eucalyptophylla	Gargaloo, Monkey Vine
Asteraceae		
ACTINOB ULIG	Actinobole uliginosum	Flannel Cudweed
* ARCTOTH CALE	Arctotheca calendula	Capeweed, Cape Dandelion
* ASTER SUBU	Aster subulatus	Bushy Starwort, Wild Aster
BRACHYCO CILI SUBI	Brachycome ciliaris var. subintegrifolia	Variable Daisy, Fringed Daisy
BRACHYCO HETE	Brachycome heterodonta	Lobed-seeded Daisy
BRACHYCO LINE	Brachycome lineariloba	Hard-headed Daisy
BRACT BRAC	Bracteantha bracteata	Common Everlasting, Golden Everlasting
BRACT VISC	Bracteantha viscosa	Sticky Everlasting
CALOCEP SOND	Calocephalus sonderi	Pale Beauty-heads
CALOTI ANTH	Calotis anthemoides	Cut-leaved Burr-daisy
CALOTI CUNEI	Calotis cuneifolia	Purple Burr-daisy
CALOTI HISP	Calotis hispidula	Bogan Flea
CALOTI LAPP	Calotis lappulacea	Yellow Burr-daisy
CALOTI SCAB INTE	Calotis scabiosifolia var. integrifolia	Rough Burr-daisy
CALOTI SCAB SCAB	Calotis scabiosifolia var. scabiosifolia	Rough Burr-daisy

Bot. name code	Botanical name	Common name
CALOTI SCAP	Calotis scapigera	Tufted Burr-daisy
* CARDU TENU	Carduus tenuiflorus	Winged Slender Thistle
* CART LANA	Carthamus lanatus	Saffron Thistle
CASSINI LAEV	Cassinia laevis	Cough-bush
* CENTAURE MELI	Centaurea melitensis	Maltese Cockspur
CENTIP CUNN	Centipeda cunninghamii	Common Sneezeweed
CENTIP MINI	Centipeda minima var. minima	Spreading Sneezeweed
* CHONDR JUNC	Chondrilla juncea	Skeleton Weed
CHRYSOCE APIC	Chrysocephalum apiculatum	Common Everlasting, Yellow Buttons
CHRYSOCE SEMI	Chrysocephalum semipapposum	Clustered Everlasting, Yellow Buttons
* CIRS VULG	Cirsium vulgare	Spear Thistle
* CONY BONA	Conyza bonariensis	Flaxleaf Fleabane
COTU AUST	Cotula australis	Common Cotula
ECLI PLAT	Eclipta platyglossa	Yellow Twin-heads
GNAP SPHA	Gnaphalium sphaericum	Common Cudweed
* HEDYP RHAG CRET	Hedypnois rhagadioloides subsp. cretica	Cretan Weed
HYAL SEMI	Hyalosperma semisterile	Orange Sunray
* HYPOCH GLAB	Hypochoeris glabra	Smooth Cat's-ears
ISOETO GRAM	Isoetopsis graminifolia	Grass Cushions
* LACT SERR	Lactuca serriola	Prickly Lettuce, Compass Plant
LEPTOR PANA	Leptorhynchos panaetioides	Woolly Buttons
MILLO MYOS	Millotia myosotidifolia	Broad-leaf Millotia
MINU LEPT	Minuria leptophylla	Minnie Daisy
* PSEUDOGN LUTE	Pseudognaphalium luteoalbum	Jersey Cudweed
PYCNOSO CHRY	Pycnosorus chrysanthus	Billy Buttons
RHODAN CORY	Rhodanthe corymbiflora	Small White Sunray
RHODAN FLOR	Rhodanthe floribunda	Everlasting, White Sunray, Paper Daisy
RHODAN PYGM	Rhodanthe pygmaea	Pigmy Sunray
SIGE AUST	Sigesbeckia australiensis	Pale Indian Weed
* SOLIV ANTH	Soliva anthemifolia	Dwarf Jo-jo, Button Burrweed
* SOLIV STOL	Soliva stolonifera	Jo-Jo, Carpet Burrweed
* SONC ASPE	Sonchus asper	Prickly Sow-thistle, Rough Milk-thistle
* SONC OLER	Sonchus oleraceus	Common Sow-thistle, Milk-thistle
STUA MUEL	Stuartina muelleri	Spoon Cudweed
TRIPT PYGM	Triptilodiscus pygmaeus	Common Sunray
VITT CUNE CUNE	Vittadinia cuneata var. cuneata	Fuzzweed
VITT CUNE HIRS	Vittadinia cuneata var. hirsuta	Fuzzweed
VITT GRAC	Vittadinia gracilis	
* XANTHI OCCI	Xanthium occidentale	Noogoora Burr
* XANTHI SPIN	Xanthium spinosum	Bathurst Burr
Bignoniaceae		
PANDO PAND (NAR	Pandorea pandorana (narrow-leaved inland race	Inland Wonga Vine, Spearwood Bush
Boraginaceae		
* ECHIU PLAN	Echium plantagineum	Paterson's Curse, Salvation Jane
HELIO EURO	Heliotropium europaeum	Common Heliotrope, Potato Weed
Brassicaceae		
* CAPSE BURS	Capsella bursa-pastoris	Shepherd's Purse
LEPIDI PAPI	Lepidium papillosum	Warty Peppercress
LEPIDI PSEU	Lepidium pseudohyssopifolium	
* SISYM IRIO	Sisymbrium irio	London Rocket
* SISYM ORIE	Sisymbrium orientale	Indian Hedge Mustard
Campanulaceae		
WAHL COMM	Wahlenbergia communis	Australian Bluebell
WAHL FLUM	Wahlenbergia fluminalis	River Bluebell
WAHL GRAC	Wahlenbergia gracilis	Sprawling Bluebell
WAHL STRI ALTE	Wahlenbergia stricta subsp. alterna	Tall Bluebell

Bot. name code	Botanical name	Common name
Capparaceae		
APOP ANOM	Apophyllum anomalum	Warrior-bush, Currant-bush
Caryophyllaceae		
GYPS AUST	Gypsophila australis	Annual Chalkwort
* PETROR NANT	Petrorhagia nanteuilii	Proliferous Pink
* PETROR VELU	Petrorhagia velutina	Proliferous Pink
* POLYC TETR	Polycarpon tetraphyllum	Four-leaf Allseed
* SILE GALL QUIN	Silene gallica var. quinquevulnera	French Catchfly
* SILE NOCT	Silene nocturna	Mediterranean Catchfly
* SPERG RUBR	Spergularia rubra	Sandspurry
STEL FILI	Stellaria filiformis	
Casuarinaceae		
ALLO LUEH	Allocasuarina luehmannii	Bulloak
ALLO VERT	Allocasuarina verticillata	Drooping She-oak
CASU CRIS	Casuarina cristata	Belah
CASU CUNN	Casuarina cunninghamiana	River Oak, River She oak
Chenopodiaceae		
ATRI SPIN	Atriplex spinibractea	Spiny-fruit Saltbush
* CHEN AMBR	Chenopodium ambrosioides	Mexican Tea, Wormseed
CHEN DESE MICR	Chenopodium desertorum subsp. microphyllum	Desert Goosefoot
CHEN MELA	Chenopodium melanocarpum	Black Crumbweed
CHEN NITR	Chenopodium nitrariaceum	Nitre Goosefoot
CHEN PUMI	Chenopodium pumilio	Small Crumbweed
EINA HAST	Einadia hastata	Berry Saltbush
EINA NUTA	Einadia nutans	Climbing Saltbush
ENCH TOME TOME	Enchylaena tomentosa var. tomentosa	Ruby Saltbush
MAIR DECA	Maireana decalvans	Black Cottonbush
MAIR ENCH	Maireana enchylaenoides	Wingless Fissure-weed
MAIR HUMI	Maireana humillima	
MAIR MICR	Maireana microphylla	Eastern Cottonbush
MAIR PENTAG	Maireana pentagona	Slender Fissure-weed
MAIR SP.	Maireana sp.	
RHAG SPIN	Rhagodia spinescens	Spiny Saltbush
SALS KALI KALI	Salsola kali var. kali	Roly-Poly, Buckbush, Prickly Saltwort
SCLEROB ATRI	Scleroblitum atriplicinum	Purple Goosefoot, Lamb's Tongue
SCLEROL BIRC	Sclerolaena birchii	Galvanised Burr
SCLEROL DIAC	Sclerolaena diacantha	Grey Copperburr
SCLEROL MURI SEMI	Sclerolaena muricata var. semiglabra	Black Rolypoly
SCLEROL SP.	Sclerolaena sp.	
SCLEROL STEL	Sclerolaena stelligera	Star Copperburr
Clusiaceae		
HYPE GRAM	Hypericum gramineum	Small St Johns-wort
* HYPE PERF	Hypericum perforatum	St Johns-wort
Convolvulaceae		
CONVO ERUB	Convolvulus erubescens	Native Bindweed, Blushing Bindweed, Pink Bi
DICHON MICR	Dichondra micrantha	Kidney-weed
DICHON REPE	Dichondra repens	Kidney-weed, Mercury Bay Weed
Crassulaceae		
CRASS COLO ACUM	Crassula colorata var. acuminata	Dense Stonecrop
CRASS DECU	Crassula decumbens	Spreading Stonecrop
CRASS PEDU	Crassula peduncularis	Purple Stonecrop
CRASS SIEB	Crassula sieberiana	Australian Stonecrop
Cucurbitaceae		
* CITRUL LANA	Citrullus lanatus	Camel Melon, Wild Melon, Bitter Melon

Bot. name code	Botanical name	Common name
Droseraceae		
DROS PELT	Drosera peltata	Pale Sundew
Elatinaceae		
ELATI GRAT	Elatine gratioloides	Waterwort
Euphorbiaceae		
CHAMAESY DRUM	Chamaesyce drummondii	Caustic Weed, Flat Spurge, Caustic Creeper
Fabaceae Caesalpinioideae		
SENN ARTE FILI	Senna artemisioides subsp. filifolia	Punty Bush, Desert Cassia
SENN ARTE ZYGO	Senna artemisioides subsp. zygophylla	Punty Bush
Fabaceae Faboideae		
GLYCI CANE	Glycine canescens	Silky Glycine
GLYCI CLAN	Glycine clandestina	Twining Glycine
GLYCI SP.	Glycine sp.	
GLYCI TABA	Glycine tabacina	Variable Glycine
GLYCY ACAN	Glycyrrhiza acanthocarpa	Native Liquorice, Native Lucerne
HARD VIOL	Hardenbergia violacea	False Sarsaparilla
INDI AUST	Indigofera australis	Native Indigo
* MEDICA MINI	Medicago minima	Small Woolly Burr-medic
* MEDICA POLY	Medicago polymorpha	Burr Medic
* MEDICA SATI	Medicago sativa	Lucerne, Alfalfa
* MEDICA TRUN	Medicago truncatula	Barrel Medic
PULT LARG	Pultenaea largiflorens	Twiggy Bush-pea
PULT LAXI	Pultenaea laxiflora	Loose-flower Bush-pea
* TRIF ANGU	Trifolium angustifolium	Narrow-leaved Clover
* TRIF ARVE	Trifolium arvense	Haresfoot Clover
* TRIF CAMP	Trifolium campestre	Hop Clover
* TRIF DUBI	Trifolium dubium	Yellow Suckling Clover
* TRIF GLOM	Trifolium glomeratum	Clustered Clover
* TRIF SUBT	Trifolium subterraneum	Subterranean Clover
* TRIF TOME	Trifolium tomentosum	Woolly Clover
Fabaceae Mimosoideae		
ACAC AMBL	Acacia amblygona	Fan Wattle
ACAC DEAN DEAN	Acacia deanei subsp. deanei	Green Wattle, Deane's Wattle
ACAC DECO	Acacia decora	Western Golden Wattle, Showy Wattle
ACAC DIFF	Acacia difformis	Drooping Wattle
ACAC DORA	Acacia doratoxylon	Currawang, Lancewood, Spearwood
ACAC HOMA	Acacia homalophylla	Yarran
ACAC OSWA	Acacia oswaldii	Miljee
ACAC PEND	Acacia pendula	Weeping Myall, Boree
ACAC STEN	Acacia stenophylla	River Cooba
Fumariaceae		
* FUMA SP.	Fumaria sp.	Fumitory
Gentianaceae		
* CENTAURI ERYT	Centaurium erythraea	Common Centaury
CENTAURI SPIC	Centaurium spicatum	Spike Centaury
* CENTAURI TENU	Centaurium tenuiflorum	Centaury
* CICEN QUAD	Cicendia quadrangularis	Square Cicendia
Geraniaceae		
EROD CICU	Erodium cicutarium	Crowfoot, Heronsbill
EROD CRIN	Erodium crinitum	Blue Crowfoot, Native Crowfoot
GERA RETR	Geranium retrorsum	Common Cranesbill
Goodeniaceae		
GOODE CYCL	Goodenia cycloptera	Serrated Goodenia
GOODE FASC	Goodenia fascicularis	Silky Goodenia
GOODE HEDE	Goodenia hederacea subsp. hederacea	Ivy Goodenia

Bot. name code	Botanical name	Common name
GOODE PINN	Goodenia pinnatifida	Scrambled Eggs
Haloragaceae		
GONO ELAT	Gonocarpus elatus	Hill Raspwort
GONO TETR	Gonocarpus tetragynus	Raspwort
HALO ASPE	Haloragis aspera	Rough Raspwort
HALO GLAU	Haloragis glauca	Grey Raspwort
HALO HETE	Haloragis heterophylla	Raspwort
MYRIOP CRIS	Myriophyllum crispatum	Water-milfoil
MYRIOP GLOM	Myriophyllum glomeratum	
MYRIOP SP.	Myriophyllum sp.	Water-milfoil
MYRIOP VARI	Myriophyllum variifolium	Water-milfoil
MYRIOP VERR	Myriophyllum verrucosum	Red Water-milfoil
Lamiaceae		
AJUG AUST	Ajuga australis	Native Bugle, Australian Bugle
* MARR VULG	Marrubium vulgare	Horehound
MENT SATU	Mentha satureioides	Native Pennyroyal
* SALV VERB	Salvia verbenaca	Wild Sage
TEUC RACE	Teucrium racemosum	Grey Germander
Lobeliaceae		
ISOT AXIL	Isotoma axillaris	Showy Isotome
PRAT CONC	Pratia concolor	Poison Pratia, Milky Lobelia
Loranthaceae		
AMYE MIQU	Amyema miquelii	Box Mistletoe, Drooping Mistletoe
AMYE QUAN QUAN	Amyema quandang var. quandang	Grey Mistletoe
Lythraceae		
LYTH HYSS	Lythrum hyssopifolia	Hyssop Loosestrife, Small Loosestrife
Malvaceae		
LAVAT PLEB	Lavatera plebeia	Native Hollyhock
* MALVA PARV	Malva parviflora	Small-flower Mallow
* MODI CARO	Modiola caroliniana	Red-flower Mallow
SIDA AFCO	Sida sp. aff. corrugata	
SIDA AMMO	Sida ammophila	Sand Sida
SIDA CORR	Sida corrugata	Corrugated Sida, Sage Weed
SIDA CUNN	Sida cunninghamii	Ridge Sida
SIDA FILI	Sida filiformis	Fine Sida
SIDA TRIC	Sida trichopoda	High Sida
Moraceae		
* FICU CARI TUBR	Ficus carica cv. Turkish Brown	
Myoporaceae		
EREMOP DESE	Eremophila deserti	Turkey-bush
EREMOP MITC	Eremophila mitchellii	Budda
MYOP MONT	Myoporum montanum	Waterbush, Western Boobialla
MYOP PLAT PLAT	Myoporum platycarpum subsp. platycarpum	Sugarwood, False Sandalwood
Myrtaceae		
CALYT TETR	Calytrix tetragona	Fringe-myrtle
EUCA CAMA	Eucalyptus camaldulensis	River Red Gum
EUCA CLAD	Eucalyptus cladocalyx	Sugar Gum
EUCA CONI	Eucalyptus conica	Fuzzy Box
EUCA DWYE	Eucalyptus dwyeri	Dwyer's Red Gum
EUCA LARG	Eucalyptus largiflorens	Black Box
EUCA MELL	Eucalyptus melliodora	Yellow Box
EUCA MICROC	Eucalyptus microcarpa	Western Grey Box
EUCA POPU BIMB	Eucalyptus populnea subsp. bimbil	Bimble Box, Poplar Box
EUCA SIDEROX	Eucalyptus sideroxylon	Mugga, Red Ironbark
EUCA VIRI	Eucalyptus viridis	Green Mallee

Bot. name code	Botanical name	Common name
Nyctaginaceae		
BOER DOMI	Boerhavia dominii	Tar Vine
Onagraceae		
EPIL BILL CINE	Epilobium billardierianum subsp. cinereum	Smooth Willow-herb
LUDW PEPL MONT	Ludwigia peploides subsp. montevidensis	Water Primrose
* OENO AFFI	Oenothera affinis	Long-flowered Evening Primrose
Oxalidaceae		
OXAL PERE	Oxalis perennans	
Pittosporaceae		
PITT PHYL	Pittosporum phylliraeoides	Berrigan, Weeping Pittosporum
Plantaginaceae		
PLANT CUNN	Plantago cunninghamii	Sago-weed
PLANT TURR	Plantago turrifera	Small Sago-weed
Polygonaceae		
MUEH FLOR	Muehlenbeckia florulenta	Lignum
PERSI DECI	Persicaria decipiens	Slender Knotweed
* POLYGO AVIC	Polygonum aviculare	Wireweed
RUME BROW	Rumex brownii	Slender Dock
* RUME CRIS	Rumex crispus	Curled Dock
RUME CRYS	Rumex crystallinus	Shiny Dock
RUME TENA	Rumex tenax	Shiny Dock
Portulacaceae		
CALAND CALY	Calandrinia calyptrata	Small-leaf Parakeelya
CALAND EREM	Calandrinia eremaea	Small Purslane
Proteaceae		
GREV FLOR	Grevillea floribunda	Rusty Spider-flower
HAKE TEPH	Hakea tephrosperma	Hooked Needlewood, Striped Hakea
Ranunculaceae		
RANU SESS SESS	Ranunculus sessiliflorus var. sessiliflorus	Small-flowered Australian Buttercup
Rosaceae		
APHANE AUST	Aphanes australiana	
Rubiaceae		
ASPE CONF	Asperula conferta	Common Woodruff
ASPE CUNN	Asperula cunninghamii	
* GALIU APAR	Galium aparine	Cleavers, Goose-grass, Bedstraw
GALIU GAUD	Galium gaudichaudii	Rough Bedstraw
Rutaceae		
GEIJ PARV	Geijera parviflora	Wilga
Sapindaceae		
ALEC OLEI ELON	Alectryon oleifolius subsp. elongatus	Western Rosewood, Boonaree
DODO HETE	Dodonaea heteromorpha	Propellor Bush
DODO PEDU	Dodonaea peduncularis	Stalked Hopbush
DODO VISC CUNE	Dodonaea viscosa subsp. cuneata	Hopbush
Scrophulariaceae		
GLOSSOS DIAN	Glossostigma diandrum	Small Mudmat
GLOSSOS ELAT	Glossostigma elatinoides	Small Mudmat
GRAT PUMI	Gratiola pumilo	
LIMOS CURD	Limosella curdieana	Large Mudwort
* OROB MINO	Orobanche minor	Broomrape
* VERBA VIRG	Verbascum virgatum	Twiggy Mullein
Solanaceae		
* LYCI FERO	Lycium ferocissimum	African Boxthorn
SOLA CINE	Solanum cinereum	Narrawa Burr
SOLA ESUR	Solanum esuriale	Quena

Bot. name code	Botanical name	Common name
* SOLA NIGR	Solanum nigrum	Blackberry Nightshade
Stackhousiaceae		
STACK MONO	Stackhousia monogyna	Candles
Sterculiaceae		
BRACHYCH POPU TRIL	Brachychiton populneus subsp. trilobus	Kurrajong
Thymelaeaceae		
PIME LINI LINI	Pimelea linifolia subsp. linifolia	Slender Rice-flower
Urticaceae		
PARI DEBI	Parietaria debilis	Native Pellitory
* URTI UREN	Urtica urens	Small Nettle
Verbenaceae		
* PHYLA NODI	Phyla nodiflora	Carpet Weed, Lippia
* VERBE BONA	Verbena bonariensis	Purple Top, Purple-top Verbena
* VERBE OFFI	Verbena officinalis	European Vervain
Violaceae		
HYBA MONO	Hybanthus monopetalus	Slender Violet-bush

4. Monocotyledons

Bot. name code	Botanical name	Common name
Alismataceae		
DAMA MINU	Damasonium minus	Starfruit
Amaryllidaceae		
CALOS PURP	Calostemma purpureum	Pink Garland-Lily
Anthericaceae		
ARTHROPO MILL	Arthropodium milleflorum	Vanilla Lily
ARTHROPO MINU	Arthropodium minus	Small Vanilla Lily
DICHOP FIMB	Dichopogon fimbriatus	Nodding Chocolate-lily
THYS PATE	Thysanotus patersonii	Twining Fringe Lily
TRICO ELAT	Tricoryne elatior	Yellow Rush Lily
Asphodelaceae		
BULBINE BULB	Bulbine bulbosa	Bulbine Lily, Wild Onion
BULBINE SEMI	Bulbine semibarbata	Leek Lily
Colchicaceae		
WURM DIOI	Wurmbaea dioica	Early Nancy
Cyperaceae		
CARE APPR	Carex appressa	Tall Sedge
CARE BICH	Carex bichenoviana	
CARE INVE	Carex inversa	Knob Sedge
CYPE BIFA	Cyperus bifax	Downs Nutgrass
CYPE DIFF	Cyperus difformis	Dirty Dora
* CYPE ERAG	Cyperus eragrostis	Drain Flat-sedge, Umbrella Sedge
CYPE EXAL	Cyperus exaltatus	Giant Sedge, Tall Flat-sedge
CYPE FULV	Cyperus fulvus	Sticky Sedge
CYPE GUNN	Cyperus gunnii subsp. gunnii	Flecked Flat-sedge
CYPE GYMN	Cyperus gymnocaulos	Spiny Sedge
CYPE SP.	Cyperus sp.	
ELEO PALL	Eleocharis pallens	Pale Spike-rush
ELEO PLAN	Eleocharis plana	Ribbed Spike-rush
ELEO SP.	Eleocharis sp.	Spike-rush
FIMB DICH	Fimbristylis dichotoma	
ISOL CONG	Isolepis congrua	
ISOL SP.	Isolepis sp.	Club-rush
SCHOENU APOG	Schoenus apogon	Fluke Bog-rush, Common Bog-rush
Hydrocharitaceae		
OTTE OVAL	Ottelia ovalifolia	Swamp Lily
VALL GIGA	Vallisneria gigantea	Ribbonweed, Eelweed

Bot. name code	Botanical name	Common name
Juncaceae		
JUNC ARID	Juncus aridicola	Tussock Rush
* JUNC BUFO	Juncus bufonius	Toad Rush
JUNC FLAV	Juncus flavidus	
JUNC HOMA	Juncus homalocaulis	
JUNC RADU	Juncus radula	Hoary Rush
JUNC SP.	Juncus sp.	Rush
JUNC USIT	Juncus usitatus	Common Rush, Tussock Rush
Juncaginaceae		
TRIGL PROC	Triglochin procerum	Water Ribbons
Lemnaceae		
LEMN DISP	Lemna disperma	Duckweed
Lomandraceae		
LOMAN BRAC	Lomandra bracteata	
Orchidaceae		
MICROT UNIF	Microtis unifolia	Onion Orchid
PRAS ODOR	Prasophyllum odoratum	Scented Leek Orchid
PTEROS MUTI	Pterostylis mutica	Midget Greenhood
PTEROS SP.	Pterostylis sp.	Greenhood Orchid
THELY SP.	Thelymitra sp.	Sun Orchid
Phormiaceae		
DIANE LONG LONG	Dianella longifolia var. longifolia	Smooth Flax-lily
STYPA GLAU	Stypandra glauca	Nodding Blue-Lily
Poaceae		
AGROSTI AVEN	Agrostis avenacea	Blown Grass, Fairy Grass
* AIRA ELEG	Aira elegantissima	Delicate Hairgrass
AMPHIB MACR	Amphibromus macrorhinus	Swamp Wallaby Grass
ARISTI BEHR	Aristida behriana	Bunch Wiregrass
ARISTI JERI SUBS	Aristida jerichoensis var. subspinulifera	Jericho Wiregrass
ARISTI RAMO SPEC	Aristida ramosa var. speciosa	Purple Wiregrass
* AVEN FATU	Avena fatua	Wild Oats
BOTH DECI	Bothriochloa decipiens	Redleg Grass, Pitted Bluegrass
* BRIZ MINO	Briza minor	Shivery Grass
* BROM AREN	Bromus arenarius	Sand Brome, Native Brome, Seaside Brome
* BROM CATH	Bromus catharticus	Prairie Grass
* BROM DIAN	Bromus diandrus	Ripgut Brome
* BROM MADR	Bromus madritensis	Madrid Brome
* BROM MOLL	Bromus molliformis	Silky Brome, Soft Brome
* BROM RACE	Bromus racemosus	Smooth Brome
* BROM RUBE	Bromus rubens	Red Brome, Foxtail Brome
* BROM SP.	Bromus sp.	Brome Grass
CHLORI SP.	Chloris sp.	Rhodes Grass
CHLORI TRUN	Chloris truncata	Windmill Grass
CYNOD DACT	Cynodon dactylon	Couch Grass, Bermuda Grass
DANT AURI	Danthonia auriculata	Lobed Wallaby Grass
DANT CAES	Danthonia caespitosa	Ringed Wallaby Grass, White-top
DANT DUTT	Danthonia duttoniana	Brown-back Wallaby Grass
DANT ERIA	Danthonia eriantha	Hill Wallaby Grass
DANT LINK FULV	Danthonia linkii var. fulva	Wallaby Grass
DANT SETA	Danthonia setacea	Small-flowered Wallaby Grass
DANT SP.	Danthonia sp.	Wallaby Grass
DICHA SERI	Dichanthium sericeum	Silky Blue-grass
DICHE MICR	Dichelachne micrantha	Short-haired Plume Grass
DIGITAR BROW	Digitaria brownii	Cotton Panic Grass
DIGITAR DIFF	Digitaria diffusa	
DIGITAR DIVA	Digitaria divaricatissima	Umbrella Grass

Bot. name code	Botanical name	Common name
DIGITAR HYST	Digitaria hystrichoides	Umbrella Grass
DIPLAC FUSC	Diplachne fusca	Brown Beetle Grass
DIPLAC PARV	Diplachne parviflora	Small-flowered Beetle Grass
ELYM SCAB	Elymus scaber	Rough Wheatgrass
ENNE NIGR	Enneapogon nigricans	Bottlewashers, Niggerheads
ENTE ACIC	Enteropogon acicularis	Curly Windmill Grass
ERAG AUST	Eragrostis australasica	Swamp Canegrass, Bamboo Grass
ERAG BROW	Eragrostis brownii	Brown's Lovegrass
ERAG LACU	Eragrostis lacunaria	Purple Lovegrass
ERAG PARV	Eragrostis parviflora	Weeping Lovegrass
ERIOCHL PSEU	Eriochloa pseudoacrotricha	Early Spring Grass
EULA AURE	Eulalia aurea	Silky Browntop
HOMOP PROL	Homopholis proluta	Rigid Panic
* HORD GLAU	Hordeum glaucum	Northern Barley Grass
* HORD HYST	Hordeum hystrix	Mediterranean Barley Grass
* HORD LEPO	Hordeum leporinum	Barley Grass
* HORD MARI	Hordeum marinum	Sea Barley Grass
* LAMA AURE	Lamarckia aurea	Golden-top Grass
* LOLI PERE	Lolium perenne	Perennial Ryegrass
MICROL STIP	Microlaena stipoides	Meadow Rice-grass, Weeping Grass
PANI DECO	Panicum decompositum	Native Millet
PANI EFFU	Panicum effusum	Hairy Panic
* PANI GILV	Panicum gilvum	Sweet Panic
PANI QUEE QUEE	Panicum queenslandicum	Yadbila Grass, Coolibah Grass
PANI SUBX	Panicum subxerophilum	Gilgai Grass
* PARAPH INCU	Parapholis incurva	Curly Ryegrass
PASPALI CONS	Paspalidium constrictum	Knottybutt Grass
PASPALI JUBI	Paspalidium jubiflorum	Warrego Grass
PASPALI SP.	Paspalidium sp.	
* PASPALU DILA	Paspalum dilatatum	Paspalum, Golden Crown Grass
PASPALU DIST	Paspalum distichum	Water Couch
PENTASC AIRO	Pentaschistis airoides	False Hairgrass
* PHALA PARA	Phalaris paradoxa	Paradoxa Grass
PHRA AUST	Phragmites australis	Common Reed
POA SIEB HIRT	Poa sieberiana var. hirtella	Fine-leaf Tussock Grass
PSEUDORA SPIN	Pseudoraphis spinescens	Spiny Mudgrass
* ROSTR CRIS	Rostraria cristata	Annual Cat's Tail
* SORG HALE	Sorghum halepense	Johnson Grass
SPOROB CARO	Sporobolus caroli	Fairy Grass
SPOROB CREB	Sporobolus creber	Slender Rat's-tail Grass
SPOROB MITC	Sporobolus mitchellii	Rat's-tail Couch
STIP ARIS	Stipa aristiglumis	Plains Grass
STIP BLAC	Stipa blackii	Crested Speargrass
STIP DENS	Stipa densiflora	Foxtail Speargrass
STIP ELEG	Stipa elegantissima	Feather Speargrass
STIP PLAT	Stipa platychaeta	Flat-awned Speargrass
STIP SCAB FALC	Stipa scabra subsp. falcata	Delicate Speargrass, Corkscrew Grass
STIP SCAB SCAB	Stipa scabra subsp. scabra	Rough Speargrass, Corkscrew Grass
STIP SETA	Stipa setacea	Corkscrew Grass
STIP TUCK	Stipa tuckeri	Tucker's Speargrass
THEM AUST	Themeda australis	Kangaroo Grass
THYR MITC	Thyridolepis mitchelliana	Mulga Grass
TRIPO LOLI	Tripogon loliiformis	Five-minute Grass
* VULP MURA	Vulpia muralis	Rats-tail Fescue
* VULP SP.	Vulpia sp.	Rats-tail Fescue
Potamogetonaceae		
POTA TRIC	Potamogeton tricarinatus	Floating Pondweed

Bot. name code	Botanical name	Common name
Typhaceae		
TYPHA ORIE	Typha orientalis	Broad-leaf Cumbungi, Bulrush
5. Bryophytes		
Ricciaceae		
RICCIO NATA	Ricciocarpos natans	Floating Liverwort

(60 km2, most of which was lake) and is a more intensive survey of the Lake Cowal region than any previous flora survey.

The vegetation communities were mapped using CaLM Land Centre colour aerial photographs (approximate scale 1:50 000) dated 20 August 1993 supplemented with field survey data.

The field survey data in the current survey were collected from 115 10 m-wide transects (Appendix 1; full species names given in Table 2), 126 spot locations (Appendix 2) and recording of tree and shrubs present on roadsides and adjacent paddocks between sampling points.

The relative frequency of plant species was assessed by recording the presence/absence of each species in three contiguous 10 m x 10 m quadrats within transects. In each 10 m x 10 m quadrat, the heights and numbers of individuals of all tree species were recorded (Table 3). The presence/absence of herb and shrub species in 5 m x 5 m sub-quadrats were recorded. Transects were located so as to sample relatively homogenous areas of vegetation, visually assessed at time of sampling.

The purpose of the transects was to record the presence of species and their relative abundance. These data describe the vegetation at the time of sampling and can be used to assess changes over time.

3.2.2 Plant communities recognised in this survey

The clearing of the native vegetation for agriculture has been extensive (Figure 2). None of the stands of vegetation observed in this survey was weed free. All areas, with the possible exception of parts of the rocky ridges and parts of the gilgais, have been modified by past or present human activity: the flat areas cleared for crops or grazing, the hilltops for mining, quarrying for road base, and for some sheep and cattle grazing. Mining took place mainly between 1890 and 1910. Since about 1950 there has been some oversowing with exotic grasses (notably *Lolium perenne*) and fertilising of pasture and cropping areas.

The terrestrial plant communities recognised in this study fall into six broad groups, namely:

1. Ridge top vegetation with dominant species *Acacia doratoxylon, E. dwyeri, Callitris glaucophylla*.

2. lower slopes of ridges and lower ridges, a transitional between ridge top vegetation and the flatter land, dominated by *Callitris glaucophylla*

3. open woodland on undulating landform dominated by *E. populnea*

4. open woodland on undulating landform with gilgais dominated by *E. populnea*,

Table 3
Transect statistics of trees and shrubs (>2m in height)

Transects consist of three contiguous quadrats 10 m x 10 m in size in which number and maximum height of species are recorded.

A = percentage of quadrat in which species present
B = mean number of individuals per quadrat
C = range of number of individuals per quadrat
(* = juveniles <2m)
D = mean maximum height (m) of individuals present in quadrats
E = range of heights (m) of individuals present

	A	B	C	D	E
Transect 1					
creek line vegetation on John Wood's property, Manna Park, north exit of water from Nerang Cowal					
E. camaldulensis	33	0.3	0-1	12	12
E. largiflorens	100	9.3	6-12	11.6	10-12
E. populnea	33	0.7	0-2	12	12
Transect 2					
Travelling stock route on side of road with red sandy loam soil					
Callitris glaucophylla	67	0.7	0-1	10	8-12
Hakea tephrosperma	33	5	0-15	2	2
Transect 3					
base of granite hill on Jan Buttenshaw's property, Minnimanna					
Acacia doratoxylon	33	0.3	0-1	12	12
E. dwyeri	100	1.7	1-2	13.2	12-14
Transect 4					
Top of granite hill on Jan Buttenshaw's property, Minnimanna					
Acacia doratoxylon	100	4.7	4-5	6	6
E. dwyeri	67	0.7	0-1	4	4
Transect 5					
Bald patch on granite hilltop on Jan Buttenshaw's property, Minnimanna					
Acacia doratoxylon	33	0.3	0-1	8	8
E. dwyeri	67	0.7	0-1	4	2-6
E. populnea	33	0.3	0-1	30cm	30cm
Transect 6					
Callitris glaucophylla	100	2.7	2-4	10.5	10-12
Dodonaea viscosa	33	0.3	0-1	2.5	2.5
Eremophila mitchellii	33	0.3	0-1	4	4
E. microcarpa	33	0.3	0-1	18	18

E. sideroxylon	33	0.3	0-1	12	12
Transect 7					
Acacia doratoxylon	33	0.3	0-1	7	7
Callitris glaucophylla	100	32	6-50	4.5	4-9
E. dwyeri	100	2	1-3	8	8
E. sideroxylon	67	1.0	0-2	9.3	8-12
Transect 8					
Clear Ridge State Forest					
Allocasuarina luehmannii	67	2	0-4	10.3	10-12
Callitris glaucophylla	33	1.8	0-5	4	4
Eremophila mitchellii	67	1.8	0-3	5.2	2-10
E. microcarpa	33	0.7	0-2	16	16
Senna artemisioides	67	1.8	0-3	2	2
Transect 9					
Clear Ridge State Forest creek line					
Acacia deanei	100	1	1	3.2	2.5-4
Allocasuarina luehmannii	33	1	0-3	6	6
Callitris glaucophylla	33	0.3	0-1	7	7
E. camaldulensis	100	2	1-3	12	6-14
Transect 10					
Road and gravel extraction					
Acacia doratoxylon	100	2.7	1-4	6	6
E. dwyeri	67	0.7	0-1	10	8-12
Transect 11					
Gilgai with standing water at time of sampling					
Transect 12					
Near entrance to Geopeko shed					
E. populnea	67	2	0-5	9.7	8-10
Transect 13					
Grazing land near Geopeko DIP 60 mark					
Transect 14					
South edge of Mount Wamboyne on Andrew Buttenshaw's property "Coniston"					
E. dwyeri	100	2.3	1-5	8.7	5-8
Transect 15					
Grazing land with Callitris glaucophylla and E. microcarpa in surrounding area					
E. microcarpa	33	0.3	0-1	12	12
Transect 16					
Disturbance from Callitris glaucophylla removal about 30 years ago, at northern base of Billys Lookout					

Acacia doratoxylon	67	1	0-2	8	8
Callitris glaucophylla	100	117	100-150	4.6	4-6
E. dwyeri	33	0.7	0-2	6	2,10

Transect 17
Unimproved rocky pasture near northern base of Billys Lookout

Callitris glaucophylla	33	0.3	0-1	8	8

Transect 18
creek line of very shallow gully with large granite outcropping low slope of Billys Lookout

Callitris glaucophylla	33	0.3	0-1	12	12
E. dwyeri	100	5.3	2-9	4.1	2-5

Transect 19
Large granite outcropping towards top of Billys Lookout

Acacia doratoxylon	33	0.3	0-1	5	5
Callitris glaucophylla	33	0.3	0-1	1.5	1.5
E. dwyeri	100	2	2	4	2-8

Transect 20
Lows Road parallel to Burcher Road E->W

Alectryon oleifolius	67	1	0-2	3	3

Transect 21
Parallel to road in property separated from lake by channel 600 mm deep lined with yellow plastic cloth - pasture with no trees

Transect 22
Reedy patch up to 30 cm high

Transect 23
wet patch - no trees

Transect 24

Casuarina cristata	33	0.3	0-1	6	6
E. camaldulensis	33	0.3	0-1	4	4
E. populnea	67	1	0-2	11	10-12

Transect 25
Parallel to fence on roadside with wheat in the paddock, soils cracking black - no trees

Transect 26
Under fence along water coarse

E. camaldulensis	33	0.3	0-1	7	7
E. populnea	67	0.7	0-1	12	12

Transect 27

E. populnea	67	1	0-2	8	8

Transect 28
At time of sampling 300-500mm water depth - no trees

Transect 29
Rocky hilltop, Callitris glaucophylla cut about 20 years ago

Callitris glaucophylla	100	1.3	1-2	10	10
E. dwyeri	33	0.3	0-1	8	8

Transect 30

Callitris glaucophylla	33	0.3	0-1	10	10
E. dwyeri	67	1.3	0-2	8	8

Transect 31
Roadside about 300m from railway line

Acacia deanei	67	5.7	0-14	2.7	1.5-3
Callitris glaucophylla	67	7	0-18	7.7	6-8

Transect 32
Roadside - no trees

Transect 33
80 m south of railway line

Acacia deanei	33	0.3	0-1	2	2
Brachychiton populneus	67	0.7	0-1	6	6

Transect 34
0.4 km from house and about 0.2 km from cement tank, Callitris glaucophylla cut about 20 years ago

Callitris glaucophylla	100	2	1-3	7	6-8
E. populnea	33	0.3	0-1	10	10

Transect 35
Quartz rock outcrop

E. dwyeri	33	0.3	0-1	10	10

Transect 36
South facing slope

E. dwyeri	100	1.7	1-2	6.6	4-10

Transect 37
Up creek line

Callitris glaucophylla	33	0.7	0-2	3	3
E. dwyeri	67	1	0-2	5.7	2.5-12

Transect 38
Sheep grazing paddock with Wilga outside transect

E. sideroxylon	67	0.7	0-1	13	12-14
Transect 39					
Rocky ridge					
E. dwyeri	67	0.7	0-1	8	8
Transect 40					
Parallel to fence about 200-300 m from road into forest about 20 m on the "Hillgrove" ridge					
Acacia doratoxylon	67	1	0-2	5.3	2-7
E. dwyeri	33	1	0-3	8	8
Transect 41					
Bottom of slope of the "Hillgrove" ridge					
Callitris endlicheri	33	0.3	0-1	8	8
Casuarina cristata	33	0.3	0-1	8	8
E. microcarpa	100	3.7	1-6	6.8	2-14
E. sideroxylon	100	3	2-4	9.8	8-12
Transect 42					
Top of ridge line, lots of fallen dead trees					
Allocasuarina verticillata	67	0.7	0-1	5	5
Acacia doratoxylon	100	1	1	5.3	2-8
E. dwyeri	67	2	0-3	8	6-10
Transect 43					
Black Cypress around edge of southern hill					
Acacia doratoxylon	100	1	1	5.3	2-8
Callitris glaucophylla	100	9.3	5-13	7.4	6-9
E. dwyeri	67	1	0-2	5	5
Transect 44					
Upslope					
Callitris endlicheri	100	16	8-25	7	6-8
E. dwyeri	100	3	1-6	10	10
Grevillea floribunda	33	0.3	0-1	2.5	2.5
Transect 45					
On ridgetop					
Callitris endlicheri	67	2.7	0-6	6	6
E. dwyeri	100	2.7	1-5	8	8
Transect 46					
Stand of Casuarina cristata on "Lake Cowal" property					
Casuarina cristata	67	1.3	0-3	11	8-12
Transect 47					
Lake edge on "Lake Cowal" property, sandy soil					
E. camaldulensis	100	1.3	1-2	11.5	10-12

Transect 48
Lake edge on "Lake Cowal" property 0.8 km from T47, sandy soil

Acacia stenophylla	33	1.7	0-3	7	7
E. camaldulensis	100	2.7	1-5	11.8	10-12

Transect 49
Lake edge on Bill Buttenshaw's property, Lake Cowal

E. camaldulensis	33	0.3	0-1	12	12

Transect 50
Wet vegetation around edge of dam - no trees

Transect 51
Sandy Creek

E. camaldulensis	67	1.3	0-3	9	6-10

Transect 52
Three Callitris glaucophylla on fence 3m in height - no trees in transect

Transect 53
No trees

Transect 54

E. microcarpa	33	0.3	0-1	10	10

Transect 55
1 m deep roadside ditch

Acacia deanei	67	1	0-2	2.7	2-3
Callitris glaucophylla	100	13.7	3-30	5.6	4-6
E. conica	67	2	0-4	4	4
E. camaldulensis	100	9	5-15	5.2	4-8

Transect 56

Casuarina cristata	100	1.3	1-2	12	12

Transect 57
Creek line

Casuarina cristata	33	0.3	0-1	4	4
E. camaldulensis	33	0.7	0-2	14	14

Transect 58
River edge

E. camaldulensis	33	0.3	0-1	14	14

Transect 59
no trees

Transect 60
Fallow wheat paddock

Geijera parviflora	33	0.3	0-1	6	6
Transect 61					
0.4 km from "Coolola", stock exclusion area					
Acacia decora	67	0.7	0-1	2	2
Callitris glaucophylla	100	5.8	3-10	5.3	4-8
E. dwyeri	100	1.3	1-2	10	10
E. populnea	33	0.3	0-1	10	10
Transect 62					
200 m on road edge with exclusion area					
Acacia decora	33	0.3	0-1	3	3
Callitris glaucophylla	100	18.7	11-25	3.6	2-4
E. microcarpa	67	1.3	0-3	7	4-16
E. populnea	33	0.3	0-1	16	16
Transect 63					
E. camaldulensis	100	1	1	10	2-14
Transect 64					
Geijera parviflora	67	1	0-2	9.5	8-10
Transect 65					
Casuarina cristata	33	0.3	0-1	16	16
Geijera parviflora	33	0.3	0-1	6	6
Transect 66					
Gilgai					
Transect 67					
Gilgai					
Transect 68					
Gilgai					
Transect 69					
Gilgai					
Casuarina cristata	33	2	0-6	14	14
Transect 70					
Gilgai					
Transect 71					
About 20 m from roadside					
Acacia stenophylla	100	5.7	2-10	5	5
E. camaldulensis	33	0.3	0-1	5	5
Transect 72					
At heritage bridge					

E. camaldulensis	67	0.7	0-1	14	14

Transect 73
Undisturbed grassland near highway - no trees

Transect 74
no trees - gilgai

Transect 75
no trees - gilgai

Transect 76
At water edge, in deeper water E. camaldulensis

E. microcarpa	67	0.7	0-1	11	10-12

Transect 77
At southern end of transect, large exposed rock

E. dwyeri	33	0.3	0-1	50cm	50cm

Transect 78
Rocky slope on Billys Lookout

Acacia doratoxylon	67	0.7	0-1	3	2-4
E. dwyeri	100	4.3	1-8	2.5	1-3

Transect 79
Downslope on rocky slope on Billys Lookout

E. dwyeri	100	2.7	1-4	7	6-8

Transect 80
Sheep paddock

Casuarina cristata	100	1	1	12.7	10-16
E. microcarpa	33	0.7	0-2	12	12

Transect 81
Sheep paddock

Geijera parviflora	67	0.7	0-1	7	7
Alectryon oleifolius	33	0.3	0-1	4	4

Transect 82
Paddock

Acacia pendula	67	0.7	0-1	4.5	4-5

Transect 83
Gilgai overhung with Acacia pendula (Weeping Myall) on Colin Carnegie' property, "Cowal West"

Acacia pendula	67	1	0-2	7.3	7-8

Transect 84

Alectryon oleifolius	33	0.3	0-1	8	8

Casuarina cristata	67	1	*-3	14	14
Transect 85					
Roadside					
E. populnea	100	1.7	1-3	10	10
Transect 86					
Rocky ridge on "Cowal West"					
Callitris glaucophylla	100	3	1-5	8.2	8-10
E. dwyeri	67	1.3	0-3	6.5	5-7
Transect 87					
Alectryon oleifolius	33	0.3	0-1	4	4
Casuarina cristata	33	0.3	0-1	8	8
E. populnea	33	0.3	0-1	14	14
Transect 88					
Lake edge					
E. camaldulensis	33	0.7	0-2	10	10
Transect 89					
Edge of dam - no trees					
Transect 90					
E. camaldulensis	33	0.3	0-1	12	12
Transect 91					
E. camaldulensis	33	0.3	0-1	12	12
Transect 92					
Parallel with lake about 10 m from old E. camaldulensis and 30-50 m from exclusion area					
E. camaldulensis	67	2	0-5	36cm	20-40cm
Transect 93					
E. camaldulensis	33	0.3	0-1	12	12
Transect 94					
near "Conistan"					
Casuarina cristata	33	0.3	0-1	7	7
E. populnea	100	2.3	1-4	10.6	8-12
Transect 95					
Callitris glaucophylla	33	0.3	0-1	6	6
E. dwyeri	67	1.3	0-3	11.5	10-12
Transect 96					
on Mount Wamboyne					
Acacia doratoxylon	67	0.7	0-1	9	8-10

Callitris glaucophylla	67	13.3	0-30	6.5	6-8
E. dwyeri	100	7	3-11	5.9	5-6

Transect 97
Ridge top south of T96 on Mount Wamboyne

Acacia doratoxylon	67	1	0-2	10	10
Allocasuarina verticillata	33	6	0-18	6	6
E. dwyeri	67	1	0-2	6	6

Transect 98
Top of first crest on Mount Wamboyne

Allocasuarina verticillata	67	2.3	0-5	8	8
Callitris glaucophylla	67	1.7	0-3	5.2	4-6
E. dwyeri	100	3.3	2-5	8.6	8-10

Transect 99
on Mount Wamboyne

Brachychiton populneus	67	0.7	0-1	8	8
Callitris glaucophylla	100	6.7	5-10	13	12-14

Transect 100
Black Cypress Pine close to bottom of Mount Wamboyne with White Cypress Pine

Acacia doratoxylon	67	0.7	0-1	9	8-10
Callitris endlicheri	100	3	1-7	7.8	6-8
E. dwyeri	100	2	1-3	6.3	5-7

Transect 101

E. microcarpa	33	0.3	0-1	6	6

Transect 102

Callitris glaucophylla	33	0.3	0-1	10	10
E. microcarpa	33	0.3	0-1	10	10
Geijera parviflora	33	0.7	0-2	4	4

Transect 103
Ross Harmer "Strathnoon"

E. microcarpa	33	0.3	0-1	8	8

Transect 104

Acacia deanei	33	1	0-3	2	2
Geijera parviflora	33	0.3	0-1	3	3
Callitris glaucophylla	67	3	0-9	9.6	6-10
E. populnea	67	1	0-2	4	2-5

Transect 105

E. microcarpa	67	1.7	0-4	12	12
E. sideroxylon	33	0.3	0-1	12	12
Geijera parviflora	33	0.3	0-1	1.5	1.5

Transect 106

Callitris glaucophylla	100	1.7	1-3	9.2	8-10
Casuarina cristata	33	0.7	0-7	8	8
Senna artemisioides	33	0.3	0-1	2.5	2.5

Transect 107
0.8 km from Lake View owned by Geoff West on roadside

Acacia deanei	33	0.3	0-1	2	2
Acacia difformis	67	0.7	0-1	2	2
Callitris glaucophylla	100	5.3	1-11	4.4	3-6
E. dwyeri	100	2	1-4	7.5	5-8
E. sideroxylon	33	0.3	0-1	8	8

Transect 108
At corner of the lane

Acacia deanei	100	4.7	4-5	4	4
Brachychiton populneus	100	2	1-3	6.3	4-8
Callitris glaucophylla	33	0.7	0-2	5	5
E. populnea	33	0.7	0-2	14	14
Myoporum montanum	33	0.7	0-2	2	2

Transect 109

Acacia doratoxylon	33	0.3	0-1	2.5	2.5
Callitris glaucophylla	33	0.3	0-1	3	3
E. dwyeri	100	4	3-5	7.2	6-8
E. sideroxylon	33	0.3	0-1	8	8

Transect 110
1 km after Buttenshaw Lane

Acacia deanei	100	1.3	1-2	2.4	2-3
Brachychiton populneus	67	1	0-2	3.7	3-4
Callitris glaucophylla	100	7	1-11	4.2	4-10
Dodonaea viscosa	100	5.7	2-9	3.2	2.5-4
E. populnea	67	1	0-2	11.3	6-14
Geijera parviflora	33	1.7	0-5	4	4

Transect 111
Ridgetop to east with E. dwyeri on hilltop

Acacia deanei	67	1.3	0-2	2.5	2-3
Acacia doratoxylon	67	1.7	0-4	4.4	4-6
Acacia difformis	33	0.3	0-1	3	3
Eucalyptus sideroxylon	67	1.3	0-3	6.3	4-7
Callitris glaucophylla	juveniles 30cm				

Transect 112
3.5 km from junction and 0.3km on west from paddock entrance. Trees logged about 20 + years ago

Callitris glaucophylla	33	0.3	0-1	12	12

Transect 113
Gilgai nearest road - no trees

Transect 114
E. camaldulensis row to the west with band of seedlings
- no trees

Transect 115

E. camaldulensis	67	0.3	0-1	8	*-8

4a. with *Casuarina cristata* in wetter undrained (not ploughable) patches

5. forest, narrow band of *Eucalyptus camaldulensis* on lake, river and creek lines

5a. scattered *Eucalyptus camaldulensis* on wetland fringe

6. farming and grazing

plus the wetland communities identified in waterbird investigation (Lane 1990) with locations checked on 1993 aerial photographs, namely:

7. *Muehlenbeckia florulenta* (Lignum) dominance

8. *Eragrostis australasica* (Swamp Cane Grass) dominance

The main species of the terrestrial communities are discussed under trees, shrubs/small tree and herbs.

3.2.2.1 Tree species

Callitris endlicheri (Black Cypress-pine) was restricted to rocky slopes and ridge tops and was only recorded in transect 41, 44, 45 (Hillgrove), 99, 100 (Mount Wamboyne) (Map in rear pocket).

Callitris glaucophylla (White Cypress-pine) was widespread in a number of different vegetation communities, occurring in 34 of the 115 transects. *Callitris glaucophylla* has a low fire tolerance but tends to not burn as readily as Eucalypt communities without *C. glaucophylla* (Cardale 1987). Regeneration of *Callitris glaucophylla* fluctuates over time with episodes of prolific regeneration recorded between 1880 and 1905 and between 1952 and the present. The regeneration appears to be related to successions of high rainfall years, decline in frequency of fire and large scale clearing of vegetation which providing openings for regeneration establishment. Grazing, particularly by rabbits and sheep, also appears to be a controlling influence (Lacey 1972 cited Cardale 1987). Sheep grazing is a commonly used practice to limit regeneration in Forestry Commission holdings.

Members of the Casuarinaceae are widespread over the study area, extending from drainage-impeded gilgai areas on grey soils, where *Casuarina cristata* (Belah) frequently dominates, to better drained mainly red soils with *Allocasuarina luehmannii* (Bull Oak), and rocky ridges with occasional stands or individual trees of *Allocasuarina verticillata* (Drooping She-oak).

There were ten eucalypt species recorded, each with a specific habitat range. *E. camaldulensis* (River Red Gum) is restricted to river and creek lines and lake shores; *E. conica* occurred in one transect only (transect 55) on red soil on a low ridge; *E. dwyeri* was restricted to rocky ridge-tops, where it occurred commonly; *E. largiflorens* was recorded in only one transect (transect 1) on a creek line in alluvial clay soil subject to inundation; *E. melliodora* (Yellow Box), here at its western limit, was recorded from one site only, in light-textured soil on a low ridge in Nerang Cowal State Forest (spot location 1S); *E. microcarpa* (Inland Grey Box) is widespread in the area, mainly on lower slopes of ridges and in red soils; *E. populnea* subsp. *bimbil* (Bimble or Poplar Box) is the most widespread species in the area, ranging from drainage lines to gilgai soils, red soils, sandy soils, lower rocky ridges, and rocky or stony slopes; *E. sideroxylon* (Mugga Ironbark) is confined to lower, flatter ridges with deep red sandy or gravelly soils.

3.2.2.2 Shrub/small tree species

Indigofera australis (Native Indigo) was uncommon in the area, occurring only in transects 100 and 109, on hill slopes in stony soils.

Nine species of *Acacia* were recorded in this survey: *A. amblygona* (Fan Wattle) occurred only in transect 109; *A. deanei* subsp. *deanei* was fairly widely distributed on lower slopes in deeper soils of light texture, mainly on roadsides; *A. decora* was somewhat less frequent, on rocky slopes; *A. difformis* occurred fairly widely on lower slopes in deeper sandy loams, especially in disturbed areas such as roadsides; *A. doratoxylon* (Currawang, Lancewood, Spearwood) was restricted to rocky habitats, mainly along ridge tops; *A. pendula* (Weeping Myall) is confined to alluvial soil flats where it is associated with *Geijera parviflora* (Wilga) and *Alectryon oleifolius* (Rosewood); *A. stenophylla* (River Cooba) is restricted to creek lines and lake shores subject to occasional inundation. *A. oswaldii* (Miljee) was relatively uncommon, occurring on heavy soil flats dominated by *Casuarina cristata.*

Four members of the Myoporaceae were recorded in this survey. Plants of this family are regarded unfavourably by many farmers, as they are not commonly browsed by stock, and may cause poisoning due to a glycoside, prunasin. Poisoning usually only occurs in hungry or travelling stock (Auld and Medd 1987). *Eremophila deserti* (Turkey-bush) was not widespread on the grazing land, recorded in transect 8 in Clear Ridge Forest and transect 106 and in scattered locations (spot locations 1Y, 1Z, 2X, 3C, 3E, 5G) on heavy red soils to rocky hillside; *Eremophila mitchellii* (Budda) occurred on heavy red soils and sandy loams. *Myoporum montanum* (Waterbush, Western Boobialla) extends from the heavy red soil to rocky hillsides. *Myoporum platycarpum* subsp. *platycarpum* (Sugarwood, False Sandalwood) occurred in only one roadside transect (transect 108) on heavy red soil.

Pittosporum phylliraeoides (Berrigan, Weeping Pittosporum) was recorded in transect 98 on Mount Wamboyne on rocky soil. Cunningham *et al.* (1992) described its habitat as on soils ranging from grey clays to sandy red earths.

Grevillea floribunda (Rusty Spider Flower) and *Hakea tephrosperma* (Hooked Needlewood, Striped Hakea) were recorded on red sandy soils and rocky ridge soils.

Geijera parviflora (Wilga) is widespread in the area, reaching its best development on alluvial gilgai soils and other heavy soils on flats or lower slopes, rocky slopes, commonly associated with trees such as *Alectryon oleifolius, Casuarina cristata* and *Eucalyptus microcarpa*. It occurs in other habitats as well, for example in *Eucalyptus populnea* woodland on slopes and ridge tops in deeper sandy soils.

Family Sapindaceae is represented by the small tree *Alectryon oleifolius* subsp. *elongatus* (Rosewood) and four shrubby species of *Dodonaea* (Hopbush). Rosewood was widespread in grazing paddocks on lower hill slopes, chiefly on heavier red soils, and did not extend onto the rocky soils.

3.2.2.3 Herbaceous species

The native herbaceous vegetation, notably grasses, has survived despite a century or more of human activities. Of the 86 grass species recorded, 26 are exotic including two (*Lolium perenne* and *Paspalum dilatatum*) that are used for pasture improvement, though not necessarily in this region. The exotic grasses were dominated by the genera *Bromus* and *Hordeum*, doubtless a consequence of the extreme inedibility of most of their species. There were eight Bromus species (Brome Grass) and four *Hordeum* species (Barley Grass).

The exotic grass, *Hordeum marinum* (Sea Barley Grass) is an uncommon weed occurring in saline areas of NSW (Harden 1993). It was recorded in transects 48, 54, 85-87, 92, 97, 99, 106, 108, 113, 115, which consist of areas close to the lake with the exception of transects 97 and 99 on Mount Wamboyne. *Parapholis incurva* (Curly Ryegrass) also is characteristic of saline habitats (Harden 1993); it was recorded in transects 12, 13, 15 on or near the proposed lease area.

The exotic grasses, *Bromus arenarius*, *B. madritensis* (Madrid Brome), and *B. rubens* (Red Brome) usually grow in sandy soils in drier areas of NSW (Harden 1993).

Moore (1959) describes the modifications observed through time of native woodlands with grassy understorey, under grazing pressure, from an original ground cover dominated by *Themeda australis* associated with *Poa caespitosa* (now *P. sieberiana*) and *Stipa aristiglumis*. Under light grazing, *Stipa falcata* (now *S. scabra* subsp. *falcata*) and *Danthonia* spp. replace *Themeda* and *Poa* as dominants, but both the *Stipa* and the *Danthonia* species tend to disappear under heavier grazing regimes, giving way in turn to native composites, *Chloris truncata*, *Euphorbia drummondii* (now *Chamaesyce drummondii*) and *Atriplex leptocarpa*. Under very severe grazing, the most common species are the introduced annuals *Hordeum leporinum* (Barley Grass), *Medicago denticulata* (now *M. polymorpha*) (Burr Medic), *Carthamus lanatus* (Saffron Thistle) and *Cryptostemma lanatus* (now *Arctotheca calendula*) (Capeweed).

In this study, the moderate to severe grazing impact on the herbaceous species is shown (Figure 5).

"The overall effects of sheep and cattle grazing in many areas may be hard to separate as in many properties they may be run in the same paddocks. Patersons Curse (*Echium plantagineum*) is common on areas grazed by cattle but is generally absent on adjacent paddocks grazed by sheep. In general, cattle are less destructive to grasses than sheep, and it is noteworthy that Kangaroo Grass is more persistent in cattle country." Moore 1959).

In the study area, *Echium plantagineum* (Paterson's Curse) was recorded in only 27 of 115 transects. This low occurrence may due to the impact of sheep grazing. Similarly, *Themeda australis* was found to be rare, its only occurrence being on an ungrazed creek line. Sheep grazing pressure appears to be moderate to severe.

3.2.3 Status of native vegetation

3.2.3.1 Species

3.2.3.1.1 Rare or threatened

None of the species recorded for the Lake Cowal region are listed as rare or threatened (Briggs and Leigh 1988 or the current CSIRO listing).

The only plant species recorded in this survey which is not relatively common was a small semi-aquatic fern in family Marsileaceae, *Pilularia novae-hollandiae* (Austral Pillwort). This species is know from only a very few collections from New South Wales in the National Herbarium, Sydney.

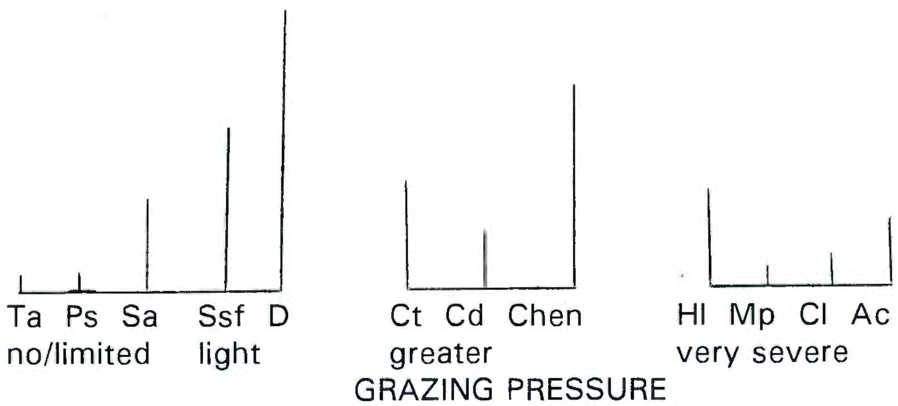
Pilularia novae-hollandiae is described in Harden (1990) as "widespread but not common in seasonally dry depressions and margins of marshes; may grow submerged." The regions listed for this species are Central Coast, Southern Tablelands, South Western Slopes, but not Central Western Slopes (in which Lake Cowal is located). It has been recorded in Victoria, Tasmania and South Australia. This recording appears to represent a new location for this species in New South Wales.

In this survey, *Pilularia* was recorded in Transects 11 and 75. The transects were through gilgai with standing water or recently receded water at the time of sampling.

3.2.3.1.2 Exotic species

There were 89 exotic species (62 dicots and 27 monocots) recorded in the survey. Only five species were listed as noxious in Bland Shire (Noxious Weed Act 1993). There were three in the noxious W2 category; *Hypericum perforatum* (St John's Wort), *Lycium ferocissimum* (African Boxthorn), *Sorghum*

Figure 5
The number of transects in which indicator species of different grazing regimes were recorded



No/limited grazing
Themeda australis (Ta) only recorded in an ungrazed creekline (transect 37) **1**
Poa sieberiana var. *hirtella* (Ps) recorded in transects 36 and 37 **2**
Stipa aristiglumis (Sa) recorded in transects 3, 4, 12, 15, 20, 25, 31-33, 52-54, 65, 71, 73, 74, 80-82, 84, 85, 104, 108, 110 **24**

Under light grazing,
Stipa falcata (now *S. scabra* subsp. *falcata* (Ssf) recorded in transects 1,2, 5-7, 9, 10, 12-20, 24, 27, 31, 34-37, 41, 43, 46-48, 54, 56, 61, 62, 64, 79, 81, 82, 84-87, 92, 94, 96, 104-106, 112, 115 **48**
Danthonia spp. (7 species) (D) recorded in transects 1-10, 12-19, 27, 30-41, 43-46, 52-59, 61-65, 73-75, 78-82, 84-87, 94-97, 99, 100, 102-112) **77**

greater grazing pressure
Chloris truncata (Dt) recorded in transects 1, 14-16, 20, 21, 25, 29-34, 39, 41, 47, 53, 54, 60, 65, 71, 74, 77, 79, 106 **24**
Chamaesyce drummondii (Cd) recorded in transects 19, 21, 31, 32, 33, 34, 39, 53, 54, 56, 60, 104, 106, 112 **14**
Atriplex leptocarpa, 23 species of Chenopodiaceae recorded (Chen), not including *A. leptocarpa,* recorded in transects 1, 2, 6-8, 10, 12-15, 20, 23-25, 27, 29-34, 38, 41, 44, 46-48, 54, 56, 58, 60-62, 64, 65, 71, 73, 74, 79, 80, 81, 82, 84-88.90,92,94, 96-99, 102-103, 105-108, 110-113, 115 **62**

Under very severe grazing, the most common species are introduced annuals
Hordeum leporinum (Barley Grass) (Hl) (4 species of Barley Grass recorded with the most widespread being *H. leporinum* recorded in transects 1, 6, 12-14, 20, 21, 24, 25, 27, 29, 38, 47, 56, 60, 64, 65, 71, 80, 81, 82, 84, 85, 115 **24**
Medicago polymorpha (Burr Medic) (Mp) (4 species of Medicago recorded) with *M. polymorpha* recorded in transects 1, 13, 15, 30, 53, 54 **6**
Carthamus lanatus (Saffron Thistle) (Cl) recorded in transects 6, 53, 64, 74, 110, 112 **6**
Arctotheca calendula (Capeweed) (Ac) recorded in transects 2-5, 10, 12-17, 19, 86, 87, 94, 97, 99, 106, 112, 115 **20**

halepense (Johnson Grass) and two in the W3 category; *Xanthium* spp.

The two species of *Xanthium* recorded were *X. occidentale* (Noogoora Burr) and *X. spinosum* (Bathurst Burr). These Burrs were found in transects 60, 63, 65, 71; and transects 27, 47, 115 respectively (Appendix 1). Their habitats vary from lakeshores with *E. camaldulensis* (transects 47, 63, 71, 115), fallow wheat paddock (transect 60) to ridges with *E. dwyeri* (transect 65) (Table 3).

A W3 weed is considered to pose a threat to agriculture, the environment, or the community and has the potential to spread to other areas, but is so widespread that total suppression and destruction is impractical. The onus is on land holders to prevent the spread and reduce the numbers and the distribution of W3 weeds to the satisfaction of the local control authority (Gray *et al.* 1993).

The location of W2 category noxious species are:

- *Hypericum perforatum* (St Johns-wort), observed at only two locations: spot locations 5H (roadside near railway crossing) and 5S (beside Lake Road) (Appendix 2).

- *Lycium ferocissimum* (African Boxthorn) recorded in locations near the entrance from Lake Road to Geopeko shed in a drainage line with *E. populnea* (transect 12), gilgai soil with *Casuarina cristata* (transect 56) and rocky ridgetops (transects 29 and 30).

- *Sorghum halepense* (Johnson Grass), recorded only in transect 63 on the lake shore.

As with W3 category weeds, W2 pose a threat to agriculture, the environment, or the community and have the potential to spread to other areas. However, private land holders, public authorities and local control authorities must fully and continuously suppress and destroy all W2 weeds (Gray *et al.* 1993).

Hypericum perforatum and *Sorghum halepense* appear to have only spot occurrences and should be controlled to limit their possible spread. *Lycium ferocissimum* and *Xanthium* spp. appear to have more widespread occurrences and their control is likely to be more difficult.

3.2.3.2 Plant communities

None of the plant communities found in the Lake Cowal region is rare, nor is any community restricted in distribution to the region.

Most of the study area is used for grazing and agriculture. Like the majority of important grazing lands (*sensu* Moore and Perry 1970 cited Gillison and Walker 1981), it was once woodland with extensive grass understorey. Much of the present distribution of native woodlands reflects patterns of land use and most of the semi-intact woodlands are today under considerable grazing pressure (Gillison and Walker 1981).

The cleared woodland community with a grassy understorey, is well represented locally, regionally and statewide. The few small uncleared patches are not well represented at any level and are of high conservation value.

Areas never cultivated, such as the waterlogged gilgai soils, or the rocky ridge tops have retained more of the native shrub and tree cover. These too have not escaped the effects of grazing.

According to a statewide conservation assessment of major wetland vegetation habitats (Benson 1987 cited in National Parks Association of NSW 1990), the Lignum community is not threatened but inadequately conserved whereas the Red Gum community is vulnerable and inadequately conserved.

4.0 Impact of the proposed mining operation

The Lake Cowal Project is a proposed open cut gold mine. The proposed pit is estimated to be of the order of 800 m by 800 m in size and about 300 m deep.

Approximately 7 km^2 in total would be impacted by the operation. This includes about 1 km^2 of lake. This "lake" area is perpetual leasehold farming land - grazed and cropped periodically when lake levels are low.

The landward edge of the pit, the potential overburden placement sites, tailing structures and processing plant are on grazing land and a wooded ridge.

5.0 Ameliorating impacts

The proposed mining operation will only have a localised impact compared with that of farming. Tree loss from previous clearing in the district has been high and ground water salinity appears to be rising.

Re-introduction of local native tree and shrub species is recommended to ameliorate the impacts of a century of farming in the Lake Cowal region. Clearing of land for cropping and grazing, and prevention of regeneration by grazing pressure are the major factors contributing to native vegetation losses (Porteners 1993).

Attempts to re-instate the original flora would include:

- stock exclusion areas be established to develop and retain the seed sources of the local native species on the mining lease

- the vegetated ridge line within the proposed mining area be retained as it represents one of the few uncleared areas of native vegetation.

- only local native species (trees, shrubs, grasses and herbs) be used for any rehabilitation in the area, as these species withstand the extreme environmental conditions such as droughts and floods.

- develop techniques for best practice methods for re-establishment of the local native tree/shrub species (see rehabilitation trials, Appendix 3).

During the operation, it is important that sound, light and visual impacts are minimised. There is an opportunity to re-establish the local native woodland communities with grassy understorey to provide part of a buffering between the mining lease and the adjoining farm land. Re-establishment trials (Appendix 3) are underway on a proposed stock route on the northern boundary of the proposed mining lease with local native seeds having been collected and tubestock grown in readiness for the 1995 autumn/winter rains.

6.0 Rehabilitation of the proposed mining operation

In rehabilitating a modern open cut gold mine, there are:

- the pit
- rocks not containing gold
- rocks containing gold.

to consider. In a modern operation, the rehabilitation should be clearly directed towards proposed final land uses. These land uses should be of benefit to the local community. Any decisions regarding final land uses need to be made with the aid of solid scientific information and in co-operation with a well-informed local community.

6.1 Potential wildlife habitats

6.1.1 Wetlands

Currently the southern end of Lake Cowal has lower wildlife value than the northern end due to the lack of vegetation cover (Australian Heritage Commission 1992). The creation of the pit may provide an opportunity to create a water body with shallows (and possibly islands) designed for key faunal species.

6.1.2 Rocky ridge tops

The large volume of overburden (rock not containing gold) and tailings (the resultant material post extraction from finely pulverised gold bearing materials) can be placed to form ridge lines of similar shape as existing rocky ridges. The regional landform has north-south strike ridges, parallel to the lake with some points (Wamboyne Mountain 400 m and Billys Lookout 368 m) rising up to 200 m above the relatively flat surrounding farming land. The ridges have in general retained their original flora cover with the additions of grazing and farm associated weeds. In this flora survey, the vegetation of the ridge lines have been recorded in detail. These local ridges are likely to be a good source of seed for rehabilitating the overburden stockpiles and the tailings areas.

Creation of fauna habitats on the overburden stockpile and tailing areas should be planned as part of the structural form. Open cavities between rocks on the east and north of newly created ridges could potentially provide habitat for Peregrine Falcons, Brush Tail Rock Wallabies as well as other mammals, reptiles and bats (Dominic Fanning pers. comm. July 1994). Problems are occurring with Rock Wallabies being eaten by foxes (Dr Leong Lim, pers. comm., July 1994) - a relative steep rock area may need to be considered for Rock Wallaby.

The landform is related to the soils with clay rich soils forming an undulating landform and rocky outcrops related to a more roughed landform. The post mining landform needs to reflect the soil or rocks used in these overburden and tailings areas. The soils of the alluvial plain are cracking clays which tend to form gilgais. If these soils are to be mounded, the rate of cracking and gilgai formation may affect the stability of the mounds, the root penetration in the surface soil and subsoil drying to the point of not supporting local native vegetation. The easiest way to know what the outcomes are is to observe mounds over time. Mounds have been formed associated with a minor dam on the proposed lease during the drilling operation. This area is not currently grazed. It is recommended that this area is inspected and photographed monthly to assess the extent of cracking, formations of gilgais and colonisation rates by grasses.

7.0 Conclusions

The areas of local native woodland are scarce in the Central Western Slopes region of NSW. The Lake Cowal district has a rich grass flora that has persisted despite grazing and cropping. This mix of native grasses and herbs is a valuable resource for both grazing in times of drought as well as for use in rehabilitation. The topsoils are likely to be rich in seeds of the drought resistant local native herbaceous seeds and may contain seeds of native tree and shrub species currently suppressed by the grazing pressure.

The rehabilitation post mining has the potential to re-establish the local native shrub and tree components of woodlands with a grassy understorey. Past tree and shrub removals are considered to be associated with regional problem of rising ground water and increasing soil salinity. Re-establishment of the local native trees and shrub may ameliorate the impacts of farming and associated clearing.

The rehabilitated proposed mining lease is of sufficient size to contribute to conservation of tree and shrub species in the district. Rehabilitation of buffer zones of the proposed lease areas should be designed to be green corridors of local native vegetation between existing treed areas.

As well as the potential rehabilitation to local native woodland on the overburden and tailings and in the buffer zones, the pit and lake buffer could be

rehabilitated as wetland habitat.

References

Anderson J., Gates G. and Mount T.J. (1993) *Hydrogeology of the Jemalong and Wyles Plains irrigation districts*. New South Wales Department of Water Resources Technical Services division.

Auld B.A. and Medd R.W. (1987) *Weeds. An illustrated botanical guide to the weeds of Australia.* Inkata Press, Sydney.

Australian Heritage Commission (1992) Lake Cowal 016581 1/07/257/0003/01 registered listing dated 19/08/92.

Barker P.J. and Wild J. (1994) *Soil survey - Lake Cowal project - consultancy report to North Mining.* Department of Conservation and Land Management.

Beadle N.C.W. (1948) *The vegetation and pastures of western New South Wales with special reference to soil erosion.* Department of Conservation of New South Wales, Sydney.

Beadle N.C.W. (1981) *Vegetation of Australia.* Cambridge University Press.

Bland Historical Society (1993) *Lake Cowal Historical Research*. unpub. manuscript.

Briggs J.D. and Leigh J.H. (1988) *Rare or threatened Australian plants.* Revised edition. Special Publication [14]. Australian National Parks and Wildlife Service, Canberra.

Bureau of Meteorology (1988) *Climatic averages. Australia.* Aust. Gov. Pub. Serv., Canberra.

Cardale S. (1987) Vegetation. in Goldney D.C. and Bowie I.J.S. (ed) *Scenic and scientific survey of the central western region.* A report to the Australia Heritage Commission. Chapter 8, 111-135.

Cambage R.H. (1901) Notes on the botany of the interior of New South Wales. Part IV. - From Mount Hope to Parkes. *Proc. Linn. Soc. NSW.* 317-333.

Cunningham G.M., Mulham W.E., Milthorpe P.L. and Leigh J.H. (1992) *Plants of Western New South Wales*. Inkata Press, Sydney.

Forestry Commission of NSW
State Forests. in Goldney D.C. and Bowie I.J.S. (ed) *Scenic and scientific survey of the central western region.* A report to the Australia Heritage Commission. Chapter 14, 220-236.

Gillison A.N. and Walker J. (1981)
Woodlands. in Groves R.H. (ed.) *Australian Vegetation.* Cambridge University Press, Sydney.

Goldney D.C. and Bowie I.J.S. (1990)
Some management implications for the conservation of vegetation remnants and associated fauna in the central eastern region of New South Wales. *Proc. Ecol. Soc. Aust.* **16**, 427-440.

Gray P., Trounce B. and Gorham P. (1993)
NSW noxious weed legislation. Agnote DPI/78. NSW Agriculture. Sept. 1993.

Harden G.J. (ed.) (1990-93)
Flora of New South Wales. N.S.W. Univ. Press, Kensington NSW, in conjunction with the Royal Botanic Gardens, Sydney (Volumes 1-4).

Jemalong-Wyldes Plain Community Steering Committee (1994)
Water wise farming. released by Jemalong-Wyldes Plain Community Steering Committee, c/- P.O. 136 Forbes 2871. March 1994.

Lane B.A. (1990)
West Wyalong Prospect waterbird investigation data report. unpub. report prepared NSR Consultants Pty Ltd. Report: CR 521/2, Sept. 1990.

Kelly I.D. (1971)
Jemalong and Wyldes Plains irrigation districts. Geomorphology, soils and groundwater conditions. Water Resources and Irrigation Commission NSW.

Mitchell Late Mrs Anne (n.d)
The flora. as printed in "West of the Bland" - a history of the Wyalong District.

Moore R.M. (1959)
Ecological observations on plant communities grazed by sheep in Australia. in Keast J.A., Crocker R.L. and Christian C.S. (ed.) *Biography and Ecology in Australia.* Junk, The Hague, 500-512.

Muddle P. (1983)
Land capacity 1:100 000 Wyalong map. Soil Conservation Service of NSW.

National Parks Association of NSW (1990)
Submission to Department of Water Resources Lake Cowal Environmental Study.

Noxious Weed Act (1993)
Official Notices 12 August 1994. *New South Wales Government Gazette*, No. 104.

Perry T.M. (1963)
Australia's first frontier. The spread of settlement in New South Wales 1788-1829. Melbourne Univ. Press, Melbourne.

Porteners M.F. (1993)
The natural vegetation of the Hay Plain: Booligal-Hay and Deniliquin-Bendigo 1:250 000 maps. *Cunninghamia.* **3(3)**, 1-122.

Rankine and Hill Pty Ltd Consulting Engineers (1980)
Summary report on proposals for the partial drainage of Lake Cowal. unpub. report prepared for Water Resources Commission.

Rodd A.N. and Clements A. (1995)
The proposed Girilambone Copper Mine extension. unpub. report to R.W.Corkery & Co. Pty Ltd. 22 January 1995.

Schwinghamnier T. (1987).
Waterways and wetlands. in Goldney D.C. and Bowie I.J.S. (ed) *Scenic and scientific survey of the central western region.* A report to the Australia Heritage Commission. Chapter 11, 161-186.

Vestjens W.J.M. (1977)
Status, habitats and food if vertebrates at Lake Cowal, N.S.W. Division of Wildlife Research Technical Memorandum No. 12, CSIRO, Canberra. July 1977.

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- Vanessa Miller of Cooinooi (1B),
- Jan Buttenshaw of Minimanna (1C, 1D, 1E, T3, T4, T5, 1F),
- Kevin Boneham of Tanrana (on northern section of Mt Wamboyne (T95, T96, T97, T98, T99, T100),
- Andrew Buttenshaw of Conistan (T14, 2P, 2C),
- Howard and Betty Menglesdorf of Corran (Waroona property 2G, Billys Lookout T17, T18, T19, T77, T78, T79, T37, T36, T35, T34),
- Colin Carnegie of Cowal West (T83, T84, T85, T86, T87),
- Bill, Gloria and Helen Buttenshaw of Lake Cowal (T46, T47, T48, T49, T50, T56, T57, T58),
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- Geoff West of Lakeview,
- Anna, a tenant, 7-8 km east of Nerang Cowal.

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Jan Denardo for assisting with the grass identifications. The staff of the National Herbarium and the Royal Botanic Gardens, Sydney for checking specimen identifications.

Voucher specimens for the area have been lodged with the National Herbarium, Sydney. A duplicate set of specimens have been prepared for use as a field herbarium.

APPENDIX 1 - Part I: species presence in Transects 1–47

(For full species names see Table 2; value 1, 2 or 3 in table represents number of quadrats in which the species occurs)

348

Bot. name code	Transects																																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
1. Pteridophytes																																															
Azollaceae																																															
AZOL FILI RUBR	2																											3																			
Marsileaceae																																															
MARSI ANGU																																															
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PILU NOVA											1																																				
Ophioglossaceae																																															
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Sinopteridaceae																																															
CHEILA AUST																																															
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2. Gymnosperms																																															
Cupressaceae																																															
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3. Dicotyledons																																															
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Bot. name code	Transects																																													
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BRACT VISC							1																																				1		3		
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CALOTI CUNEI				1	3	3		2	1					3	2					1																											
CALOTI HISP		2	3			1	1			2		1		1			1		1															2	1			3	2								
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Bot. name code	Transects																																													
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*LACT SERR																								2			2			1																	1
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MILLO MYOS			1																																												
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*PSEUDOGN LUTE																1																1															
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TRIPT PYGM		2	3	1	3									3		3	3	2	2													1					3		2	1			2				
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Bot. name code	Transects																																													
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WAHL STRI ALTE							3										2																				2										
Capparaceae																																															
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GYPS AUST																																			1												
*PETROR NANT																																															
*PETROR VELU													1	1		1	2	2																					3								
*POLYC TETR																																							1								
*SILE GALL QUIN														1																																	
*SILE NOCT														1		1																															
*SPERG RUBR								1						1							3	1																1									
STEL FILI																																															
Casuarinaceae																																															
ALLO LUEH								2	1																																						
ALLO VERT																																										2					
CASU CRIS																								1																	1					2	
CASU CUNN																																															
Chenopodiaceae																																															
ATRI SPIN	2	2						3							3					1					1		1				1		1	1												2	
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ENCH TOME TOME																																															
MAIR DECA																									1																						
MAIR ENCH						3		2							3														1	3	1		1	2				3			1					3	
MAIR HUMI		3													2																							1								2	
MAIR MICR		2													3																																
MAIR PENTAG																																															
MAIR SP.																																															
RHAG SPIN												1																																			
SALS KALI KALI								1																1			2																				
SCLEROB ATRI																																															
SCLEROL BIRC												3	3		3					2			2	1	2		3							2												3	1

Bot. name code	Transects																																													
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SCLEROL DIAC	3								1						1																																
SCLEROL MURI SEMI	2																															1															
SCLEROL SP.								3																																							
SCLEROL STEL																									1																						
Clusiaceae																																															
HYPE GRAM																																			1		2										
*HYPE PERF																																															
Convolvulaceae																																															
CONVO ERUB		1						1																							3	1	1						1								
DICHON MICR																1																					1										
DICHON REPE												1	1																		3	2	1			1											
Crassulaceae																																															
CRASS COLO ACUM																																						1									
CRASS DECU													2																																		
CRASS PEDU																																															
CRASS SIEB		3	2	1	1	3	1			3		1		3			3	2	3										3	3	2		1	3	3			1		1	1						
Cucurbitaceae																																															
*CITRUL LANA																																															
Droseraceae																																															
DROS PELT																1		1																									1				
Elatinaceae																																															
ELATI GRAT											1															1		1																			
Euphorbiaceae																																															
CHAMAESY DRUM																			1		1										2	1	1	2					2								
Fabaceae Caesalpinioideae																																															
SENN ARTE FILI								2																																							
SENN ARTE ZYGO																																															
Fabaceae Faboideae																																															
GLYCI CANE																																							1				2				
GLYCI CLAN																																															
GLYCI SP.																																															
GLYCI TABA								1							1	1																															
GLYCY ACAN																							1		1							3															
HARD VIOL																																															
INDI AUST								1																																							

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Bot. name code	Transects																																													
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*MEDICA MINI	1															2																															
*MEDICA POLY	1												2		1															2																	
*MEDICA SATI	3																																														
*MEDICA TRUN																																															
PULT LARG																																															
PULT LAXI																																															
*TRIF ANGU									1				2	1		2		1		1											2	3	3							1							1
*TRIF ARVE													1	1	1	2	1	2	3	1														1	3	3	1		1								
*TRIF CAMP																1		1													1						1						1				
*TRIF DUBI																																			2	3											
*TRIF GLOM					2				1			1	3		1		1		3	1									3	3	2	3	3	1	1	3	2	2	1	2			1				
*TRIF SUBT																																2															
*TRIF TOME														2															3	1					1					1							
Fabaceae Mimosoideae																																															
ACAC AMBL																																															
ACAC DEAN DEAN									3																						2		1				1						1				
ACAC DECO																																															
ACAC DIFF								1																												1	1										
ACAC DORA			1	3	1		1			3						2			1																					2		3	3		2		
ACAC HOMA																																															
ACAC OSWA																																															
ACAC PEND													1																																		
ACAC STEN																																															
Fumariaceae																																															
*FUMA SP.																																															
Gentianaceae																																															
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CENTAURI SPIC																																															
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*CICEN QUAD																2																															
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EROD CICU		1										1																										1									
EROD CRIN		1	1	1						1				1		2	1	1	1										1	1				1													
GERA RETR																																				1											
Goodeniaceae																																															
GOODE CYCL															1		3	1																													
GOODE FASC	1																				3		2												1												

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Bot. name code	Transects																																													
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GOODE HEDE			2		3		2						1					1																										3	2		
GOODE PINN		2		1				2							3							1																									
Haloragaceae																																															
GONO ELAT			3	3	3		3			1								2																	1	2	2		1	1		3	3	2	3		
GONO TETR																																															
HALO ASPE	1																																														
HALO GLAU																										1																					
HALO HETE									3																																						
MYRIOP CRIS											2																																				
MYRIOP GLOM																																															
MYRIOP SP.																																															
MYRIOP VARI																																															
MYRIOP VERR																										3																					
Lamiaceae																																															
AJUG AUST																																															
*MARR VULG	1																														2																
MENT SATU																																															
*SALV VERB												1																			2																
TEUC RACE	1																																														
Lobeliaceae																																															
ISOT AXIL																			2																												
PRAT CONC											2		1												1	1		2																			
Loranthaceae																																															
AMYE MIQU								1																																							
AMYE QUAN QUAN																				1																											
Lythraceae																																															
LYTH HYSS																				1												2															
Malvaceae																																															
LAVAT PLEB																																															
*MALVA PARV												3															1		1									1									
*MODI CARO																																															
SIDA AFCO																																															
SIDA AMMO													2																																		
SIDA CORR		3				1		1							3						3									3	3		3	3				3									
SIDA CUNN																																															
SIDA FILI																							1																								
SIDA TRIC													2												1													2									

Bot. name code	Transects																																													
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Moraceae																																															
*FICU CARI TUBR																																															
Myoporaceae																																															
EREMOP DESE								2																																							
EREMOP MITC						1		2																																							
MYOP MONT																																															
MYOP PLAT PLAT																																															
Myrtaceae																																															
CALYT TETR																																															
EUCA CAMA	1								3															1		1																					3
EUCA CLAD																																															
EUCA CONI																																															
EUCA DWYE			3	2	2		3			2				3		1		3	3										1	2					1	3	2		2	1		2	2	3	3		
EUCA LARG	3																																														
EUCA MELL																																															
EUCA MICROC						1		1							1																										3						
EUCA POPU BIMB	1				1							2												2		2	2							1													
EUCA SIDEROX						1	2																															2			3						
EUCA VIRI																																															
Nyctaginaceae																																															
BOER DOMI								1																					2	3	1	1			1			3									
Onagraceae																																															
EPIL BILL CINE																																1															
LUDW PEPL MONT																																															
*OENO AFFI																																															
Oxalidaceae																																															
OXAL PERE	2	1		2		2		2	1			1	2	2	1						2										3	1	1	1	1	1		1	2	3			3				
Pittosporaceae																																															
PITT PHYL																																															
Plantaginaceae																																															
PLANT CUNN								1																																							
PLANT TURR		1													1																							1									
Polygonaceae																																															
MUEH FLOR											3												3	2	3	3	2	3																			
PERSI DECI																																															

Bot. name code	Transects																																													
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RUME BROW																														1	2		2				1	1									
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RUME CRYS																							1																								
RUME TENA	2										1	1																																			
Portulacaceae																																															
CALAND CALY			1																																												
CALAND EREM			1	2			2			3						1	1		2																1										3		
Proteaceae																																															
GREV FLOR																																												1			
HAKE TEPH		1																																													
Ranunculaceae																																															
RANU SESS SESS							1		1																																						
Rosaceae																																															
APHANE AUST														1		1																															
Rubiaceae																																															
ASPE CONF																																															
ASPE CUNN								2												1					1																						
*GALIU APAR																																															
GALIU GAUD				1			3																																								
Rutaceae																																															
GEIJ PARV						1																																									
Sapindaceae																																															
ALEC OLEI ELON																				2																											
DODO HETE																		1																													
DODO PEDU																																															
DODO VISC CUNE						1		1																									1														
Scrophulariaceae																																															
GLOSSOS DIAN																																															
GLOSSOS ELAT																																															
GRAT PUMI																										1																					
LIMOS CURD											1																																				
*OROB MINO																															1																
*VERBA VIRG	1																																														

Bot. name code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
	Transects																																														
Solanaceae																																															
*LYCI FERO												1																	1	1																	
SOLA CINE																																								1							
SOLA ESUR																															1	2	1														
*SOLA NIGR																																															
Stackhousiaceae																																															
STACK MONO																1																															
Sterculiaceae																																															
BRACHYCH POPU TRIL																																	2														
Thymelaeaceae																																															
PIME LINI LINI																																															
Urticaceae																																															
PARI DEBI						1	1									2																															
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Verbenaceae																																															
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*VERBE BONA																																															
*VERBE OFFI	1																																														
Violaceae																																															
HYBA MONO																																															
4. Monocotyledons																																															
Alismataceae																																															
DAMA MINU											3									1						3																					
Amaryllidaceae																																															
CALOS PURP									3																																						
Anthericaceae																																															
ARTHROPO MILL																																															
ARTHROPO MINU			1	1			1			2				2		2																							1			3			3		
DICHOP FIMB								1																											1					1			3				
THYS PATE																2																															
TRICO ELAT		1	2	2												2	3	2	1																3	2			3	3		3	3				
Asphodelaceae																																															
BULBINE BULB				1																																											

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Bot. name code	Transects																																													
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BULBINE SEMI			2		2	2	1	1		3				1		3													2						1		3	3	1	2	2	2		1	2		
Colchicaceae																																															
WURM DIOI																1																															
Cyperaceae																																															
CARE APPR																																															
CARE BICH																																															
CARE INVE									1			1			1												1				2	2			3					1							
CYPE BIFA																										1																					
CYPE DIFF																																															
*CYPE ERAG																																															
CYPE EXAL																																															
CYPE FULV																																															
CYPE GUNN																																															
CYPE GYMN																																															
CYPE SP.									1																																						
ELEO PALL																				1		1																									
ELEO PLAN																						3				3																					
ELEO SP.											3																																				
FIMB DICH																																			2	1	2										
ISOL CONG																																									1						
ISOL SP.																										1																					
SCHOENU APOG																																				1											
Hydrocharitaceae																																															
OTTE OVAL																																															
VALL GIGA																																															
Juncaceae																																															
JUNC ARID													1																																		
*JUNC BUFO																																					2				1						
JUNC FLAV											2									2												3					2	1									
JUNC HOMA																																															
JUNC RADU																																	1														
JUNC SP.																				1		1																									
JUNC USIT	1		1										1																																		
Juncaginaceae																																															
TRIGL PROC																																															
Lemnaceae																																															
LEMN DISP																												2																			

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Bot. name code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
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LOMAN BRAC																								
Orchidaceae																								
MICROT UNIF																								
PRAS ODOR																	1							
PTEROS MUTI																2								
PTEROS SP.				1																				
THELY SP.																								
Phormiaceae																								
DIANE LONG LONG																								
STYPA GLAU																		3						
Poaceae																								
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*AIRA ELEG			1	3	3											3	2	3	3					
AMPHIB MACR											1													
ARISTI BEHR																								
ARISTI JERI SUBS														1			3	1	1					
ARISTI RAMO SPEC			3		3				3															
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BOTH DECI																								
*BRIZ MINO																2		1						
*BROM AREN																								
*BROM CATH																								
*BROM DIAN		2								1				3		2		1						
*BROM MADR		3																						
*BROM MOLL													3											
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*BROM RUBE						1													2					
*BROM SP.																								
CHLORI SP.																								
CHLORI TRUN	1													1	1	1				1	3			
CYNOD DACT	1																			1	3	3	1	
DANT AURI	1	2								3				3	1									
DANT CAES				2		3	3	3				2	3		3	1				2				
DANT DUTT										1														
DANT ERIA			3		3			1								3		3	3					
DANT LINK FULV																								

Bot. name code	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Lomandraceae																							
LOMAN BRAC							1																
Orchidaceae																							
MICROT UNIF																							
PRAS ODOR																							
PTEROS MUTI																							
PTEROS SP.																							
THELY SP.																				1			
Phormiaceae																							
DIANE LONG LONG																							
STYPA GLAU													3		1								
Poaceae																							
AGROSTI AVEN																	1						2
*AIRA ELEG											3	2	2		2	3			2				
AMPHIB MACR																							
ARISTI BEHR						2															1		
ARISTI JERI SUBS						1																	
ARISTI RAMO SPEC											1	2	3		3	2							
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BOTH DECI																							
*BRIZ MINO													2						1				
*BROM AREN							3																
*BROM CATH																							
*BROM DIAN							1	3	3		3	1				3	3						
*BROM MADR																							
*BROM MOLL							1	1	1							1							1
*BROM RACE																							
*BROM RUBE																							
*BROM SP.																							
CHLORI SP.																							
CHLORI TRUN	3				1	1	2	2	3	2					1		1						2
CYNOD DACT	3	2					1	2															3
DANT AURI						1					1	2	1	1	3	1			1				
DANT CAES			1			2	3	2	3					1		3			3	3	2	3	
DANT DUTT								3															
DANT ERIA																1							
DANT LINK FULV																	1						

Bot. name code	Transects																																													
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DANT SETA	3	1																																3							3						
DANT SP.									2																							3															
DICHA SERI																																	1														
DICHE MICR	1															2														1							3										
DIGITAR BROW																																				1			1								
DIGITAR DIFF			2		1														2																2	3	3		1								
DIGITAR DIVA									1																							3	3														
DIGITAR HYST																																															
DIPLAC FUSC																					2	3	3																								
DIPLAC PARV																																															
ELYM SCAB			1						1	3																				2	3							1									
ENNE NIGR																															1																
ENTE ACIC		3							1				3		3					2					1		2		3	3	3	1	3	3				2			1					3	
ERAG AUST																									1	1		3																			1
ERAG BROW																			2																1		3		1	1							1
ERAG LACU					1					1								1						2											3	1			1	2			1				
ERAG PARV																					3								1		1				1		2										
ERIOCHL PSEU																					1									1										1							
EULA AURE																																															
HOMOP PROL													1	1						1																1											
*HORD GLAU																														3																3	
*HORD HYST																																															
*HORD LEPO	3					1						3	3	1						3	3			3	3		2		3									3									3
*HORD MARI																																															
*LAMA AURE										1				2					1										2	2					1												
*LOLI PERE	3	3						1				3		2						1				3	3		3				2	3						1		3						1	3
MICROL STIP			3					1																																							
PANI DECO								2												1	1				2						1									2							
PANI EFFU														1		1	2	2	1																		1										
*PANI GILV																																															
PANI QUEE QUEE																																1			2												
PANI SUBX																			1	1												1							2	2							
*PARAPH INCU												1	2		1																																
PASPALI CONS																											2				1	1						1		1							
PASPALI JUBI											2	1											3			3																					
PASPALI SP.																																															
*PASPALU DILA																																3															
PASPALU DIST																																															2
PENTASC AIRO																			1																												

Bot. name code	Transects																																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
*PHALA PARA																				2																											
PHRA AUST																																															
POA SIEB HIRT																																				1	1							2			
PSEUDORA SPIN																																															
*ROSTR CRIS																																															
*SORG HALE																																															
SPOROB CARO													3																																		
SPOROB CREB									2																																						
SPOROB MITC																																															
STIP ARIS			1	3				1				1		1	1					3					2						2	3	2														
STIP BLAC								1																										1													
STIP DENS										3				3																					1	1					2	3	1		3		
STIP ELEG								3																																							
STIP PLAT																																															
STIP SCAB FALC	3	1			1	1	1		2	3		1	2	2	3	3	2	3	2					3			1				1			3	1	3	3				2		1			1	2
STIP SCAB SCAB			1		3	3	3							3			2		2										3	3	3		2	2	1	1		3	3	1	3			1			
STIP SETA																																															
STIP TUCK																																															
THEM AUST																																					3										
THYR MITC			2	2										3																												1					
TRIPO LOLI																																			2												
*VULP MURA																			2																3												
*VULP SP.		3	3					1		2			2	3	3	3	3	2												3	1		2	1	3	3		1	2	3	1	2	1	1	2		3
Potamogetonaceae																																															
POTA TRIC																																															
Typhaceae																																															
TYPHA ORIE																																															
5. Bryophytes																																															
Ricciaceae																																															
RICCIO NATA																												3																			

APPENDIX 1 - Part II: species presence in Transects 48–94

(For full species names see Table 2)

Bot. name code	Transects																																														
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
1. Pteridophytes																																															
Azollaceae																																															
AZOL FILI RUBR											2																																				
Marsileaceae																																															
MARSI ANGU																					1	1						2	1									1									
MARSI DRUM					2											1			1	1	1	1	3	3				2								1							2				
MARSI HIRS				1																																3											
PILU NOVA																												2																			
Ophioglossaceae																																															
OPHIOG LUSI CORI																																															
Sinopteridaceae																																															
CHEILA AUST																															1	1															
CHEILA DIST																																															
CHEILA SIEB														3	2															3	3	2							1								
2. Gymnosperms																																															
Cupressaceae																																															
CALLIT ENDL																																															
CALLIT GLAU								3						3	3																								3								
3. Dicotyledons																																															
Acanthaceae																																																
BRUNONIE AUST																																															
Amaranthaceae																																															
ALTE DENT				2	1					1																																					
ALTE SP.A		1									1					1				1					1			2	2							2					2		3	3	1		
PTILOTU SEMI																																			3		1										
PTILOTU SPAT																																															
Apiaceae																																															
DAUC GLOC														1																									1								
HYDROC LAXI														1																																	

Bot. name code	Transects																																														
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HYDROC SP.																																															
TRACHYM ORNA																																															
Apocynaceae																																															
PARS EUCA																																															
Asteraceae																																															
ACTINOB ULIG																																															
*ARCTOTH CALE																																							2	1							2
*ASTER SUBU				2																			1	3																							
BRACHYCO CILI SUBI																																															
BRACHYCO HETE																																															
BRACHYCO LINE																																			1												
BRACT BRAC														2	2															2	2								3								
BRACT VISC																																															
CALOCEP SOND									2		2							1									3	2					1		2		3	2	1	3					3		1
CALOTI ANTH																										1																					
CALOTI CUNEI															3																																
CALOTI HISP																																			1		3			3							3
CALOTI LAPP																																															
CALOTI SCAB INTE																																															
CALOTI SCAB SCAB																												1																			
CALOTI SCAP																									1																						
*CARDU TENU																																															
*CART LANA						1											1										3																				
CASSINI LAEV																																															
*CENTAURE MELI														1	1		1													1	1	3									1						
CENTIP CUNN				3																									1																		
CENTIP MINI											2										1																										
*CHONDR JUNC	1							3																						3		1															
CHRYSOCE APIC															1																																
CHRYSOCE SEMI															1																																
*CIRS VULG							1		2				2																											2							
*CONY BONA																																								3							1
COTU AUST																																															
ECLI PLAT					3																															1		2									
GNAP SPHA												1												3			3													1							1
*HEDYP RHAG CRET						1		2																			2																				
HYAL SEMI																																			1												
*HYPOCH GLAB	3													3																	1	1							2						2		

Bot. name code	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
ISOETO GRAM																																															
*LACT SERR											1	1														1						3															1
LEPTOR PANA												3														2																					
MILLO MYOS																																															
MINU LEPT																																															
*PSEUDOGN LUTE																																													3		
PYCNOSO CHRY						3	1																																								
RHODAN CORY						1											2							1											2		1	1		3							
RHODAN FLOR																																			1		2										
RHODAN PYGM																																															
SIGE AUST																														1																	
*SOLIV ANTH																																															
*SOLIV STOL																																															
*SONC ASPE																																					1										
*SONC OLER	2					1		2			1	3	1	1			3													2	2	3		1	1			2	2	3					2		2
STUA MUEL																																							2								
TRIPT PYGM																																								1							
VITT CUNE CUNE	1						2	1																																							
VITT CUNE HIRS						3	1																																								
VITT GRAC																																			1												
*XANTHI OCCI													1			1		1						3																							
*XANTHI SPIN																																															
Bignoniaceae																																															
PANDO PAND (NAR																																															
Boraginaceae																																															
*ECHIU PLAN	1					2					1	2					1	1								2	1			1			1					3							2		3
HELIO EURO																																															
Brassicaceae																																															
*CAPSE BURS																																															
LEPIDI PAPI																																											1				3
LEPIDI PSEU	1						1				1		1		1		2	1						1										2	1			3	1	1							
*SISYM IRIO									1				1				2																1	1			2			1							
*SISYM ORIE																																		1													
Campanulaceae																																															
WAHL COMM														1		1	1														2	2															
WAHL FLUM				3				2								2																															
WAHL GRAC														1																																	

364

Bot. name code	Transects																																														
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
WAHL STRI ALTE																																															
Capparaceae																																															
APOP ANOM																																															
Caryophyllaceae																																															
GYPS AUST																																															
*PETROR NANT																															1	2															
*PETROR VELU								1																																							2
*POLYC TETR																																															
*SILE GALL QUIN																																															
*SILE NOCT																																															
*SPERG RUBR																																															
STEL FILI																																															
Casuarinaceae																																															
ALLO LUEH																																															
ALLO VERT																																															
CASU CRIS									3	1								1				1											3				2			1							1
CASU CUNN																																															
Chenopodiaceae																																															
ATRI SPIN									1																									3	3		1			1							3
*CHEN AMBR																																															
CHEN DESE MICR																																							1								
CHEN MELA																																							2	2			2				
CHEN NITR																																															
CHEN PUMI	1																																														
EINA HAST																																															
EINA NUTA									1						2		1							3								1	1	2	1		2	1	2	3							2
ENCH TOME TOME							1																												1												
MAIR DECA																											2																				
MAIR ENCH							2		1					1	1		1																1	2	3		1		1	1	1						1
MAIR HUMI																																		2	2												
MAIR MICR							1		1				1					1																	1												1
MAIR PENTAG																																															
MAIR SP.																										1																					
RHAG SPIN											1																																				
SALS KALI KALI																																		1	3				1	3							
SCLEROB ATRI																																															
SCLEROL BIRC							1		3								2	1						2										2	2		2	3		3					3		

Bot. name code	Transects																																													
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SCLEROL DIAC																																															
SCLEROL MURI SEMI																																	1	2													
SCLEROL SP.																																															
SCLEROL STEL																																															
Clusiaceae																																															
HYPE GRAM				2																																											
*HYPE PERF																																															
Convolvulaceae																																															
CONVO ERUB							2										1	1																													
DICHON MICR																																															
DICHON REPE							1		1		1	1	3	3	1		2										3					1	1	1				2		3							1
Crassulaceae																																															
CRASS COLO ACUM																																															
CRASS DECU																																															
CRASS PEDU									1																												1										
CRASS SIEB								1	1						1															3	1								3						3		1
Cucurbitaceae																																															
*CITRUL LANA																		1						1																							3
Droseraceae																																															
DROS PELT																																															
Elatinaceae																																															
ELATI GRAT																												3																			
Euphorbiaceae																																															
CHAMAESY DRUM						2	1		1				1																																		
Fabaceae Caesalpinioideae																																															
SENN ARTE FILI																																															
SENN ARTE ZYGO																																															
Fabaceae Faboideae																																															
GLYCI CANE																																															
GLYCI CLAN																																															
GLYCI SP.								1																																							
GLYCI TABA														1																																	
GLYCY ACAN												1																																			
HARD VIOL																														1																	
INDI AUST																																															

Bot. name code	Transects																																														
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*MEDICA MINI													1																																		
*MEDICA POLY						1	2																																								
*MEDICA SATI						2																																									
*MEDICA TRUN																																								2							
PULT LARG																																															
PULT LAXI																																															
*TRIF ANGU	1			1	2	2	1	3				3		1	1	3											3										1	1							2		
*TRIF ARVE																														3		3							1						2		
*TRIF CAMP					1	2		2																							2																
*TRIF DUBI												1																		2		2															
*TRIF GLOM	1					1	1	1					2	1			1										1			3		3					1	1	1	2					3		
*TRIF SUBT								2																																							
*TRIF TOME						2							1																	1	1	1							1						3		1
Fabaceae Mimosoideae																																															
ACAC AMBL																																															
ACAC DEAN DEAN								2																																							
ACAC DECO														2	1																																
ACAC DIFF																																															
ACAC DORA																															2																
ACAC HOMA																																															
ACAC OSWA																												1					1														
ACAC PEND																																	1		2	2											
ACAC STEN	1																							3																							
Fumariaceae																																															
*FUMA SP.	1																																														
Gentianaceae																																															
*CENTAURI ERYT																																															
CENTAURI SPIC																																1															
*CENTAURI TENU			1																																												
*CICEN QUAD																																															
Geraniaceae																																															
EROD CICU																																															
EROD CRIN																																								2							
GERA RETR																																															
Goodeniaceae																																															
GOODE CYCL																																															
GOODE FASC							1										1											1																			

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Bot. name code	Transects																																													
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GOODE HEDE																																															
GOODE PINN															1			1																													
Haloragaceae																																															
GONO ELAT														2																1	3	3															
GONO TETR																																															
HALO ASPE																							1																								
HALO GLAU											2													3				3																			
HALO HETE		1		3																																											
MYRIOP CRIS																																															
MYRIOP GLOM																																															
MYRIOP SP.																													1																		
MYRIOP VARI																																				2											
MYRIOP VERR			3																																												
Lamiaceae																																															
AJUG AUST																																2															
*MARR VULG									1																																						
MENT SATU												2													2																						
*SALV VERB																																															
TEUC RACE																																															
Lobeliaceae																																															
ISOT AXIL																														3	3																
PRAT CONC			3		3						2	1										1	1		1	1		1	1							2							1				
Loranthaceae																																															
AMYE MIQU																																															
AMYE QUAN QUAN																																			1												
Lythraceae																																															
LYTH HYSS			1	2	3			1											1	1	1	1				1																					
Malvaceae																																															
LAVAT PLEB																																															
*MALVA PARV													2																					1			2			1							
*MODI CARO																																															
SIDA AFCO																																															
SIDA AMMO																		1																													
SIDA CORR						1	2		1					3	3		2									1	3						1	1	1		3	2		3							1
SIDA CUNN																																															
SIDA FILI																																															
SIDA TRIC						3											1	2						1		1	2																				

Bot. name code	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Moraceae																								
*FICU CARI TUBR																								
Myoporaceae																								
EREMOP DESE																								
EREMOP MITC																								
MYOP MONT																								
MYOP PLAT PLAT																								
Myrtaceae																								
CALYT TETR																								
EUCA CAMA	3	1		2				3		1	1					3								1
EUCA CLAD																								
EUCA CONI								2																
EUCA DWYE														3				1						
EUCA LARG																								
EUCA MELL																								
EUCA MICROC							1								2							1		
EUCA POPU BIMB														1	1									
EUCA SIDEROX																								
EUCA VIRI																								
Nyctaginaceae																								
BOER DOMI							1																	
Onagraceae																								
EPIL BILL CINE																								
LUDW PEPL MONT											3													1
*OENO AFFI								1								1								
Oxalidaceae																								
OXAL PERE									1			1	1	2	1		2							
Pittosporaceae																								
PITT PHYL																								
Plantaginaceae																								
PLANT CUNN									3															
PLANT TURR																								
Polygonaceae																								
MUEH FLOR											1													2
PERSI DECI																								

Bot. name code	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Moraceae																							
*FICU CARI TUBR																							
Myoporaceae																							
EREMOP DESE																							
EREMOP MITC																							
MYOP MONT																							
MYOP PLAT PLAT																							
Myrtaceae																							
CALYT TETR																							
EUCA CAMA	2																1		1	1	2	1	
EUCA CLAD																							
EUCA CONI																							
EUCA DWYE						1	3	3							2								
EUCA LARG																							
EUCA MELL																							
EUCA MICROC					1				1														
EUCA POPU BIMB														3		1							3
EUCA SIDEROX																							
EUCA VIRI																							
Nyctaginaceae																							
BOER DOMI						1								3		2							
Onagraceae																							
EPIL BILL CINE																							
LUDW PEPL MONT																			1				
*OENO AFFI																							
Oxalidaceae																							
OXAL PERE			1			1									2	2							
Pittosporaceae																							
PITT PHYL																							
Plantaginaceae																							
PLANT CUNN													2										
PLANT TURR										1						1							1
Polygonaceae																							
MUEH FLOR	3																1		2		1		
PERSI DECI																							

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Bot. name code	Transects																																													
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*POLYGO AVIC													2				1	2	1														1										1				
RUME BROW					2										2	1	1									1				1	1	2						2		3							2
*RUME CRIS																1																															
RUME CRYS																								1																	1		3		2		
RUME TENA										1									1																												
Portulacaceae																																															
CALAND CALY																																															
CALAND EREM																																															
Proteaceae																																															
GREV FLOR																																															
HAKE TEPH																																															
Ranunculaceae																																															
RANU SESS SESS																																															
Rosaceae																																															
APHANE AUST																																															
Rubiaceae																																															
ASPE CONF											1																																				
ASPE CUNN												3																																			
*GALIU APAR																																															
GALIU GAUD																																															
Rutaceae																																															
GEIJ PARV							1						1		1		2	1																2													
Sapindaceae																																															
ALEC OLEI ELON																																	1	1			1			1							
DODO HETE																																															
DODO PEDU																																															
DODO VISC CUNE																																															
Scrophulariaceae																																															
GLOSSOS DIAN																												2	3																		
GLOSSOS ELAT																					1																										
GRAT PUMI				1																																											
LIMOS CURD																				1									2																		
*OROB MINO																																															
*VERBA VIRG																															1																

370

Bot. name code	Transects																																													
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Solanaceae																																															
*LYCI FERO									1																																						
SOLA CINE																																															
SOLA ESUR						2	2					2					1	1								1	2														1						2
*SOLA NIGR																														1									1								
Stackhousiaceae																																															
STACK MONO														2																																	
Sterculiaceae																																															
BRACHYCH POPU TRIL																																															
Thymelaeaceae																																															
PIME LINI LINI																																															
Urticaceae																																															
PARI DEBI																																															
*URTI UREN																																															
Verbenaceae																																															
*PHYLA NODI																																													1		
*VERBE BONA																																															
*VERBE OFFI																																															
Violaceae																																															
HYBA MONO																															1																
4. Monocotyledons																																															
Alismataceae																																															
DAMA MINU			1																1	1	1	1	2					3	3							3											
Amaryllidaceae																																															
CALOS PURP								2								2																															
Anthericaceae																																															
ARTHROPO MILL																																															
ARTHROPO MINU														3	1																3						1										
DICHOP FIMB														3	2																1																
THYS PATE																																															
TRICO ELAT														2																	2																
Asphodelaceae																																															
BULBINE BULB																										1																					

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Bot. name code	Transects																																													
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
BULBINE SEMI																								1						2	1																
Colchicaceae																																															
WURM DIOI																																															
Cyperaceae																																															
CARE APPR																																															
CARE BICH	1										1	1																																			
CARE INVE	1				3		1	1	1		1	1	1				2					1				2												1									1
CYPE BIFA										2	2																																				
CYPE DIFF																												3																			
*CYPE ERAG																1																															
CYPE EXAL																																															
CYPE FULV				1																																											
CYPE GUNN				3	1					1	1					3																															
CYPE GYMN																																									2						
CYPE SP.																																															
ELEO PALL			2																		1	1				2																					
ELEO PLAN			3		3					3	2								1		1	1	3	1				3	3							3						1					
ELEO SP.																																															
FIMB DICH																																															
ISOL CONG																																															
ISOL SP.																																															
SCHOENU APOG																																															
Hydrocharitaceae																																															
OTTE OVAL			3																																												
VALL GIGA																																															
Juncaceae																																															
JUNC ARID																			1	1	1	1	1																								
*JUNC BUFO								2																		1																					
JUNC FLAV			3		3			1	1	2	3					1																				3						1					
JUNC HOMA				2						1																																					
JUNC RADU				2	1										1					1	1	1					1																				
JUNC SP.																																															
JUNC USIT																																															
Juncaginaceae																																															
TRIGL PROC																																															
Lemnaceae																																															
LEMN DISP																																															

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Bot. name code	Transects																																													
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Lomandraceae																																															
LOMAN BRAC														2	2																																
Orchidaceae																																															
MICROT UNIF																															1																
PRAS ODOR																																															
PTEROS MUTI																																															
PTEROS SP.																																															
THELY SP.																																															
Phormiaceae																																															
DIANE LONG LONG																										1																					
STYPA GLAU																															3	1															
Poaceae																																															
AGROSTI AVEN	1			1							1													2																			2				
*AIRA ELEG																															3	3															
AMPHIB MACR			1																									2	1							3											
ARISTI BEHR														1	3																																
ARISTI JERI SUBS																																							1								
ARISTI RAMO SPEC								2																																							
*AVEN FATU	1					3	3					3	2		1	2																															1
BOTH DECI																																															
*BRIZ MINO																																															
*BROM AREN																																															
*BROM CATH								3		1						2																															
*BROM DIAN												2																			1																
*BROM MADR																														1	1																
*BROM MOLL					3			1			1		1				2																														
*BROM RACE																																															
*BROM RUBE																														3																	
*BROM SP.																																															
CHLORI SP.																																															
CHLORI TRUN						3	1						2					1						1			3			1		1		1	1					1					1		
CYNOD DACT	3	3		2	2			1		1	1					3							2		3			2	3												3	1	3	3		2	
DANT AURI															2																																
DANT CAES	2					2	3		3		1			3	3			2									3				3	3	3	3	3		1	3		3							2
DANT DUTT					3	2				2	2	1														3																					
DANT ERIA														1	1																2								1								
DANT LINK FULV															1													3																			

Bot. name code	Transects																																													
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
DANT SETA														1			3																														
DANT SP.																																															
DICHA SERI							2																																								
DICHE MICR																																2															
DIGITAR BROW								3																							1																
DIGITAR DIFF														1																1	3	1															
DIGITAR DIVA																																															
DIGITAR HYST																																															
DIPLAC FUSC		1																						3	3			3	1												3	1	3	3		3	
DIPLAC PARV											3																																				
ELYM SCAB									3					1	2																																
ENNE NIGR																																															
ENTE ACIC	1						1		3					2	3		2	2								2	2				1			1	1		2	3	1	3					1		3
ERAG AUST	1										1													1																							
ERAG BROW				3				1																						2	3	1															
ERAG LACU																														1		1							1					1	2		
ERAG PARV				1							2																			1								2									
ERIOCHL PSEU						2	1				2		1																			1															
EULA AURE																										1																					
HOMOP PROL					1							3			1			1								3																					
*HORD GLAU																		3																					2								3
*HORD HYST																																															
*HORD LEPO									1				2				3	1						2									3	3	2		3	2									
*HORD MARI	1						3		1																													2	2	3					2		
*LAMA AURE																																															
*LOLI PERE	3			1	2	2	2	2		1	3	3	3	2		2	2	3						3									3					2							2		1
MICROL STIP																																															
PANI DECO													1											1			1					1															
PANI EFFU			1											2																2	1																
*PANI GILV																												1																			
PANI QUEE QUEE						3																																									
PANI SUBX															1																																
*PARAPH INCU																																															
PASPALI CONS				1																																		1		1							2
PASPALI JUBI										3														3	3																						
PASPALI SP.																																															
*PASPALU DILA				2						1						3																															
PASPALU DIST				1						3									1																						1		1				
PENTASC AIRO																														1																	

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Bot. name code	Transects																																													
	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
*PHALA PARA					2			1			3	3	3						1					3		3																					
PHRA AUST																																															
POA SIEB HIRT																																2															
PSEUDORA SPIN										2																			2																	3	
*ROSTR CRIS																						1																							1		
*SORG HALE																1																															
SPOROB CARO						2	3		1																									1	2		1										
SPOROB CREB								1								1																															
SPOROB MITC	1																																	1											3		
STIP ARIS					1	3	3											2						1		3	3						1	3	1		1	1									
STIP BLAC						2								1			2																														
STIP DENS																															2								1								
STIP ELEG																																															
STIP PLAT																																															
STIP SCAB FALC	3						1		2					2	2		2															2		3	3		3	2	1	2					3		2
STIP SCAB SCAB														2	2															3	3	3							2								
STIP SETA														2																																	
STIP TUCK																																															
THEM AUST																																															
THYR MITC																																															
TRIPO LOLI																																															
*VULP MURA																																															
*VULP SP.	2						1		2				1	1	2												3			3	3				3		2		3	1					3		1
Potamogetonaceae																																															
POTA TRIC			1																										2																		
Typhaceae																																															
TYPHA ORIE																																															
5. Bryophytes																																															
Ricciaceae																																															
RICCIO NATA																																															

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APPENDIX 1 - Part III: species presence in Transects 95–115

(For full species names see Table 2)

Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
1. Pteridophytes																					
Azollaceae																					
AZOL FILI RUBR																				1	
Marsileaceae																					
MARSI ANGU																					
MARSI DRUM							3												2	1	3
MARSI HIRS																					
PILU NOVA																					
Ophioglossaceae																					
OPHIOG LUSI CORI																					
Sinopteridaceae																					
CHEILA AUST					1	1															
CHEILA DIST					1																
CHEILA SIEB		1	2	1	2	3									1	1	2	1			
2. Gymnosperms																					
Cupressaceae																					
CALLIT ENDL					1	3															
CALLIT GLAU	1	2		2		3		1		2		3	3	1	1	3	1	1			
3. Dicotyledons																					
Acanthaceae																					
BRUNONIE AUST																1					
Amaranthaceae																					
ALTE DENT																					
ALTE SP.A																			1	3	3
PTILOTU SEMI																					
PTILOTU SPAT					1																
Apiaceae																					
DAUC GLOC		3	3	3	3	1															
HYDROC LAXI					1					2											

Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
HYDROC SP.																					
TRACHYM ORNA																					
Apocynaceae																					
PARS EUCA		1		3																	
Asteraceae																					
ACTINOB ULIG																					
*ARCTOTH CALE			1		1							2						2			1
*ASTER SUBU																					
BRACHYCO CILI SUBI																					
BRACHYCO HETE																					
BRACHYCO LINE																					
BRACT BRAC				3												3	3				
BRACT VISC															3						
CALOCEP SOND																					
CALOTI ANTH																					
CALOTI CUNEI											3	1				1					
CALOTI HISP		1	2																		
CALOTI LAPP																					
CALOTI SCAB INTE																					
CALOTI SCAB SCAB																					
CALOTI SCAP																					
*CARDU TENU				3	3	1															
*CART LANA																2		1			
CASSINI LAEV																					
*CENTAURE MELI				1												2					
CENTIP CUNN																			3		2
CENTIP MINI																					
*CHONDR JUNC										1								3			
CHRYSOCE APIC																					
CHRYSOCE SEMI																					
*CIRS VULG										2											3
*CONY BONA				1																	
COTU AUST																					
ECLI PLAT							1												3		3
GNAP SPHA												1									
*HEDYP RHAG CRET																		1			
HYAL SEMI																					
*HYPOCH GLAB	1	3	2		1	3			1		1				1		2				

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Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
ISOETO GRAM																					
*LACT SERR														1							
LEPTOR PANA																					
MILLO MYOS																					
MINU LEPT																					
*PSEUDOGN LUTE																					
PYCNOSO CHRY																					
RHODAN CORY																					
RHODAN FLOR																					
RHODAN PYGM																					
SIGE AUST			1	2	1																
*SOLIV ANTH																					1
*SOLIV STOL																					
*SONC ASPE																					
*SONC OLER		1	1		3	1		1		3		1		3		2					2
STUA MUEL		3	2		2	1															
TRIPT PYGM			1			1												1			
VITT CUNE CUNE								1													
VITT CUNE HIRS								1	1	2	1		1								
VITT GRAC								1	1	1	2	1									
*XANTHI OCCI																					
*XANTHI SPIN																					1
Bignoniaceae																					
PANDO PAND (NAR				1	2																
Boraginaceae																					
*ECHIU PLAN								2		3		3		3				3			
HELIO EURO																					3
Brassicaceae																					
*CAPSE BURS																					
LEPIDI PAPI					1			3													
LEPIDI PSEU										3		3									
*SISYM IRIO																					
*SISYM ORIE												2				3		1			
Campanulaceae																					
WAHL COMM					2	3									3	1					
WAHL FLUM																					
WAHL GRAC			2			1						2					2				

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Bot. name code	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
WAHL STRI ALTE				3																	
Capparaceae																					
APOP ANOM																					
Caryophyllaceae																					
GYPS AUST																					
*PETROR NANT																					
*PETROR VELU			2	1													2	2			
*POLYC TETR				1	2																
*SILE GALL QUIN																		1			
*SILE NOCT				1	2																
*SPERG RUBR																					
STEL FILI		1				1															
Casuarinaceae																					
ALLO LUEH																					
ALLO VERT			1	2																	
CASU CRIS												1									
CASU CUNN																					
Chenopodiaceae																					
ATRI SPIN								3	2		1	1					1				
*CHEN AMBR																					2
CHEN DESE MICR									1		3					1	3				
CHEN MELA		1	2	1	3														1		
CHEN NITR																					
CHEN PUMI												1									
EINA HAST		1																			
EINA NUTA				1							1		1	2		2					
ENCH TOME TOME								1	1												
MAIR DECA																					
MAIR ENCH								1	3		2	2	3			2	3	2			
MAIR HUMI									1				2								
MAIR MICR								1	1		3	1				1	1				
MAIR PENTAG																					
MAIR SP.																					
RHAG SPIN																	2				
SALS KALI KALI									3									1			
SCLEROB ATRI																					
SCLEROL BIRC									1			2									2

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Bot. name code	Transects 95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
SCLEROL DIAC																					
SCLEROL MURI SEMI																					
SCLEROL SP.																					
SCLEROL STEL									1												
Clusiaceae																					
HYPE GRAM																					
*HYPE PERF																					
Convolvulaceae																					
CONVO ERUB										3								1			
DICHON MICR					1			1													
DICHON REPE														1				1			
Crassulaceae																					
CRASS COLO ACUM																					
CRASS DECU																					
CRASS PEDU																					
CRASS SIEB		1	2		2				3									1			
Cucurbitaceae																					
*CITRUL LANA																					1
Droseraceae																					
DROS PELT																					
Elatinaceae																					
ELATI GRAT																					
Euphorbiaceae																					
CHAMAESY DRUM										1		1						1			
Fabaceae Caesalpinioideae																					
SENN ARTE FILI																					
SENN ARTE ZYGO												1									
Fabaceae Faboideae																					
GLYCI CANE										3											
GLYCI CLAN														1							
GLYCI SP.																					
GLYCI TABA				1	3											1					
GLYCY ACAN																					
HARD VIOL																					
INDI AUST						1									1						

Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
*MEDICA MINI																					
*MEDICA POLY																					
*MEDICA SATI													1								
*MEDICA TRUN																					
PULT LARG																					
PULT LAXI																					
*TRIF ANGU								1	3	2		3		3		1		3			
*TRIF ARVE			1	1					2	1											
*TRIF CAMP																					1
*TRIF DUBI				1						1											
*TRIF GLOM		3			3					3		2						2			
*TRIF SUBT																					
*TRIF TOME		3			1																
Fabaceae Mimosoideae																					
ACAC AMBL															2						
ACAC DEAN DEAN										1			3	3		3	2				
ACAC DECO																					
ACAC DIFF													2		1		1				
ACAC DORA		2	2			2									1		2				
ACAC HOMA																					
ACAC OSWA																					
ACAC PEND																					
ACAC STEN																					
Fumariaceae																					
*FUMA SP.																					
Gentianaceae																					
*CENTAURI ERYT									1	1								3			
CENTAURI SPIC																					
*CENTAURI TENU																					
*CICEN QUAD																					
Geraniaceae																					
EROD CICU																					
EROD CRIN																					
GERA RETR																					
Goodeniaceae																					
GOODE CYCL																					
GOODE FASC																					

Bot. name code	Transects 95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
GOODE HEDE	3												2		3		2				
GOODE PINN											1										
Haloragaceae																					
GONO ELAT	3	3				3									3						
GONO TETR			1																		
HALO ASPE																					
HALO GLAU																					
HALO HETE																					
MYRIOP CRIS																					
MYRIOP GLOM																					2
MYRIOP SP.																				1	
MYRIOP VARI																					
MYRIOP VERR																					
Lamiaceae																					
AJUG AUST					1																
*MARR VULG														1							
MENT SATU																					
*SALV VERB										3				1				2			
TEUC RACE																					
Lobeliaceae																					
ISOT AXIL																					
PRAT CONC																			1		2
Loranthaceae																					
AMYE MIQU																					
AMYE QUAN QUAN																					
Lythraceae																					
LYTH HYSS							3														
Malvaceae																					
LAVAT PLEB																					
*MALVA PARV																					
*MODI CARO														1							
SIDA AFCO																					
SIDA AMMO																					
SIDA CORR								3	3	2	2	3				3	3	3			
SIDA CUNN					2											2					
SIDA FILI																					
SIDA TRIC																					

Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
Moraceae																					
*FICU CARI TUBR																					
Myoporaceae																					
EREMOP DESE												2									
EREMOP MITC																					
MYOP MONT													2	1							
MYOP PLAT PLAT														1							
Myrtaceae																					
CALYT TETR																					
EUCA CAMA																					2
EUCA CLAD																					
EUCA CONI																					
EUCA DWYE	2	3	2	3		3							3		3						
EUCA LARG																					
EUCA MELL																					
EUCA MICROC							1	1	1		2										
EUCA POPU BIMB										2				1		3					
EUCA SIDEROX											1		1		1		2				
EUCA VIRI																					
Nyctaginaceae																					
BOER DOMI								1									1	2			
Onagraceae																					
EPIL BILL CINE																					
LUDW PEPL MONT																					
*OENO AFFI																					
Oxalidaceae																					
OXAL PERE		2	2	1		1				1	1				1						
Pittosporaceae																					
PITT PHYL				2																	
Plantaginaceae																					
PLANT CUNN					2																
PLANT TURR																					
Polygonaceae																					
MUEH FLOR																			1	1	
PERSI DECI																					

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Bot. name code	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
*POLYGO AVIC										1											
RUME BROW		1			1				1		1			2			1	1			2
*RUME CRIS							3	1													
RUME CRYS																			2		1
RUME TENA																					
Portulacaceae																					
CALAND CALY																					
CALAND EREM																					
Proteaceae																					
GREV FLOR																					
HAKE TEPH																					
Ranunculaceae																					
RANU SESS SESS																					
Rosaceae																					
APHANE AUST			1																		
Rubiaceae																					
ASPE CONF																					
ASPE CUNN																					
*GALIU APAR			1																		
GALIU GAUD		2			2	2															
Rutaceae																					
GEIJ PARV								1		1	1					1					
Sapindaceae																					
ALEC OLEI ELON																					
DODO HETE															1						
DODO PEDU																					
DODO VISC CUNE																3	1				
Scrophulariaceae																					
GLOSSOS DIAN																					
GLOSSOS ELAT																					
GRAT PUMI																					
LIMOS CURD																					
*OROB MINO																					
*VERBA VIRG																					

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Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
Solanaceae																					
*LYCI FERO																					
SOLA CINE																					
SOLA ESUR													1				1				
*SOLA NIGR									1	1											3
Stackhousiaceae																					
STACK MONO																					
Sterculiaceae																					
BRACHYCH POPU TRIL					2									3		3					
Thymelaeaceae																					
PIME LINI LINI	3					2									2						
Urticaceae																					
PARI DEBI																					
*URTI UREN																					2
Verbenaceae																					
*PHYLA NODI																					3
*VERBE BONA																					
*VERBE OFFI																					
Violaceae																					
HYBA MONO																					
4. Monocotyledons																					
Alismataceae																					
DAMA MINU																			2		
Amaryllidaceae																					
CALOS PURP																					
Anthericaceae																					
ARTHROPO MILL		2				3										1					
ARTHROPO MINU			2	1	1																
DICHOP FIMB																					
THYS PATE																					
TRICO ELAT																		2			
Asphodelaceae																					
BULBINE BULB																					2

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Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
BULBINE SEMI		2	1		1																
Colchicaceae																					
WURM DIOI																					
Cyperaceae																					
CARE APPR																					
CARE BICH																					
CARE INVE									1												2
CYPE BIFA																					
CYPE DIFF																					1
*CYPE ERAG																					
CYPE EXAL								1													
CYPE FULV																					
CYPE GUNN																					
CYPE GYMN																					
CYPE SP.																					
ELEO PALL																			1		
ELEO PLAN							3												2	1	3
ELEO SP.																					
FIMB DICH									1												
ISOL CONG																					
ISOL SP.																					2
SCHOENU APOG																					
Hydrocharitaceae																					
OTTE OVAL																					
VALL GIGA																					
Juncaceae																					
JUNC ARID																					
*JUNC BUFO																			2		1
JUNC FLAV							3			2									3		2
JUNC HOMA																					
JUNC RADU																					
JUNC SP.																					
JUNC USIT																					
Juncaginaceae																					
TRIGL PROC																					
Lemnaceae																					
LEMN DISP																				1	1

Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
Lomandraceae																					
LOMAN BRAC											2										
Orchidaceae																					
MICROT UNIF																					
PRAS ODOR																					
PTEROS MUTI																					
PTEROS SP.																					
THELY SP.																					
Phormiaceae																					
DIANE LONG LONG																					
STYPA GLAU																					
Poaceae																					
AGROSTI AVEN																			3		1
*AIRA ELEG						3															
AMPHIB MACR							3												3	2	2
ARISTI BEHR										1			1		1	1	2	3			
ARISTI JERI SUBS																					
ARISTI RAMO SPEC	2														2		1	1			
*AVEN FATU								3	1	3		1	3			3					1
BOTH DECI								1													
*BRIZ MINO																					
*BROM AREN					1																
*BROM CATH																2					
*BROM DIAN		1	3		2	1		2	1	2		1				1					
*BROM MADR																					
*BROM MOLL		1							1	1		3						2			2
*BROM RACE																					
*BROM RUBE				3	1																
*BROM SP.													2								
CHLORI SP.												2									
CHLORI TRUN				1					2	2		3						3			1
CYNOD DACT							2											1	2	3	2
DANT AURI					3	1			3	2	3			1		2					
DANT CAES					1	1		3	3	1		1	3		3	1	3				
DANT DUTT																					
DANT ERIA	3		1										3					1			
DANT LINK FULV													3		2		2				

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Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
DANT SETA											3						3				
DANT SP.																					
DICHA SERI																					
DICHE MICR					1	2		1													
DIGITAR BROW																					
DIGITAR DIFF	1																				
DIGITAR DIVA										1							2				
DIGITAR HYST																	1				
DIPLAC FUSC																				2	
DIPLAC PARV																					
ELYM SCAB		1								2	1			1		2		2			
ENNE NIGR														2							
ENTE ACIC					1			3	3	3	1	3				1	2	3			
ERAG AUST																					
ERAG BROW																					1
ERAG LACU									1								2				1
ERAG PARV										1		2						2			2
ERIOCHL PSEU																					2
EULA AURE																					
HOMOP PROL																					
*HORD GLAU																					
*HORD HYST																					
*HORD LEPO																					2
*HORD MARI			1		2							3		1					2		3
*LAMA AURE		2	2	3																	
*LOLI PERE							1	3	2	1	2	3	2		3	1					1
MICROL STIP				1																	
PANI DECO								1													1
PANI EFFU										2	2	3				1	2	1			
*PANI GILV																					
PANI QUEE QUEE																					
PANI SUBX				2																	
*PARAPH INCU																					
PASPALI CONS								2		3	2	2		2							
PASPALI JUBI																					
PASPALI SP.																					
*PASPALU DILA								2													
PASPALU DIST							1														
PENTASC AIRO																					

Bot. name code	Transects																				
	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
*PHALA PARA							3														
PHRA AUST																					
POA SIEB HIRT																					
PSEUDORA SPIN																					
*ROSTR CRIS			1																		
*SORG HALE																					
SPOROB CARO																					
SPOROB CREB																					
SPOROB MITC																			1		
STIP ARIS										1				3		2					
STIP BLAC																					
STIP DENS	1		1	2									1		3						
STIP ELEG																					
STIP PLAT																					
STIP SCAB FALC		2								3	2	3						2			3
STIP SCAB SCAB	3	2	2	2	3			2	3		3		3				3				
STIP SETA																					
STIP TUCK																2					
THEM AUST																					
THYR MITC															1						
TRIPO LOLI																					
*VULP MURA																					
*VULP SP.		3	3			3			3		1	3				1		3			1
Potamogetonaceae																					
POTA TRIC																					
Typhaceae																					
TYPHA ORIE																					
5. Bryophytes																					
Ricciaceae																					
RICCIO NATA																					

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APPENDIX 2 - Part I: species presence in Spot locations 1A–1Z, 2A–2U

(For full species names see Table 2)

Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
1. Pteridophytes																																															
Azollaceae																																															
AZOL FILI RUBR																																															
Marsileaceae																																															
MARSI ANGU																																															
MARSI DRUM																											X																				
MARSI HIRS																																															
PILU NOVA																																															
Ophioglossaceae																																															
OPHIOG LUSI CORI																																					X										
Sinopteridaceae																																															
CHEILA AUST																																															
CHEILA DIST																																															
CHEILA SIEB																																															
2. Gymnosperms																																															
Cupressaceae																																															
CALLIT ENDL																																															
CALLIT GLAU	X	X	X				X	X	X		X		X	X	X	X	X	X	X	X	X			X	X	X			X			X			X									X			X
3. Dicotyledons																																															
Acanthaceae																																															
BRUNONIE AUST																																															
Amaranthaceae																																															
ALTE DENT																																															
ALTE SP.A				X																							X										X	X									
PTILOTU SEMI																																															
PTILOTU SPAT																																															
Apiaceae																																															
DAUC GLOC					X																																										
HYDROC LAXI																																															

Bot. name code	Spot locations																																														
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
HYDROC SP.				X																																											
TRACHYM ORNA																																															
Apocynaceae																																															
PARS EUCA											X				X																																
Asteraceae																																															
ACTINOB ULIG																																															
*ARCTOTH CALE	X	X	X		X						X																	X	X				X					X					X				
*ASTER SUBU																																															
BRACHYCO CILI SUBI																																															
BRACHYCO HETE																																															
BRACHYCO LINE																																															
BRACT BRAC											X																		X																		
BRACT VISC																																															
CALOCEP SOND																																						X									
CALOTI ANTH																																															
CALOTI CUNEI											X																	X										X									
CALOTI HISP																																						X				X	X				
CALOTI LAPP					X																								X																		
CALOTI SCAB INTE																																															
CALOTI SCAB SCAB																																															
CALOTI SCAP																																															
*CARDU TENU																																															
*CART LANA			X								X																																				
CASSINI LAEV																												X																			
*CENTAURE MELI																																															
CENTIP CUNN																																															
CENTIP MINI																																															
*CHONDR JUNC																																															
CHRYSOCE APIC																																															
CHRYSOCE SEMI																																															
*CIRS VULG																																															
*CONY BONA																																															
COTU AUST				X																																											
ECLI PLAT																																															
GNAP SPHA																																															
*HEDYP RHAG CRET																																															
HYAL SEMI																																															
*HYPOCH GLAB				X																																											

Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
ISOETO GRAM																																															
*LACT SERR																																															
LEPTOR PANA																						X																									
MILLO MYOS																																															
MINU LEPT																																															
*PSEUDOGN LUTE																																															
PYCNOSO CHRY																																															
RHODAN CORY																																						X									
RHODAN FLOR																																															
RHODAN PYGM																																															
SIGE AUST																																															
*SOLIV ANTH																																															
*SOLIV STOL																																						X									
*SONC ASPE																																															
*SONC OLER																													X																		
STUA MUEL																																															
TRIPT PYGM																																															
VITT CUNE CUNE																																															
VITT CUNE HIRS																																						X									
VITT GRAC																																						X									
*XANTHI OCCI																																															
*XANTHI SPIN																																															
Bignoniaceae																																															
PANDO PAND (NAR																																															
Boraginaceae																																															
*ECHIU PLAN	X	X	X		X						X																		X			X						X			X						
HELIO EURO																																															
Brassicaceae																																															
*CAPSE BURS																																															
LEPIDI PAPI																																															
LEPIDI PSEU	X		X																										X			X						X									
*SISYM IRIO																																															
*SISYM ORIE																																															
Campanulaceae																																															
WAHL COMM											X																		X																		
WAHL FLUM																																															
WAHL GRAC				X	X																																										

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[redacted]

Bot. name code	Spot locations																																														
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
WAHL STRI ALTE																																														
Capparaceae																																														
APOP ANOM									X																																		X		
Caryophyllaceae																																														
GYPS AUST																																														
*PETROR NANT																																														
*PETROR VELU				X																																									
*POLYC TETR																																														
*SILE GALL QUIN																																														
*SILE NOCT																																														
*SPERG RUBR			X																																										
STEL FILI																																														
Casuarinaceae																																														
ALLO LUEH		X	X				X		X	X						X	X	X		X						X				X					X	X	X				X			
ALLO VERT										X																																			
CASU CRIS																																									X			X		
CASU CUNN																																														
Chenopodiaceae																																														
ATRI SPIN		X																								X	X								X								
*CHEN AMBR																																														
CHEN DESE MICR																																														
CHEN MELA																																														
CHEN NITR																																														
CHEN PUMI																																														
EINA HAST																																														
EINA NUTA		X																									X								X								
ENCH TOME TOME																																														
MAIR DECA																																														
MAIR ENCH		X																																											
MAIR HUMI										X																										X								
MAIR MICR																																X				X								
MAIR PENTAG																																														
MAIR SP.																																														
RHAG SPIN																															X														
SALS KALI KALI																																					X								
SCLEROB ATRI																																														
SCLEROL BIRC		X		X																																X								

Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
SCLEROL DIAC																																															
SCLEROL MURI SEMI																																															
SCLEROL SP.																												X																			
SCLEROL STEL																																															
Clusiaceae																																															
HYPE GRAM																																															
*HYPE PERF																																															
Convolvulaceae																																															
CONVO ERUB																																															
DICHON MICR																																															
DICHON REPE																													X									X									
Crassulaceae																																															
CRASS COLO ACUM																																					X										
CRASS DECU				X																																	X										
CRASS PEDU				X																																											
CRASS SIEB																												X	X				X				X										
Cucurbitaceae																																															
*CITRUL LANA																																															
Droseraceae																																															
DROS PELT																																															
Elatinaceae																																															
ELATI GRAT																																															
Euphorbiaceae																																															
CHAMAESY DRUM																																															
Fabaceae Caesalpinioideae																																															
SENN ARTE FILI																										X																					
SENN ARTE ZYGO																																															
Fabaceae Faboideae																																															
GLYCI CANE																																															
GLYCI CLAN																																															
GLYCI SP.																																															
GLYCI TABA																																															
GLYCY ACAN																																															
HARD VIOL																																															
INDI AUST																																															

Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
*MEDICA MINI																																															
*MEDICA POLY	X		X																																												
*MEDICA SATI																																															
*MEDICA TRUN																																															
PULT LARG																																	X														
PULT LAXI																																															
*TRIF ANGU	X																																					X									
*TRIF ARVE	X				X																																						X				
*TRIF CAMP																																											X				
*TRIF DUBI					X																																										
*TRIF GLOM	X			X																							X																X				
*TRIF SUBT																																															
*TRIF TOME	X																										X																				
Fabaceae Mimosoideae																																															
ACAC AMBL																																															
ACAC DEAN DEAN											X	X								X									X		X		X		X												
ACAC DECO																													X																		
ACAC DIFF	X																									X		X					X														
ACAC DORA		X										X																																			
ACAC HOMA																																															
ACAC OSWA	X																																														
ACAC PEND																																		X					X	X	X	X					
ACAC STEN																																															
Fumariaceae																																															
*FUMA SP.																																															
Gentianaceae																																															
*CENTAURI ERYT																																															
CENTAURI SPIC																																															
*CENTAURI TENU																																															
*CICEN QUAD																																															
Geraniaceae																																															
EROD CICU					X																																										
EROD CRIN																													X														X				
GERA RETR																																															
Goodeniaceae																																															
GOODE CYCL																																															
GOODE FASC				X																																											

Bot. name code	Spot locations																									
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z
GOODE HEDE																										
GOODE PINN																										
Haloragaceae																										
GONO ELAT																										
GONO TETR																										
HALO ASPE																										
HALO GLAU																										
HALO HETE																										
MYRIOP CRIS																										
MYRIOP GLOM																										
MYRIOP SP.																										
MYRIOP VARI																										
MYRIOP VERR																										
Lamiaceae																										
AJUG AUST																										
*MARR VULG																										
MENT SATU																										
*SALV VERB							X				X															
TEUC RACE																										
Lobeliaceae																										
ISOT AXIL																										
PRAT CONC																										
Loranthaceae																										
AMYE MIQU																				X						
AMYE QUAN QUAN																										
Lythraceae																										
LYTH HYSS																										
Malvaceae																										
LAVAT PLEB																										
*MALVA PARV	X																									
*MODI CARO																										
SIDA AFCO																										
SIDA AMMO																										
SIDA CORR																										
SIDA CUNN																										
SIDA FILI																										
SIDA TRIC																										

Bot. name code	Spot locations																				
	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
GOODE HEDE							X														
GOODE PINN		X										X									
Haloragaceae																					
GONO ELAT																					
GONO TETR																					
HALO ASPE																					
HALO GLAU																					
HALO HETE																					
MYRIOP CRIS																					
MYRIOP GLOM																					
MYRIOP SP.																					
MYRIOP VARI																					
MYRIOP VERR																					
Lamiaceae																					
AJUG AUST																					
*MARR VULG																					
MENT SATU																					
*SALV VERB			X																		
TEUC RACE																					
Lobeliaceae																					
ISOT AXIL																					
PRAT CONC																					
Loranthaceae																					
AMYE MIQU								X													
AMYE QUAN QUAN																					
Lythraceae																					
LYTH HYSS						X															
Malvaceae																					
LAVAT PLEB																					
*MALVA PARV																					
*MODI CARO																					
SIDA AFCO																					
SIDA AMMO		X																			
SIDA CORR			X									X					X				
SIDA CUNN																					
SIDA FILI																					
SIDA TRIC																					

Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
Moraceae																																															
*FICU CARI TUBR																																															
Myoporaceae																																															
EREMOP DESE																									X	X																					
EREMOP MITC	X		X					X		X	X						X																									X			X		
MYOP MONT																																															
MYOP PLAT PLAT																																															
Myrtaceae																																															
CALYT TETR																																															
EUCA CAMA																																															
EUCA CLAD																																															
EUCA CONI																																															
EUCA DWYE					X							X			X									X									X											X			
EUCA LARG																																															
EUCA MELL													X						X																												
EUCA MICROC		X	X		X		X	X	X	X	X	X	X	X		X	X	X		X	X			X	X			X							X			X									
EUCA POPU BIMB		X	X				X				X		X	X		X					X				X				X						X							X				X	
EUCA SIDEROX									X			X		X										X									X										X	X			
EUCA VIRI																																															X
Nyctaginaceae																																															
BOER DOMI	X																																														
Onagraceae																																															
EPIL BILL CINE																																															
LUDW PEPL MONT																																															
*OENO AFFI																																															
Oxalidaceae																																															
OXAL PERE																													X			X															
Pittosporaceae																																															
PITT PHYL																									X	X																					
Plantaginaceae																																															
PLANT CUNN																																															
PLANT TURR																																															
Polygonaceae																																															
MUEH FLOR																																															
PERSI DECI																																															

Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
*POLYGO AVIC																																															
RUME BROW	X																										X																				
*RUME CRIS																																X															
RUME CRYS				X																																											
RUME TENA																																															
Portulacaceae																																															
CALAND CALY																																															
CALAND EREM																																															
Proteaceae																																															
GREV FLOR																																															
HAKE TEPH																														X								X									
Ranunculaceae																																															
RANU SESS SESS																																															
Rosaceae																																															
APHANE AUST																																															
Rubiaceae																																															
ASPE CONF																																															
ASPE CUNN																																															
*GALIU APAR																																															
GALIU GAUD																																															
Rutaceae																																															
GEIJ PARV										X	X														X	X			X			X								X		X			X		
Sapindaceae																																															
ALEC OLEI ELON	X									X																										X			X	X		X	X		X		
DODO HETE											X																																				
DODO PEDU																																															
DODO VISC CUNE											X			X		X									X																						
Scrophulariaceae																																															
GLOSSOS DIAN																																															
GLOSSOS ELAT																																															
GRAT PUMI																																															
LIMOS CURD				X																																											
*OROB MINO																																															
*VERBA VIRG																																															

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Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
Solanaceae																																															
*LYCI FERO																																															
SOLA CINE																																															
SOLA ESUR																																															
*SOLA NIGR																																															
Stackhousiaceae																																															
STACK MONO																																															
Sterculiaceae																																															
BRACHYCH POPU TRIL	X						X						X							X					X	X									X					X			X		X		
Thymelaeaceae																																															
PIME LINI LINI																																															
Urticaceae																																															
PARI DEBI																																															
*URTI UREN																							X																								
Verbenaceae																																															
*PHYLA NODI																																															
*VERBE BONA																																															
*VERBE OFFI																																															
Violaceae																																															
HYBA MONO																																															
4. Monocotyledons																																															
Alismataceae																																															
DAMA MINU																																															
Amaryllidaceae																																															
CALOS PURP																																															
Anthericaceae																																															
ARTHROPO MILL																																															
ARTHROPO MINU																																															
DICHOP FIMB																													X																		
THYS PATE																																															
TRICO ELAT																																															
Asphodelaceae																																															
BULBINE BULB					X						X																		X																		

Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
BULBINE SEMI				X																								X					X														
Colchicaceae																																															
WURM DIOI																													X																		
Cyperaceae																																															
CARE APPR																																															
CARE BICH																																															
CARE INVE																											X					X															
CYPE BIFA																																															
CYPE DIFF																																															
*CYPE ERAG																																															
CYPE EXAL																																															
CYPE FULV																																															
CYPE GUNN																																															
CYPE GYMN																																															
CYPE SP.																																															
ELEO PALL				X																																											
ELEO PLAN																																															
ELEO SP.																																															
FIMB DICH																																															
ISOL CONG																																															
ISOL SP.																																					X										
SCHOENU APOG																																															
Hydrocharitaceae																																															
OTTE OVAL																																															
VALL GIGA																																															
Juncaceae																																															
JUNC ARID				X																												X									X						
*JUNC BUFO																																					X										
JUNC FLAV																																															
JUNC HOMA																																															
JUNC RADU																																															
JUNC SP.																																															
JUNC USIT				X																							X						X					X									
Juncaginaceae																																															
TRIGL PROC																																															
Lemnaceae																																															
LEMN DISP																																															

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Bot. name code	Spot locations																																													
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
Lomandraceae																																															
LOMAN BRAC																																															
Orchidaceae																																															
MICROT UNIF																																															
PRAS ODOR																																															
PTEROS MUTI																																															
PTEROS SP.																																															
THELY SP.																																															
Phormiaceae																																															
DIANE LONG LONG																																															
STYPA GLAU																																															
Poaceae																																															
AGROSTI AVEN																																															
*AIRA ELEG																																					X										
AMPHIB MACR				X																							X																				
ARISTI BEHR																																															
ARISTI JERI SUBS																																															
ARISTI RAMO SPEC																																															
*AVEN FATU	X										X																		X																		
BOTH DECI																																															
*BRIZ MINO																																															
*BROM AREN																																															
*BROM CATH																																															
*BROM DIAN																																X															
*BROM MADR																													X																		
*BROM MOLL																																X						X									
*BROM RACE	X																																														
*BROM RUBE																																															
*BROM SP.																																															
CHLORI SP.																																															
CHLORI TRUN			X								X																					X						X					X				
CYNOD DACT																																X															
DANT AURI					X																												X										X				
DANT CAES											X																	X	X									X					X				
DANT DUTT																																															
DANT ERIA																																						X									
DANT LINK FULV																																															

Bot. name code	Spot locations																									
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z
DANT SETA																										
DANT SP.																										
DICHA SERI																										
DICHE MICR																										
DIGITAR BROW																										
DIGITAR DIFF																										
DIGITAR DIVA																										
DIGITAR HYST																										
DIPLAC FUSC																										
DIPLAC PARV																										
ELYM SCAB																										
ENNE NIGR																										
ENTE ACIC																										
ERAG AUST																										
ERAG BROW																										
ERAG LACU																										
ERAG PARV																										
ERIOCHL PSEU																										
EULA AURE																										
HOMOP PROL																										
*HORD GLAU																										
*HORD HYST																										
*HORD LEPO																										
*HORD MARI																										
*LAMA AURE				X																						
*LOLI PERE	X		X																							
MICROL STIP																										
PANI DECO																										
PANI EFFU																										
*PANI GILV																										
PANI QUEE QUEE																										
PANI SUBX																										
*PARAPH INCU																										
PASPALI CONS																										
PASPALI JUBI																										
PASPALI SP.																										
*PASPALU DILA																										
PASPALU DIST																										
PENTASC AIRO																										

Bot. name code	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
DANT SETA																					
DANT SP.							X														
DICHA SERI																					
DICHE MICR																					
DIGITAR BROW																					
DIGITAR DIFF																					
DIGITAR DIVA																					
DIGITAR HYST																					
DIPLAC FUSC	X																				
DIPLAC PARV																					
ELYM SCAB			X																		
ENNE NIGR																	X				
ENTE ACIC		X	X			X	X														
ERAG AUST																					
ERAG BROW																					
ERAG LACU		X																			
ERAG PARV																					
ERIOCHL PSEU																					
EULA AURE																					
HOMOP PROL																					
*HORD GLAU																					
*HORD HYST																					
*HORD LEPO												X									
*HORD MARI																					
*LAMA AURE																					
*LOLI PERE		X	X			X	X					X			X						
MICROL STIP																					
PANI DECO																					
PANI EFFU																					
*PANI GILV																					
PANI QUEE QUEE																					
PANI SUBX		X																			
*PARAPH INCU																					
PASPALI CONS																					
PASPALI JUBI																					
PASPALI SP.																					
*PASPALU DILA																					
PASPALU DIST																					
PENTASC AIRO																					

Bot. name code	Spot locations																									
	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q	1R	1S	1T	1U	1V	1W	1X	1Y	1Z
*PHALA PARA																										
PHRA AUST																										
POA SIEB HIRT																										
PSEUDORA SPIN																										
*ROSTR CRIS																										
*SORG HALE																										
SPOROB CARO																										
SPOROB CREB																										
SPOROB MITC																										
STIP ARIS											X															
STIP BLAC																										
STIP DENS					X																					
STIP ELEG																										
STIP PLAT																										
STIP SCAB FALC	X	X	X		X																					
STIP SCAB SCAB			X								X															
STIP SETA																										
STIP TUCK																										
THEM AUST																										
THYR MITC																										
TRIPO LOLI																										
*VULP MURA	X																									
*VULP SP.																										
Potamogetonaceae																										
POTA TRIC																										
Typhaceae																										
TYPHA ORIE																										
5. Bryophytes																										
Ricciaceae																										
RICCIO NATA																										

Bot. name code	Spot locations																				
	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L	2M	2N	2O	2P	2Q	2R	2S	2T	2U
*PHALA PARA																					
PHRA AUST																					
POA SIEB HIRT																					
PSEUDORA SPIN																					
*ROSTR CRIS																					
*SORG HALE																					
SPOROB CARO																					
SPOROB CREB																					
SPOROB MITC																					
STIP ARIS			X		X																
STIP BLAC																					
STIP DENS																					
STIP ELEG																					
STIP PLAT																					
STIP SCAB FALC		X	X									X			X		X				
STIP SCAB SCAB							X														
STIP SETA																					
STIP TUCK																					
THEM AUST																					
THYR MITC																					
TRIPO LOLI																					
*VULP MURA																					
*VULP SP.												X					X				
Potamogetonaceae																					
POTA TRIC																					
Typhaceae																					
TYPHA ORIE																					
5. Bryophytes																					
Ricciaceae																					
RICCIO NATA																					

APPENDIX 2 - Part II: species presence in Spot locations 2V–2Z, 2A–3Z, 4A–4P

(For full species names see Table 2)

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
1. Pteridophytes																																															
Azollaceae																																															
AZOL FILI RUBR																																															
Marsileaceae																																															
MARSI ANGU																																															
MARSI DRUM																																															
MARSI HIRS																																															
PILU NOVA																																															
Ophioglossaceae																																															
OPHIOG LUSI CORI																																															
Sinopteridaceae																																															
CHEILA AUST																																															
CHEILA DIST																																															
CHEILA SIEB																																															
2. Gymnosperms																																															
Cupressaceae																																															
CALLIT ENDL																																													X		X
CALLIT GLAU		X	X	X		X	X	X	X		X	X				X		X				X	X							X					X										X		X
3. Dicotyledons																																															
Acanthaceae																																															
BRUNONIE AUST																																															
Amaranthaceae																																															
ALTE DENT																																															
ALTE SP.A																																															
PTILOTU SEMI																																															
PTILOTU SPAT																																														X	
Apiaceae																																															
DAUC GLOC										X																																					
HYDROC LAXI																																													X		

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
HYDROC SP.																																															
TRACHYM ORNA																																															
Apocynaceae																																															
PARS EUCA			X	X																																											
Asteraceae																																															
ACTINOB ULIG																																															
*ARCTOTH CALE														X		X																															
*ASTER SUBU																																															
BRACHYCO CILI SUBI																																															
BRACHYCO HETE																																															
BRACHYCO LINE																																															
BRACT BRAC																																															
BRACT VISC							X	X																																							
CALOCEP SOND																																															
CALOTI ANTH																																															
CALOTI CUNEI										X																																					
CALOTI HISP																																															
CALOTI LAPP																																															
CALOTI SCAB INTE																																															
CALOTI SCAB SCAB																																															
CALOTI SCAP																																															
*CARDU TENU																																															
*CART LANA																																															
CASSINI LAEV								X																																							X
*CENTAURE MELI																																															
CENTIP CUNN																																															
CENTIP MINI																																															
*CHONDR JUNC																																															
CHRYSOCE APIC							X	X																																							
CHRYSOCE SEMI																																															
*CIRS VULG																																															
*CONY BONA																																															
COTU AUST																																															
ECLI PLAT																																															
GNAP SPHA																																															
*HEDYP RHAG CRET																																															
HYAL SEMI																																															
*HYPOCH GLAB												X																																			

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
ISOETO GRAM																																															
*LACT SERR																																															
LEPTOR PANA																																															
MILLO MYOS																																															
MINU LEPT																																															
*PSEUDOGN LUTE																																															
PYCNOSO CHRY																																															
RHODAN CORY										X																																					
RHODAN FLOR																																															
RHODAN PYGM																																															
SIGE AUST																																															
*SOLIV ANTH																																															
*SOLIV STOL																																															
*SONC ASPE																																															
*SONC OLER																																															
STUA MUEL																																															
TRIPT PYGM										X																																					
VITT CUNE CUNE																																															
VITT CUNE HIRS											X																																				
VITT GRAC												X																																			
*XANTHI OCCI																																															
*XANTHI SPIN																																															
Bignoniaceae																																															
PANDO PAND (NAR																																															
Boraginaceae																																															
*ECHIU PLAN											X		X	X																																	
HELIO EURO																																															
Brassicaceae																																															
*CAPSE BURS																																															
LEPIDI PAPI																																															
LEPIDI PSEU																																															
*SISYM IRIO																																															
*SISYM ORIE																																															
Campanulaceae																																															
WAHL COMM										X																																					
WAHL FLUM																																															
WAHL GRAC																		X																													

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Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
WAHL STRI ALTE																																															
Capparaceae																																															
APOP ANOM																																		X													
Caryophyllaceae																																															
GYPS AUST																																															
*PETROR NANT																																															
*PETROR VELU																																															
*POLYC TETR																																															
*SILE GALL QUIN																																															
*SILE NOCT																																															
*SPERG RUBR										X																																					
STEL FILI																																															
Casuarinaceae																																															
ALLO LUEH							X	X	X	X		X		X		X											X		X									X									
ALLO VERT																																															
CASU CRIS																																	X				X		X				X				
CASU CUNN																										X																					
Chenopodiaceae																																															
ATRI SPIN																																															
*CHEN AMBR																																															
CHEN DESE MICR																																															
CHEN MELA																																															
CHEN NITR																																															
CHEN PUMI																																															
EINA HAST																																															
EINA NUTA										X																																					
ENCH TOME TOME																																															
MAIR DECA																																															
MAIR ENCH																																															
MAIR HUMI																																															
MAIR MICR																		X																													
MAIR PENTAG																																															
MAIR SP.																																															
RHAG SPIN																																															
SALS KALI KALI										X																																					
SCLEROB ATRI																																															
SCLEROL BIRC											X																																				

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
SCLEROL DIAC										X																																					
SCLEROL MURI SEMI										X																																					
SCLEROL SP.																																															
SCLEROL STEL																																															
Clusiaceae																																															
HYPE GRAM																																															
*HYPE PERF																																															
Convolvulaceae																																															
CONVO ERUB																																															
DICHON MICR																																															
DICHON REPE										X																																					
Crassulaceae																																															
CRASS COLO ACUM																																															
CRASS DECU																																															
CRASS PEDU																																															
CRASS SIEB																																															
Cucurbitaceae																																															
*CITRUL LANA																																															
Droseraceae																																															
DROS PELT																																															
Elatinaceae																																															
ELATI GRAT																																															
Euphorbiaceae																																															
CHAMAESY DRUM																																															
Fabaceae Caesalpinioid																																															
SENN ARTE FILI										X																																					
SENN ARTE ZYGO																																															
Fabaceae Faboideae																																															
GLYCI CANE																																															
GLYCI CLAN																									X																						
GLYCI SP.																																															
GLYCI TABA																																															
GLYCY ACAN																																															
HARD VIOL																														X																	
INDI AUST																																															

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Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
*MEDICA MINI																																															
*MEDICA POLY											X																																				
*MEDICA SATI																																															
*MEDICA TRUN																																															
PULT LARG																																															
PULT LAXI																																															
*TRIF ANGU																																															
*TRIF ARVE												X																																			
*TRIF CAMP																																															
*TRIF DUBI																																															
*TRIF GLOM																																															
*TRIF SUBT																																															
*TRIF TOME																																															
Fabaceae Mimosoideae																																															
ACAC AMBL																																															
ACAC DEAN DEAN				X		X	X	X			X																																				
ACAC DECO			X																																												
ACAC DIFF			X		X																																										
ACAC DORA		X																																													X
ACAC HOMA																																															
ACAC OSWA																																															
ACAC PEND																															X										X	X					
ACAC STEN																																															
Fumariaceae																																															
*FUMA SP.																																															
Gentianaceae																																															
*CENTAURI ERYT																																															
CENTAURI SPIC																																															
*CENTAURI TENU																																															
*CICEN QUAD																																															
Geraniaceae																																															
EROD CICU																																															
EROD CRIN																																															
GERA RETR																																															
Goodeniaceae																																															
GOODE CYCL																																															
GOODE FASC																																															

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
GOODE HEDE										X								X																													
GOODE PINN																																															
Haloragaceae																																															
GONO ELAT																																															
GONO TETR																																															
HALO ASPE																																															
HALO GLAU																																															
HALO HETE																																															
MYRIOP CRIS																																															
MYRIOP GLOM																																															
MYRIOP SP.																																															
MYRIOP VARI																																															
MYRIOP VERR																																															
Lamiaceae																																															
AJUG AUST								X																						X																	
*MARR VULG																																															
MENT SATU																																															
*SALV VERB																																															
TEUC RACE																																															
Lobeliaceae																																															
ISOT AXIL																																															
PRAT CONC																																															
Loranthaceae																																															
AMYE MIQU																																															
AMYE QUAN QUAN																																															
Lythraceae																																															
LYTH HYSS													X																																		
Malvaceae																																															
LAVAT PLEB																																															
*MALVA PARV																																															
*MODI CARO																																															
SIDA AFCO																																															
SIDA AMMO																																															
SIDA CORR																																															
SIDA CUNN																																															
SIDA FILI										X																																					
SIDA TRIC																																															

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
Moraceae																																															
*FICU CARI TUBR																																															
Myoporaceae																																															
EREMOP DESE			X					X		X																																					
EREMOP MITC										X																										X											
MYOP MONT																																															
MYOP PLAT PLAT																																															
Myrtaceae																																															
CALYT TETR							X																																								
EUCA CAMA																			X																												
EUCA CLAD																																															
EUCA CONI																																															
EUCA DWYE	X	X			X																	X		X																							X
EUCA LARG																																															
EUCA MELL																																															
EUCA MICROC		X	X	X		X	X	X	X		X	X	X	X		X		X					X														X										
EUCA POPU BIMB				X																																					X						
EUCA SIDEROX	X	X		X																	X																										X
EUCA VIRI																																															
Nyctaginaceae																																															
BOER DOMI																																															
Onagraceae																																															
EPIL BILL CINE																																															
LUDW PEPL MONT																																															
*OENO AFFI																																															
Oxalidaceae																																															
OXAL PERE										X																																					
Pittosporaceae																																															
PITT PHYL														X																																	
Plantaginaceae																																															
PLANT CUNN																																															
PLANT TURR																																															
Polygonaceae																																															
MUEH FLOR																																															
PERSI DECI																																															

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
*POLYGO AVIC																																															
RUME BROW																																															
*RUME CRIS											X																																				
RUME CRYS																																															
RUME TENA																																															
Portulacaceae																																															
CALAND CALY																																															
CALAND EREM																																															
Proteaceae																																															
GREV FLOR																																															
HAKE TEPH																																			X												
Ranunculaceae																																															
RANU SESS SESS																																															
Rosaceae																																															
APHANE AUST																																															
Rubiaceae																																															
ASPE CONF																																															
ASPE CUNN																																															
*GALIU APAR																																															
GALIU GAUD																																															
Rutaceae																																															
GEIJ PARV											X																	X				X					X										
Sapindaceae																																															
ALEC OLEI ELON																		X			X								X				X		X		X			X		X					
DODO HETE																																															
DODO PEDU																																															
DODO VISC CUNE			X	X				X		X																																					
Scrophulariaceae																																															
GLOSSOS DIAN																																															
GLOSSOS ELAT																																															
GRAT PUMI																																															
LIMOS CURD																																															
*OROB MINO																																															
*VERBA VIRG																																															

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Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
Solanaceae																																															
*LYCI FERO																																															
SOLA CINE																									X																						
SOLA ESUR																																															
*SOLA NIGR																																															
Stackhousiaceae																																															
STACK MONO									X																																						
Sterculiaceae																																															
BRACHYCH POPU TRIL			X	X	X	X															X									X																	
Thymelaeaceae																																															
PIME LINI LINI																																															
Urticaceae																																															
PARI DEBI																																															
*URTI UREN																																															
Verbenaceae																																															
*PHYLA NODI																																															
*VERBE BONA																																															
*VERBE OFFI																																															
Violaceae																																															
HYBA MONO																																															
4. Monocotyledons																																															
Alismataceae																																															
DAMA MINU																																															
Amaryllidaceae																																															
CALOS PURP																																															
Anthericaceae																																															
ARTHROPO MILL																																															
ARTHROPO MINU																																															
DICHOP FIMB																																															
THYS PATE																																															
TRICO ELAT																																															
Asphodelaceae																																															
BULBINE BULB																																															

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Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
BULBINE SEMI																																															
Colchicaceae																																															
WURM DIOI																																															
Cyperaceae																																															
CARE APPR																																															
CARE BICH																																															
CARE INVE																																															
CYPE BIFA																																															
CYPE DIFF																																															
*CYPE ERAG																																															
CYPE EXAL																																															
CYPE FULV																																															
CYPE GUNN																																															
CYPE GYMN																																															
CYPE SP.																																															
ELEO PALL																																															
ELEO PLAN																																															
ELEO SP.																																															
FIMB DICH																																															
ISOL CONG																																															
ISOL SP.																																															
SCHOENU APOG																																															
Hydrocharitaceae																																															
OTTE OVAL																																															
VALL GIGA																																															
Juncaceae																																															
JUNC ARID													X			X																															
*JUNC BUFO																																															
JUNC FLAV																				X																											
JUNC HOMA																																															
JUNC RADU																																															
JUNC SP.													X																																		
JUNC USIT																				X																											
Juncaginaceae																																															
TRIGL PROC																																															
Lemnaceae																																															
LEMN DISP																																															

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
Lomandraceae																																															
LOMAN BRAC																																											X				
Orchidaceae																																															
MICROT UNIF																																															
PRAS ODOR																																															
PTEROS MUTI																																															
PTEROS SP.																																															
THELY SP.																																															
Phormiaceae																																															
DIANE LONG LONG										X																																					
STYPA GLAU																																															
Poaceae																																															
AGROSTI AVEN																																															
*AIRA ELEG																																															
AMPHIB MACR													X																																		
ARISTI BEHR																																															
ARISTI JERI SUBS																																															
ARISTI RAMO SPEC																																															
*AVEN FATU											X	X	X	X		X																															
BOTH DECI																																															
*BRIZ MINO																																															
*BROM AREN																																															
*BROM CATH																																															
*BROM DIAN											X																																				
*BROM MADR											X																																				
*BROM MOLL											X																																				
*BROM RACE																																															
*BROM RUBE																																															
*BROM SP.																																															
CHLORI SP.																																															
CHLORI TRUN																																															
CYNOD DACT																																															
DANT AURI																																															
DANT CAES										X					X					X																											
DANT DUTT																																															
DANT ERIA																																															
DANT LINK FULV																																															

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
DANT SETA																																															
DANT SP.																																															
DICHA SERI																																															
DICHE MICR																																													X		
DIGITAR BROW																																															
DIGITAR DIFF																																															
DIGITAR DIVA																																															
DIGITAR HYST																																															
DIPLAC FUSC																																															
DIPLAC PARV																																															
ELYM SCAB																																															
ENNE NIGR																																															
ENTE ACIC										X																																					
ERAG AUST																																															
ERAG BROW																																															
ERAG LACU																																															
ERAG PARV																																															
ERIOCHL PSEU																																															
EULA AURE																																															
HOMOP PROL																																															
*HORD GLAU																																															
*HORD HYST																																															
*HORD LEPO														X																																	
*HORD MARI																																															
*LAMA AURE																																															
*LOLI PERE													X	X		X																															
MICROL STIP																																															
PANI DECO																																															
PANI EFFU										X																																					
*PANI GILV																																															
PANI QUEE QUEE																																															
PANI SUBX																																															
*PARAPH INCU																																															
PASPALI CONS																																															
PASPALI JUBI																																															
PASPALI SP.																																															
*PASPALU DILA																																															
PASPALU DIST																																															
PENTASC AIRO																																															

Bot. name code	Spot locations																																													
	2V	2W	2X	2Y	2Z	3A	3B	3C	3D	3E	3F	3G	3H	3I	3J	3K	3L	3M	3N	3O	3P	3Q	3R	3S	3T	3U	3V	3W	3X	3Y	3Z	4A	4B	4C	4D	4E	4F	4G	4H	4I	4J	4K	4L	4M	4N	4O	4P
*PHALA PARA													X																																		
PHRA AUST																																															
POA SIEB HIRT										X																																					
PSEUDORA SPIN																																															
*ROSTR CRIS																																															
*SORG HALE																																															
SPOROB CARO																																															
SPOROB CREB																																															
SPOROB MITC																																															
STIP ARIS										X	X			X	X	X		X																													
STIP BLAC																																															
STIP DENS	X																								X																						
STIP ELEG																																															
STIP PLAT																																															
STIP SCAB FALC									X		X	X			X	X		X																													
STIP SCAB SCAB																																															
STIP SETA																																															
STIP TUCK																																															
THEM AUST																																															
THYR MITC																																															
TRIPO LOLI																																															
*VULP MURA																																															
*VULP SP.										X	X	X																																			
Potamogetonaceae																																															
POTA TRIC																																															
Typhaceae																																															
TYPHA ORIE																	X																														
5. Bryophytes																																															
Ricciaceae																																															
RICCIO NATA																																															

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APPENDIX 2 - Part III: species presence in Spot locations 4Q–4Z, 5A–5V
(For full species names see Table 2)

Bot. name code	Spot locations																														
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
1. Pteridophytes																																
Azollaceae																																
AZOL FILI RUBR																																
Marsileaceae																																
MARSI ANGU																																
MARSI DRUM																																
MARSI HIRS																																
PILU NOVA																																
Ophioglossaceae																																
OPHIOG LUSI CORI																																
Sinopteridaceae																																
CHEILA AUST																																
CHEILA DIST																																
CHEILA SIEB																																
2. Gymnosperms																																
Cupressaceae																																
CALLIT ENDL																																
CALLIT GLAU		X	X	X	X	X		X																			X	X			X	
3. Dicotyledons																																
Acanthaceae																																
BRUNONIE AUST																																
Amaranthaceae																																
ALTE DENT																																
ALTE SP.A												X			X																	
PTILOTU SEMI																																
PTILOTU SPAT																																
Apiaceae																																
DAUC GLOC																																
HYDROC LAXI																																

Bot. name code	Spot locations																															
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
HYDROC SP.																																
TRACHYM ORNA																																
Apocynaceae																																
PARS EUCA																										X						
Asteraceae																																
ACTINOB ULIG																																
*ARCTOTH CALE															X																	
*ASTER SUBU																																
BRACHYCO CILI SUBI																																
BRACHYCO HETE																																
BRACHYCO LINE																																
BRACT BRAC																																
BRACT VISC																																
CALOCEP SOND																																
CALOTI ANTH																																
CALOTI CUNEI																																
CALOTI HISP																																
CALOTI LAPP																									X							
CALOTI SCAB INTE														X																		
CALOTI SCAB SCAB																																
CALOTI SCAP														X																		
*CARDU TENU																																
*CART LANA																																
CASSINI LAEV																																
*CENTAURE MELI																																
CENTIP CUNN																																
CENTIP MINI																																
*CHONDR JUNC																																
CHRYSOCE APIC																									X							
CHRYSOCE SEMI																																
*CIRS VULG															X																	
*CONY BONA																																
COTU AUST																																
ECLI PLAT																																
GNAP SPHA												X			X																	
*HEDYP RHAG CRET																																
HYAL SEMI																																
*HYPOCH GLAB																																

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Bot. name code	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
ISOETO GRAM																																
*LACT SERR																																
LEPTOR PANA																																
MILLO MYOS																																
MINU LEPT																									X							
*PSEUDOGN LUTE																																
PYCNOSO CHRY																																
RHODAN CORY														X							X											
RHODAN FLOR																																
RHODAN PYGM																																
SIGE AUST																																
*SOLIV ANTH																																
*SOLIV STOL																																
*SONC ASPE																																
*SONC OLER															X																	
STUA MUEL																																
TRIPT PYGM																																
VITT CUNE CUNE																																
VITT CUNE HIRS																																
VITT GRAC																																
*XANTHI OCCI																																
*XANTHI SPIN															X																	
Bignoniaceae																																
PANDO PAND (NAR																																
Boraginaceae																																
*ECHIU PLAN															X																	
HELIO EURO																																
Brassicaceae																																
*CAPSE BURS															X																	
LEPIDI PAPI																																
LEPIDI PSEU																																
*SISYM IRIO															X																	
*SISYM ORIE																																
Campanulaceae																																
WAHL COMM																																
WAHL FLUM																																
WAHL GRAC																																

Bot. name code	Spot locations																														
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
WAHL STRI ALTE																																
Capparaceae																																
APOP ANOM																																
Caryophyllaceae																																
GYPS AUST																																
*PETROR NANT																																
*PETROR VELU																																
*POLYC TETR																																
*SILE GALL QUIN																																
*SILE NOCT																																
*SPERG RUBR																																
STEL FILI																																
Casuarinaceae																																
ALLO LUEH			X	X																												
ALLO VERT																																
CASU CRIS							X													X	X						X			X		
CASU CUNN																																
Chenopodiaceae																																
ATRI SPIN																																
*CHEN AMBR																																
CHEN DESE MICR																	X															
CHEN MELA																																
CHEN NITR																																
CHEN PUMI															X																	
EINA HAST																	X															
EINA NUTA																																
ENCH TOME TOME																																
MAIR DECA																					X											
MAIR ENCH																																
MAIR HUMI																																
MAIR MICR																	X															
MAIR PENTAG													X																			
MAIR SP.																																
RHAG SPIN																																
SALS KALI KALI																	X															
SCLEROB ATRI																																
SCLEROL BIRC																																

421

Bot. name code	Spot locations																														
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
SCLEROL DIAC																																
SCLEROL MURI SEMI																																
SCLEROL SP.																																
SCLEROL STEL																																
Clusiaceae																																
HYPE GRAM																																
*HYPE PERF																		X											X			
Convolvulaceae																																
CONVO ERUB																																
DICHON MICR																																
DICHON REPE																																
Crassulaceae																																
CRASS COLO ACUM																																
CRASS DECU																																
CRASS PEDU																																
CRASS SIEB																																
Cucurbitaceae																																
*CITRUL LANA																																
Droseraceae																																
DROS PELT																																
Elatinaceae																																
ELATI GRAT																																
Euphorbiaceae																																
CHAMAESY DRUM																																
Fabaceae Caesalpinioideae																																
SENN ARTE FILI																																
SENN ARTE ZYGO																									X							
Fabaceae Faboideae																																
GLYCI CANE																																
GLYCI CLAN																																
GLYCI SP.																																
GLYCI TABA																																
GLYCY ACAN																																
HARD VIOL																																
INDI AUST																																

422

Bot. name code	Spot locations																														
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
*MEDICA MINI																																
*MEDICA POLY																																
*MEDICA SATI																																
*MEDICA TRUN																																
PULT LARG																																
PULT LAXI					X																											
*TRIF ANGU																																
*TRIF ARVE																																
*TRIF CAMP																																
*TRIF DUBI																																
*TRIF GLOM																																
*TRIF SUBT																																
*TRIF TOME																																
Fabaceae Mimosoideae																																
ACAC AMBL																																
ACAC DEAN DEAN								X									X								X							
ACAC DECO																																
ACAC DIFF																																
ACAC DORA																																
ACAC HOMA																																
ACAC OSWA																					X											
ACAC PEND																				X												
ACAC STEN											X																					
Fumariaceae																																
*FUMA SP.																																
Gentianaceae																																
*CENTAURI ERYT																																
CENTAURI SPIC																																
*CENTAURI TENU																																
*CICEN QUAD																																
Geraniaceae																																
EROD CICU																																
EROD CRIN															X																	
GERA RETR																																
Goodeniaceae																																
GOODE CYCL																									X							
GOODE FASC																																

423

Bot. name code	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
GOODE HEDE																																
GOODE PINN																																
Haloragaceae																																
GONO ELAT																																
GONO TETR																																
HALO ASPE																																
HALO GLAU																																
HALO HETE																																
MYRIOP CRIS																																
MYRIOP GLOM																																
MYRIOP SP.																																
MYRIOP VARI																																
MYRIOP VERR																																
Lamiaceae																																
AJUG AUST																																
*MARR VULG																																
MENT SATU																																
*SALV VERB																																
TEUC RACE													X																			
Lobeliaceae																																
ISOT AXIL																																
PRAT CONC												X																				
Loranthaceae																																
AMYE MIQU																																
AMYE QUAN QUAN																																
Lythraceae																																
LYTH HYSS												X																				
Malvaceae																																
LAVAT PLEB															X																	
*MALVA PARV																																
*MODI CARO																																
SIDA AFCO													X																			
SIDA AMMO																																
SIDA CORR													X																			
SIDA CUNN																																
SIDA FILI																																
SIDA TRIC																																

424

Bot. name code	Spot locations																														
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
Moraceae																																
*FICU CARI TUBR	X																															
Myoporaceae																																
EREMOP DESE						X											X															
EREMOP MITC																																
MYOP MONT																																
MYOP PLAT PLAT																	X															
Myrtaceae																																
CALYT TETR																																
EUCA CAMA									X										X	X										X		
EUCA CLAD										X																						
EUCA CONI																																
EUCA DWYE																								X								
EUCA LARG																																
EUCA MELL																																
EUCA MICROC			X		X	X		X									X										X	X				
EUCA POPU BIMB			X				X								X													X		X	X	X
EUCA SIDEROX					X												X															
EUCA VIRI																																
Nyctaginaceae																																
BOER DOMI																																
Onagraceae																																
EPIL BILL CINE																																
LUDW PEPL MONT																																
*OENO AFFI																																
Oxalidaceae																																
OXAL PERE																																
Pittosporaceae																																
PITT PHYL																																
Plantaginaceae																																
PLANT CUNN																																
PLANT TURR																																
Polygonaceae																																
MUEH FLOR																																
PERSI DECI																																

425

Bot. name code	Spot locations																														
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
*POLYGO AVIC												X			X																	
RUME BROW																																
*RUME CRIS																																
RUME CRYS																																
RUME TENA																																
Portulacaceae																																
CALAND CALY																																
CALAND EREM																																
Proteaceae																																
GREV FLOR																																
HAKE TEPH																						X										
Ranunculaceae																																
RANU SESS SESS																																
Rosaceae																																
APHANE AUST																																
Rubiaceae																																
ASPE CONF																																
ASPE CUNN																																
*GALIU APAR																																
GALIU GAUD																																
Rutaceae																																
GEIJ PARV																	X															
Sapindaceae																																
ALEC OLEI ELON																X					X											
DODO HETE																																
DODO PEDU																									X							
DODO VISC CUNE								X																								
Scrophulariaceae																																
GLOSSOS DIAN																																
GLOSSOS ELAT																																
GRAT PUMI																																
LIMOS CURD																																
*OROB MINO																																
*VERBA VIRG																																

Bot. name code	Spot locations																														
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
Solanaceae																																
*LYCI FERO																																
SOLA CINE																																
SOLA ESUR																																
*SOLA NIGR															X																	
Stackhousiaceae																																
STACK MONO																																
Sterculiaceae																																
BRACHYCH POPU TRIL			X																						X							
Thymelaeaceae																																
PIME LINI LINI																																
Urticaceae																																
PARI DEBI																																
*URTI UREN															X																	
Verbenaceae																																
*PHYLA NODI									X																							
*VERBE BONA																																
*VERBE OFFI																																
Violaceae																																
HYBA MONO																																
4. Monocotyledons																																
Alismataceae																																
DAMA MINU																																
Amaryllidaceae																																
CALOS PURP																																
Anthericaceae																																
ARTHROPO MILL																																
ARTHROPO MINU																																
DICHOP FIMB																																
THYS PATE																																
TRICO ELAT																																
Asphodelaceae																																
BULBINE BULB																																

427

Bot. name code	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
BULBINE SEMI																																
Colchicaceae																																
WURM DIOI																																
Cyperaceae																																
CARE APPR																																
CARE BICH																																
CARE INVE																																
CYPE BIFA																																
CYPE DIFF												X																				
*CYPE ERAG																																
CYPE EXAL																																
CYPE FULV																																
CYPE GUNN																																
CYPE GYMN																																
CYPE SP.																																
ELEO PALL																																
ELEO PLAN												X																				
ELEO SP.																																
FIMB DICH																																
ISOL CONG																																
ISOL SP.																																
SCHOENU APOG																																
Hydrocharitaceae																																
OTTE OVAL																																
VALL GIGA												X																				
Juncaceae																																
JUNC ARID																																
*JUNC BUFO																																
JUNC FLAV																																
JUNC HOMA																																
JUNC RADU																																
JUNC SP.																																
JUNC USIT																																
Juncaginaceae																																
TRIGL PROC																																
Lemnaceae																																
LEMN DISP																																

428

Bot. name code	Spot locations																																													
	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V															
Lomandraceae																																															
LOMAN BRAC																																															
Orchidaceae																																															
MICROT UNIF																																															
PRAS ODOR																																															
PTEROS MUTI																																															
PTEROS SP.																																															
THELY SP.																																															
Phormiaceae																																															
DIANE LONG LONG																																															
STYPA GLAU																																															
Poaceae																																															
AGROSTI AVEN																																															
*AIRA ELEG																																															
AMPHIB MACR																																															
ARISTI BEHR																									X																						
ARISTI JERI SUBS																																															
ARISTI RAMO SPEC																																															
*AVEN FATU																																															
BOTH DECI																																															
*BRIZ MINO																																															
*BROM AREN																																															
*BROM CATH															X																																
*BROM DIAN																																															
*BROM MADR																																															
*BROM MOLL																																															
*BROM RACE																																															
*BROM RUBE																																															
*BROM SP.																																															
CHLORI SP.																																															
CHLORI TRUN																																															
CYNOD DACT												X																																			
DANT AURI																																															
DANT CAES																																															
DANT DUTT																																															
DANT ERIA																																															
DANT LINK FULV																																															

Bot. name code	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
DANT SETA																																
DANT SP.																																
DICHA SERI																																
DICHE MICR																																
DIGITAR BROW																																
DIGITAR DIFF																																
DIGITAR DIVA																																
DIGITAR HYST																																
DIPLAC FUSC																																
DIPLAC PARV																																
ELYM SCAB																																
ENNE NIGR																																
ENTE ACIC																																
ERAG AUST												X																				
ERAG BROW																																
ERAG LACU																																
ERAG PARV															X																	
ERIOCHL PSEU																																
EULA AURE																																
HOMOP PROL																																
*HORD GLAU																																
*HORD HYST																																
*HORD LEPO															X																	
*HORD MARI																																
*LAMA AURE																																
*LOLI PERE															X																	
MICROL STIP																																
PANI DECO																																
PANI EFFU																									X							
*PANI GILV																																
PANI QUEE QUEE																																
PANI SUBX																																
*PARAPH INCU																																
PASPALI CONS																																
PASPALI JUBI																																
PASPALI SP.																																
*PASPALU DILA																																
PASPALU DIST												X																				
PENTASC AIRO																																

Bot. name code	4Q	4R	4S	4T	4U	4V	4W	4X	4Y	4Z	5A	5B	5C	5D	5E	5F	5G	5H	5I	5J	5K	5L	5M	5N	5O	5P	5Q	5R	5S	5T	5U	5V
*PHALA PARA															X																	
PHRA AUST																																
POA SIEB HIRT																																
PSEUDORA SPIN																																
*ROSTR CRIS																																
*SORG HALE																																
SPOROB CARO																																
SPOROB CREB																																
SPOROB MITC																																
STIP ARIS																																
STIP BLAC																																
STIP DENS																																
STIP ELEG																																
STIP PLAT																																
STIP SCAB FALC													X																			
STIP SCAB SCAB																																
STIP SETA																																
STIP TUCK																																
THEM AUST																																
THYR MITC																																
TRIPO LOLI																																
*VULP MURA																																
*VULP SP.																																
Potamogetonaceae																																
POTA TRIC																																
Typhaceae																																
TYPHA ORIE												X											X									
5. Bryophytes																																
Ricciaceae																																
RICCIO NATA																																

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Appendix 3
Rehabilitation trials

Background

Establishing local native flora on the western slopes around Lake Cowal has not been widely practiced. There are few farms with established tree plantings. Consequently, the techniques for establishing local native trees and shrubs have not been optimised.

The experience from the Central Tablelands of:

- Chris Marshall formerly of Trees on Farms Program, Soil Conservation Service, Bathurst, now EPA, Bathurst (phone: 063-321-838)
- Jenny Thompson, Trees on Farms, Four Mile Creek (near Orange) (phone: 063-664-225, fax: 063-664-224)
- Anne Clements & Associates P/L, as consultant to Climax Mines (phone: 02-955-3362, fax: 02-957-4343)

from the Hay Plain and the irrigation areas near Deniliquin of:

- Martin Driver, formerly CSIRO Rangeland and Ecology Division, now Greening Australia (PO BOX 1010, Deniliquin 2710, phone 058-81-3429, Fax 058-81-1271
- Neil Druce (farmer, tree grower and wood turner), Kamarah (about 100 km SW of the site) (phone: 069-78-2358)
- John Lacy, District Agronomist, Finley (phone 058-83-1644)
- Ted Nichols, former Forestry extension Officer, Narrandera

indicates that species selection, soil preparation and weed control were the critical issue for success.

The agriculture experiences of the local farmers has on the Central Tableland proved invaluable in estimating planting times, soil conditions and soil preparation.

Trials at Lake Cowal

A 15 m wide trial site is being established on the fence line between Colin Carnegie's property "Cowal West" and Bill Buttenshaw's property "Laurel Park" on two soil types - gilgai soils and drier red soils. This area is being fenced to exclude stock.

Species selection

The use of local provenance plant species has resulted in best long-term survival and growth. This involves seed collections from the site and/or within a 20 km radius. Non local native species were found not to survive the climatic extremes, especially the cold winters and droughts (Climax Management Pty Limited 1995).

Commercial seed collections are cften from areas with more dependable seed availability. Despite being the same taxonomic species (and sometimes from similar climate), these commercially available seeds have not resulted in good survival of the tubestock. These have also been found to be less adaptable to rehabilitation sites (experience at ICI Newcastle).

Locally native plant species can be introduced to the area using four main techniques:

- tubestock planting
- direct seeding of collected seeds
- seed from nearby trees
- germination of seeds stored in the soil

For the Lake Cowal project, a seed collecting program was commenced in December 1994. Local farmers, Janelle Carnegie, Sue and Andrew Buttenshaw, Heather, Bill Buttenshaw and their teenage sons are collecting seed for the direct seeding trials. The seed collecting commenced in December 1994 and continued over the summer. Seed collecting was done in groups of at least two for reasons of safety and efficiency.

Due to the drought conditions, seed was in short supply. The available seeds tended to be species from the wetter soils (lakeshore and gilgai).

In January 1995, there was a lots of *Casuarina cristata* (Belah) seed. Heather Buttenshaw, Rob (Heather's son) and Janelle Carnegie collected 5 wool packs in 1.5 hours on one morning. They are continuing to monitor seed ripeness as they move around their farms.

On 15 May 1995, the seed available was:
Malcolm Carnegie (local farmer and tubestock grower)

- one *E. microcarpa* (Western Grey Box) tree loaded with seed
- about 3000 seed of *Brachychiton populneus* (Kurrajong)
- seed ready in spring of *Callitris glaucophylla* (White Cypress-pine).
- *Hakea* sp. - possibly enough to direct seed

Janelle Carnegie

- 18 kg (40 lb) with branches (2 wool packs) of *Casuarina cristata* (Belah)

Bill and Heather Buttenshaw
About 6-8 wool packs in total consisting of:

- *Acacia stenophylla* (River Cooba)
- *Casuarina cristata* (Belah)

and about 2 large coffee jars of pure *Eucalyptus camaldulensis* (River Red Gum)

Andrew and Sue Buttenshaw
About 2 wool packs of:

- *Casuarina cristata* (Belah)

Malcolm Carnegie has grown tubestock from seed collected in previous seasons and over the 1994/1995 summer. These are primarily from the districts wetter soil types. This resulted in the following species being available for planting in winter 1995:

. *Acacia stenophylla* (River Cooba)	420
. *Brachychiton populneus* (Kurrajong)	150
. *Callitris glaucophylla* (White Cypress-pine)	not yet germinated
. *Casuarina cristata* (Belah)	1500
. *Eucalyptus camaldulensis* (River Red Gum)	very small in May 95
. *Geijera parviflora* (Wilga)	not yet germinated
. *Acacia deanei* (Green Wattle, Deane's Wattle)	600
. *Acacia (?) deformis* small but healthy	385
. Ground cover	150

Specimens of the understorey species are being sent to us for identification.

A greater range of seed is likely to be available throughout the year. The seed collecting program is continuing. Collections of species from the better drained red soils such as *Allocasuarina leuhmannii* (Bull Oak), *Eucalyptus microcarpa* (Inland Grey Gum), *E. populnea* subsp. *bimbil* (Bimble or Poplar Box), *Acacia pendula* (Weeping Myall), *Alectryon oleifolius* (Rosewood) should be a priority for the initial trials and for the storage for rehabilitations during the mining operation.

Seeds of species from low ridges such as *E. sideroxylon* (Mugga Ironbark), *Acacia deanei, A. difformis* and *Callitris glaucophylla* (White Cypress-pine) and species restricted to upper ridges such as *E. dwyeri* (Dwyer's Red Gum) and *A. doratoxylon* (Currawang, Lancewood, Spearwood) should be collected for use on the bund walls and on the outer faces of overburden tailing emplacements.

Ripping depth

The soils, especially heavy clays present problems when ripping. At the time of ripping, the soil moisture content needs to be such that clays do not smear but shatter.

For tubestock planting, the tubes are 125 mm deep. To enhance root penetration, ripping would need to be greater than this depth.

Prior to clearing early this century and last century, these soils supported nitrogen fixing plants such as *Casuarina cristata* (Bulah) and *Acacia pendula* (Weeping Myall, Boree). The soils are likely to have been more biologically active than those of the cleared paddocks.

On red soils between Conargo and Carratholl (about 250 km SW of the study site), single tyne ripping to 200-300 mm led to root suckering in paddocks with *Casuarina cristata* (Bulah) and *Acacia pendula* (Weeping Myall, Boree). This was due to surface root damage. These two species tend to surface root (Martin

Driver, pers. comm., June 1995).

On the Tablelands and on the irrigation soils near Deniliquin, deep ripping to about 600 mm and roll back down to remove large air pockets was the best method on the heavy clay soils. The ripping added to the tilth of the soil, creating raised areas (bedding locations for the tubestock). Experience has shown that plant deaths were generally from waterlogging in the deep soils rather than death from lack of water.

Chris Marshall suggested planting 100 mm from the rip lines to reduce the risk of rooting being restricted to the rip lines or the tubestock dropping into air spaces in the rip lines.

Anna McMullen, North Parks Gold Mine, suggested scarifying the soil surface. This technique has not proved successful on the Central Tablelands as it tended to compact the soil.

John Lacy found that on heavy soils ripping 6-9 months in advance to at least 300 mm was ideal for tree planting in his district. Ripping earlier allowed the soil to weather and beecome friable. Ripping was best done when soils were on the drier side of moist as it resulted in greater shattering. In practice for community planting programs, ripping the soils one week before planting showed little difference from ripping 6-9 months in advance.

The advance ripping is consistent with the recommendation of Bill Buttenshaw of ripping 12 months in advance.

Paul Dan (Department of Agriculture at CSIRO Canberra) in a pasture study on heavy soils found on difference between rippping and not ripping (John Lacy, pers. comm., June 1995).

Stock exclusion

Tree losses in the area were initially due to clearing. The resultant low tree numbers have been maintained by stocking. Removal of stock is necessary to ensure initial establishment.

Seed stored in the soil may be brought to the surface or to a depth where germination may occur, through the use of ripping. It is possible that seed stored in the soil prior to clearing for agriculture may still be viable. In the Deniliquin area where there have been no adult trees in paddocks for at least 50 years (and probably 70-80 years), germination of *Acacia pendula* occurred. These trees established after 4 years of no grazing.

Weeds

Chemical knockdown applications such as "RoundUp" are commonly used to remove all vegetation around the plantings. Whether herbicide is required, needs to be assessed prior to planting. Weed growth generally tends to be highest on cleared land so use of herbicide may have distinct disadvantages.

At the Climax Mine site on the Central Tablelands, tubestock growth rates were reduce in areas where the exotic Perennial Rye Grass growth was dense. It may be necessary to reduce water competition from exotics around the tubestock plantings.

Factorial design of re-establishment trial

Factors

Stock exclusion is proposed for all plots.

Ripping depth at 4 levels:
. no ripping
. scarifying
. 300 mm depth
. as deep as possible (600 mm)

Delayed planting - 12 months after ripping
. 300 mm depth
. as deep as possible (600 mm)

Plantings

The smallest number of plant species available to test is 150 *Brachychition populneus*. Consequently, the maximum number of planting plots is 150 as each species tested needs to respresent at least once in each trial plot.

Seeding at 3 levels
. no seeding
. tubestock planting plus direct seeding
. direct seeding

Weed control may be important. This factor may need to be considered implying a large number of replicates in the design.

Cell types

Red soils with
No ripping
. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

Scarifying

. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

300 mm depth
. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

As deep as possible (600 mm)
. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

Gilgai soils with
No ripping
. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

Scarifying
. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

300 mm depth
. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

As deep as possible (600 mm)
. tubestocks
. direct seeding
. tubestocks and direct seeding
. no tubestocks nor direct seeding

There are 32 (2 x 4 x 4) cell types. The maximum replicate number is 4.

Timing

Soil preparation timing is fixed in this area to when it is physically possible to plough the soil. Dry soils would require a large dozer to rip them as they set like concrete.

Seed spreading

Seed addition will need to be made as seed becomes available.

Monitoring

The plots prior to treatment need to be assessed with all individuals present, being recorded. The heights and numbers of individuals of new recruitments and tubestock planting need to measured six monthly for each plot for the life of the mine.

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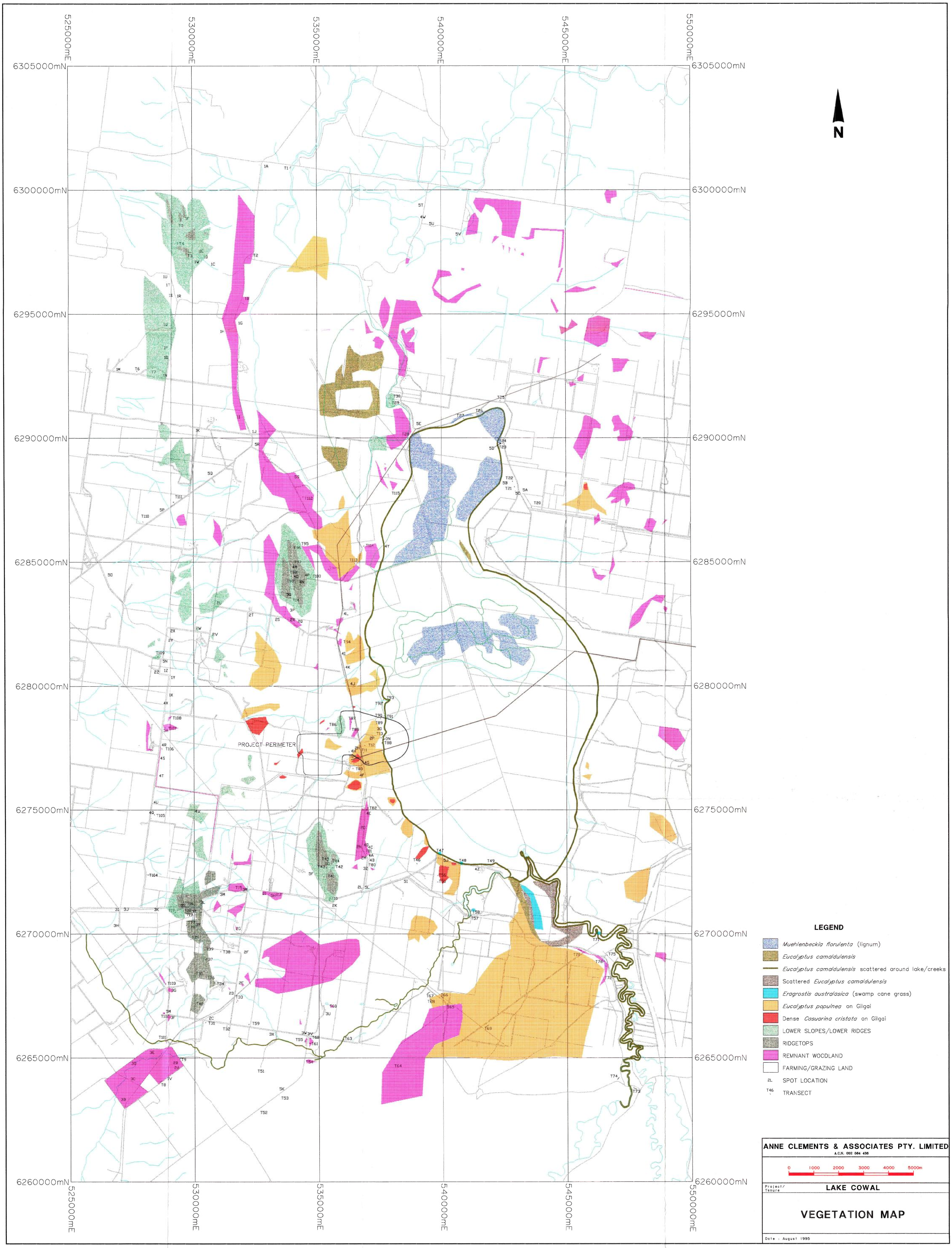
References

Climax Management Pty Limited (1995)
Junction Reefs Gold Project (ML 1189, 1242, 1243, MPL1159). Mining, rehabilitation and environmental management plan. prepared for the approval of the Minister of Mineral Resources. unpub. May 1995.



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PROJECT PERIMETER
LEGEND
Muehlenbeckia florulenta (lignum)
Eucalyptus camaldulensis
Eucalyptus camaldulensis scattered around lake/creeks
Scattered Eucalyptus camaldulensis
Eragrostis australasica (swamp cane grass)
Eucalyptus populnea on Gilgai
Dense Casuarina cristata on Gilgai
LOWER SLOPES/LOWER RIDGES
RIDGETOPS
REMNANT WOODLAND
FARMING/GRAZING LAND
2L SPOT LOCATION
T46 TRANSECT
ANNE CLEMENTS & ASSOCIATES PTY. LIMITED
A.C.N. 002 564 436
0 1000 2000 3000 4000 5000m
Project/ Tenure
LAKE COWAL
VEGETATION MAP
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