MOOLARBEN COAL PROJECT

Stage 2

APPENDIX 7

Ecological Impact Assessment

Ecological Impact Assessment

Stage 2 of the Moolarben Coal Project

Ulan, New South Wales

5 December 2008

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ECOVISION CONSULTING
PO BOX 650
CHARLESTOWN NSW 2290
TEL.FAX 02 4943 2876
MOBILE 0401 574 535
ECOLOGY@ECOVISION.NET.AU

Ecological Impact Assessment
Stage 2 of the Moolarben Coal Project
Murragamba Valley, Ulan

15 December 2008

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Ecovision Consulting
PO Box 650 Charlestown NSW 2290
TEL.FAX +61 (02) 4943 2876

ABN: 99 106 911 273

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DECLARATION

This Ecological Impact Assessment, comprising the combined works of Ecovision Consulting (Terrestrial Ecology) and Marine Pollution Research (Aquatic Ecology), has been prepared for the assessment of the Moolarben Coal Project – Stage 2 Murragamba Valley, Ulan. This independently prepared assessment is based on information acquired from extensive baseline seasonal studies and that supplied by Moolarben Coal Mines Pty Limited for this project.

Mark Aitkens – Ecovision Consulting

Mark Aitkens

Digitally signed by Mark Aitkens
DN: cn=Mark Aitkens, c=AU, o=Ecovision Consulting, email=mark@ecovision.net.au
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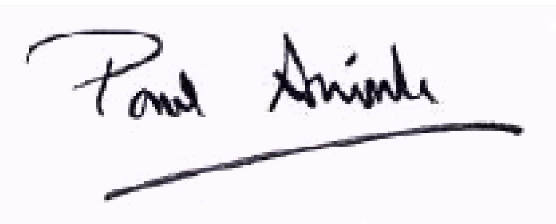

Paul Anink – Marine Pollution Research

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DEFINITIONS AND ABBREVIATIONS

Aquatic Biodiversity	Biodiversity that largely occupies aquatic environment including macroinvertebrates and fish.
DEWHA	Department of Environment, Water, Heritage and the Arts
DEC	Former name of DECC (Department of Environment and Conservation)
DECC	Department of Environment and Climate Change
Director General	Director General of the Department of Planning
Disturbed Vegetation	An area of heterogeneous floristics, being of either native and/or exotic composition, of unnatural origin
EIA	Ecological Impact Assessment
CEEC	Critically Endangered Ecological Community as defined by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*
Core habitat	Land containing resources capable of supporting both breeding and foraging activity.
EEC	Endangered Ecological Community as defined by the *NSW Threatened Species Conservation Act 1995* or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*
EP	Endangered Population as defined by the NSW *Threatened Species Conservation Act 1995* or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
GIS	Geographical Information System. Software enabling spatial database analysis.
Intact Vegetation	Refers to areas of native vegetation that are relatively continuous, relatively weed-free, contain natural habitat features, and which appear to function as a native ecological community. The term may be applied to areas of vegetation which have been previously disturbed and/or cleared, but have regenerated and recovered to the extent that natural functions have been restored, and the vegetation would be expected to progress unassisted towards a stable state.
Native Vegetation	An area consisting of structurally and floristically stable native plant assemblages (i.e. greater than 50% native plant cover).
NES	National Environmental Significance
Patch	An area of homogenous native vegetation cover, referred to as a vegetation formation or vegetation sub-formation, which may form part of a larger remnant.
Remnant	An area of continuous native vegetation cover that may contain more than one vegetation patch.
Secondary Grasslands and Shrublands	Vegetation containing a mix of natives and exotics with no linkage to an intact vegetation community described within the study area.
Secondary habitat	Land containing resources capable of supporting breeding or foraging activity but not both (refer to core habitat).
Stream health	Term used to describe the overall aquatic environment in terms of defined parameters such as the structure of aquatic macroinvertebrate assemblages, riparian and creek physical structure and cover, habitat complexity, water quantity (availability) and quality.
Study Area	Lands defined by a blue outer line on relevant figures.
Site	Land defined by the red outer line on relevant maps.
Subject species	Threatened species, populations, ecological communities and/or their habitats that are likely to be affected by the development.
Threatened Biodiversity	Threatened species, populations or communities listed as critically endangered, endangered or vulnerable within the meaning of the *NSW Threatened Species Conservation Act 1995* or the Commonwealth *Environment Protection & Biodiversity Conservation Act 1999*.
Terrestrial Biodiversity	Biodiversity that largely occupies terrestrial environment including amphibians, reptiles, mammals, avian and plants.

EXECUTIVE SUMMARY

This Ecological Impact Assessment (EIA) has been prepared in accordance with the requirements of the Director General for Planning to assess Stage 2 of the Moolarben Coal Project (MCP). The study area covers approximately 34 km^2 encompassing the Murragamba Valley and surrounding environs east of Ulan, NSW. This area is part of Exploration License 6288 (EL6288), which has an area of approximately 110km^2. The impact assessment has focused on the development's impact on terrestrial and aquatic biodiversity within the study area, particularly threatened species (i.e. vunerable, endangered, critically endangered), endangered populations (EPs), endangered ecological communities (EECs), critically endangered ecological communities (CEECs) and their habitats (collectively referred to as *threatened biodiversity*). Analysis has incorporated information sourced from a local (i.e. seasonal baseline studies for EL6288), regional and State level with the latter predominantly involving spatial datasets and literature.

The study area is located at the northern extremity of the Sydney Basin Bioregion, in a transitional zone between the western slopes of the Great Dividing Range and coastal NSW. It is located within the headwaters of the Hunter Central Rivers catchment management area (HCR CMA), more specifically in the Wilpinjong/Wollar Creek sub-catchment headwaters of the Goulburn River. The Great Divide is located some 10 km to the west. Low variable rainfall patterns typify the area, with an average of 610 mm per annum recorded at Ulan. The average annual evapotranspiration of the Ulan area is high, at about 1657mm, with the comparatively wide differential between rainfall and evapotranspiration indicating the area to be semi-arid (Worley Parsons 2008).

The geology of the study area's valleys and midslopes is typically characterised by the Permian geological formation, with Triassic geological formations dominating upper slopes, crests and plateaus. Isolated quaternary and tertiary deposits (i.e. sedimentary and basalt material) also exist, with carboniferous geological formations bordering the western extent of EL6288.

Biologically, the Ulan area is part of a broad inter-regional transition zone where many plants, animals and/or communities representative of the intergrading bordering regions. This is due in part to the study area's geographic position (i.e. near a low saddle in the Great Dividing Range (620 m elevation) – 'east meets west'; 'north meets south'), varied geological characteristics (i.e. Tertiary, Quaternary, Permian, Triassic, Jurassic and Carboniferous formations) and extreme climatic conditions. The result is a complexity of biodiversity values, with many species exhibiting distribution limits in the locality.

Objectives

The overall objective of this report is to quantify the terrestrial and aquatic biodiversity values of the study area, to assess the impacts of the proposed coal mine on this biodiversity and thus ascertain the extent of impact management required to achieve a 'Maintain and Improve' outcome within the context of the Director Generals Requirements (DGRs) issued by the Minister for Planning under Part 3A Major Projects of the *Environmental Planning and Assessment Act 1979* (EP&A Act). This involved a review, detailed field surveys, results interpretation and classification of the study area's terrestrial and aquatic biodiversity values against the local and regional biodiversity framework followed by impact analysis. To this extent a variety of government policies and guidelines were considered in meeting this objective, such as:

- Working Draft Guidelines 'Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities' (DEC 2004);
- State Groundwater Dependent Ecosystem policy guidelines (DLWC 2002);
- NSW DPI Guidelines for the assessment of aquatic habitat (NSW Fisheries 1999); and
- Management of stream/aquifer systems in coal mining developments; Hunter Region (DIPNR 2005).

Threatened biodiversity listings relevant to this assessment include those identified by the *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act) for State matters and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for Commonwealth matters.

Methods - Terrestrial

The results of desktop and field surveys, as guided by the DECC's working draft *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004), formed the basis for the consideration of the impact assessment. This initially involved a general characterisation of the study area using a variety of resources including literature, databases (i.e. DECC's Wildlife Atlas database, Birds Australia, National Herbarium) and spatial data (i.e. soil landscapes, geology, vegetation, land zoning). Stratification units were defined for the study area to strategically focus and maximise field survey effort.

Seasonal field surveys using standard, replicated sampling techniques were undertaken for both flora and fauna species. Random survey locations were used to augment the structured sampling regime to sample ecotones, areas of existing disturbance or future impacts from mining. Data interpretations involved both spatial and statistical analysis to classify and quantify biodiversity values primarily at a landscape scale. Impacts were quantitatively assessed on this basis. Details of these works for the period 2004 – 2008 are presented in the Survey Methodology and Results sections of this report.

Methods – Aquatic

Aquatic scoping study field surveys plus literature and threatened species data base reviews were undertaken in 2004 to provide a basis for a quantitative aquatic ecology study design, to provide some broad indications of potential aquatic ecological impact and to assist in the provision of constraints and opportunity advice for preliminary mine planning.

A sampling model, utilising 16 sampling sites was designed to separate out possible mining impacts from other-catchment associated impacts. The sites were assessed for overall aquatic habitat condition using a standardised Riparian-Channel-Environment (RCE) ranking scheme. At each site, the main stream health assessment method targeted aquatic macroinvertebrates, based on the AusRivAS protocol which specifies sampling in spring and autumn. The overall stream health of the macroinvertebrate assemblages at each site was assessed by comparing Site Stream Invertebrate Grade Number Average Level (SIGNAL) pollution tolerance scores within and between sample periods.

AusRivAS surveys were supplemented with aquatic plant observations, physical water quality measurements (temperature, conductivity, dissolved oxygen, pH and turbidity) and fish trapping using baited traps. Searches plus habitat assessments were also made for Platypus and Native Water Rat.

Survey Period

Terrestrial surveys were conducted between September 2004 and July 2008 involving several seasons of survey. Flora surveys involved systematic (i.e. quadrat) and non-systematic (targeted) techniques to sample the study areas floristic diversity. Fauna surveys involved diurnal and nocturnal sampling regimes such as owl call broadcast, pitfall trapping, hair tubes, spotlighting, Anabat II echolocation recordings, Harp Trapping, Elliott trapping, scat searches, timed and targeted habitat searches.

Aquatic field surveys were undertaken in spring 2004, autumn and spring 2005, summer 2006, spring 2007 and autumn 2008. Survey intensity varied between 4 and 10 sites per season, with 15 sites having sufficient water available for macroinvertebrate sampling at least once. In summary, 24 sites from the 36 visited sites had sufficient water available for sampling over the sampling period.

Results Summary– Terrestrial

The extent of intact native vegetation cover within EL6288, which excludes lands associated with current mining approvals, is approximately 6,100 ha with the study area comprising approximately 2,354 ha or 39% of this vegetation cover. Two broad vegetation formations that prominently feature within the study area are considered similar to regional vegetation classes described by Keith (2004) these being:

- Western Slopes Dry Sclerophyll Forest (e.g. Ironbark; Scribbly Gum and Box Ironbark communities); and
- Western Slopes Grassy Woodlands (e.g. Box Redgum communities).

Valley floor vegetation is predominantly cleared of its pre-European tree canopy cover, with existing fragmented, partially connected or fringing vegetation patches and remnants exhibiting a range of disturbance-related responses to the prevailing agricultural land uses. Riparian woodlands containing Box and Redgum occur as fragmented linear vegetation tracts along Murragamba, Wilpinjong and Eastern Creeks. Grassy Box Woodlands occur as highly fragmented remnants throughout the adjacent lower slopes, which grade upslope into shrubby Box Ironbark communities. Ironbark and/or Native Pine Forests dominate the ridgelines and upper slopes, with isolated grassy box woodlands and open woodlands found on scattered basalt outcrops.

Database searches and literature reviews identified 514 species within a 50 km radius of the study area, a list consisting of 467 native and 47 exotic species. The flora survey for the study area identified 513 plant species, consisting of 452 natives and 61 exotics within the above regional vegetation classes, with 15 sub-formations also recognised.

Identified from database searches, literature reviews and field surveys were a total of 30 threatened plant species/ EPs that may have potential occurrence within the study area. Of these there are 2 known threatened flora species occurrences within the study area (i.e. Scant Pomaderris (*Pomaderris queenslandica*) and *Eucalyptus scoparia*). Of the remaining 28 threatened plant species/ EPs five were assessed as having moderate to high potential habitat values within the study area. Targeted surveys failed to locate known habitat for these species/ EPs within the study area.

A single plant of the endangered Scant Pomaderris (*Pomaderris queenslandica*), listed exclusively on the TSC Act, was observed within a sheltered open depression near the boundary between the Permian – Triassic geological formations. This observed occurrence within the study area is consistent with known habitat values observed in the Sandy Hollow district. The threatened *Ecualyptus scoparia* (i.e. listed as endangered on the TSC Act and vulnerable on the EPBC Act) was identified within a highly modified landscape of the central Murragamba Valley near areas with historically intense human landuses (i.e. old school and regional road passing through Carrs Gap). The NSW Herbarium, who identified a sample of the specimen, indicated the plant as a cultivated specimen, a conclusion supported by its historical use as a roadside landscape tree and the disjunction of the site from known natural habitat (i.e. elevated granitic soils near the NSW – Queensland border).

Tracts of White Box Yellow Box Blakely's Redgum Woodland (WBYBBRW) and derived grasslands Endangered Ecological Community (EEC)/ Critically Endangered Ecological Community (CEEC) was also observed, with the latter listed under the EPBC Act.

A search of DECCs Wildlife Atlas fauna database (DECC, 2008) for the western half of HCR CMA identified 497 fauna species consisting of 474 natives and 23 exotics. The baseline fauna survey identified 256 fauna species within EL6288 comprising of 170 birds, 37 mammals, 32 reptiles and 7 amphibians. Higher fauna species richness was observed within the Western Slopes Grassy Woodlands, with the majority being woodland birds. Western Slopes Dry Sclerophyll Forest provided habitat for many microchiropteran bat species and reptiles due to the locally elevated abundance of trees with hollows and surface rock. Intergrade/ transition between these two regional vegetation classes appear to be locally important for honeyeaters and other regionally migratory species, particularly within vegetated protected gullies where a diverse array of habitat resources are concentrated. Ground mammals were rarely encountered during all seasonal studies, a result consistent with other local and regional studies.

Identified within the region, the surrounding 30 km radius of the study area and relevant literature are at least 36 threatened fauna species or their habitats that may potentially occur within the study area (DECC, 2008; Birds Australia, 2008; DEWHA, 2008). Of these 25 threatened fauna species and 14 declining woodland birds have known or potential occurrences within the study area or nearby lands. These results are largely consistent with other local studies conducted for the Ulan and Wilpinjong coal mines.

Results Summary - Aquatic

Literature review (including reviews of recent regional impacts assessments and of Ulan plus Wilpinjong Mine aquatic survey results) indicated that there were no threatened aquatic plants, fish or macroinvertebrate species or populations (as listed under Commonwealth EPBC Act or under the NSW Fisheries Management Act 1994) listed or found in the upper Goulburn River or streams flowing to the upper Goulburn River. There were no threatened species found during this study and none are expected.

Most of the creeks and drainages in the EL6288 are ephemeral or intermittent and there are few creeks with permanent (or even semi-permanent) natural ponds or riffle areas. There are numerous shallow springs within the study area and many of these are located close to drainage swales. Consequently there are in-line dams scattered throughout the study area, strategically located to collect both surface runoff plus spring water discharges. Water quality results confirm that most in-line creek sampled sites had very little water holding capacity.

Although water conductivity showed a large variation (range 53 to 2300 µS/cm), elevated conductivity readings (1000 to 2300 µS/cm) only occurred in lower Eastern Creek sites and occasionally in Wilpinjong Creek sites downstream of the MCP study area. Deeper pool or dam sites were generally stratified with depressed dissolved oxygen concentrations in bottom waters. Water acidity varied between 3 and 9 pH units. Acid seepages occurred along the lower Eastern Creek western bank and alkaline seepages (7.7 to 9 pH units) occurred in Murragamba Creek spring fed dams. Water turbidity varied widely, generally in response to wet and dry sampling conditions or in response to stock activity. Based on Riparian Channel and Environmental Inventory (RCE) analysis alone, good aquatic habitat was located in a middle Murragamba Creek section, a lower Eastern Creek section plus several small sections along Wilpinjong Creek. The aquatic macroinvertebrate sampling results indicate that the better aquatic habitat was often associated with in-line or groundwater interception dams (due to overall more permanent water storage capacity plus associated emergent vegetation) in the Eastern and Murragamba Creek sub-catchments.

There were 53 aquatic macroinvertebrate taxa recorded from the study and 48 were common to both this study and the previous study undertaken for Stage 1 of the MCP. Individual site diversity over the ten sampling days varied from 4 taxa to 25 taxa. Seasonal diversity varied from 7 taxa in autumn 2006 (from 2 sites sampled) to 41 taxa in spring 2005 and spring 2007 (from 5 and 10 sites sampled respectively). The pollution tolerance of the taxa found throughout the study ranged from very pollutant tolerant (SIGNAL score of 1) to very intolerant (SIGNAL Score of 8) with a mean value for all taxa of 4.04, indicating that there was a relatively even spread of taxa over the total study. Site SIGNAL scores were relatively similar across the study and ranged from 3.00 to 4.86 with 8 sites (33 %) providing a 'very poor' rating (i.e. < 4) and 16 sites (67 %) providing a poor rating (i.e. 4 to 5). Only two fish were caught or sighted, Plague Minnow and Long-finned Eel, all seen or caught in the lower sections of the three main creeks. No aquatic mammals (platypus or native water rat) were found during the study and although they occur downstream of the study area none are expected in the study area.

Groundwater Dependant Ecosystems

The possible occurrence of terrestrial, base flow and wetland groundwater dependant ecosystems (GDEs) was investigated by examining mapped biological values against with groundwater resources. The significance of possible GDEs was then assessed using the eight-step rapid assessment process contained within the NSW State Groundwater Dependant Ecosystem Policy (DLWC, 2002).

- One terrestrial GDE with numerous mapped occurrences was identified within the study area. (i.e. sedge herbfield). This vegetation exhibits a highly localised spatial extent, where it is generally linked to surface intercepted groundwater seepages arising from localised perched groundwater.
- There are a number of groundwater seepages which have been intercepted with constructed dams downstream and these provide suitable habitat for emergent riparian sedges, aquatic plants and aquatic fauna. In a sense these can be considered to be constructed aquatic GDEs.
- Whilst exhibiting dry terrestrial characteristics, parts of the vegetation cover classified as 'Murragamba Sands Woodlands' near the central northern parts of the study area may also be linked with local groundwater. Phreatophytic vegetation such as Blady Grass (*Imperata cylindrica*) and Blakely's Redgum (*E. blakelyi*) occur generally on the perimeter and drainage lines of a heterogeneously (partially) saturated tertiary paleochannel (Aquaterra, 2008) and could also be classed as a GDE.

Whilst groundwater is known to provide base-flow to the main creeks and the Goulburn River, assessment of riparian vegetation did not indicate any specific riparian plant communities, which could be considered groundwater dependent. The recharge source for 'groundwaters' supporting baseflow within the Murragamba, Eastern and Wilpinjong creeks is likely to be linked with localised perched groundwater

The GDEs (including 'constructed' GDEs) identified within the study area are potentially important in the formation of productive landscapes where food and reliable water resources appear to favour threatened fauna species such as the Hooded Robin, Diamond Firetail and microchiropteran bats. The permanent reliable ponded or seepage water resource is also important to the wider woodland bird cohort, which includes an array of declining species. These localised GDEs could provide important adjuncts to wider foraging habitats, particularly during breeding cycles and as drought refuge. The only threatened amphibian species recorded from the general locality with known dependence on permanent water regimes is the Giant Barred Frog, which was not recorded within the study area during the baseline surveys nor was its habitat detected within this area.

Impact Analysis

The direct impact footprint arising from the establishment and operation of the mine includes the extent of the proposed open cut (i.e. 1,274 ha), out of pit overburden emplacements (i.e. 128 ha) and infrastructure area (i.e. 105 ha). Additional to these impacts are indirect impacts including the loss of wildlife connectivity that otherwise passes through the area affected by land clearing events and from the loss of creeks/drainage lines. Other indirect impacts on surface features will occur as a consequence of two underground mines named Underground No. 1 (684 ha) and Underground No. 2 (277 ha).

In totality it is estimated that the development will directly/ indirectly modify some 73% of the study area (i.e. approximately 2,468 ha of the approximately 3,382 ha study area). **Table ES1** identifies these impacts in terms of direct (e.g. open cut operations) and indirect (e.g. underground operations) actions on intact native vegetation cover.

Table ES1: Summary of Mining Impacts on Intact Native Vegetation Cover

Operation	Footprint Area (ha)	Area (ha)	
		Direct (e.g. clearing)	Indirect (e.g. subsidence)
Open Cut 4	1274	707	0
Underground No. 1	684	0	633
Underground No. 2	277	0	272
Infrastructure	105	51	0
Out of Pit Overburben Emplacement	128	94	0
Total	2,468	851	905

Table ES2 summarises the summed direct plus indirect impact areas for each vegetation formation.

Table ES2: Summary of Direct/ Indirect Impacts of Proposed Stage 2 of the MCP – Intact Native Vegetation

Vegetation Formation	Direct (ha)	Indirect ha)
*Blakely's Redgum - Rough-barked Apple Woodland	53.21	2.18
*Blakely's Redgum - Yellow Box - Apple Woodland	40.82	6.6
Broad-leaved Ironbark Grey Gum Forest	61.81	453.75
Cyperoid Herbland	0.57	
Footslope Ironbark - Gum - Box Forest	125.24	70.19
*Grassy White Box Woodland	2.95	79.15
Grey Box - Narrow-leaved Ironbark Forest	84.37	
Hardcap Scribbly Gum - Ironbark Woodland	67.44	
*Lowland Box - Redgum Woodland	59.78	
Lowland Ironbark Forest	73.28	11.95
Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	1.74	248.79
Rough-barked Apple - Banksia Woodland	264.44	
Scribbly Gum Narrow-leaved Ironbark Woodland		22.16
Shrubby White Box Forest	15.52	9.66
Total	*851.17*	*904.43*

* Note: Denotes EEC/ CEEC

Approximately 157 ha of the mapped intact native vegetation cover that is to be permanently removed by direct impacts arising from the proposed development is consistent with definition for WBYBBRW EEC/ CEEC, representing an approximate adjustment of 53 % relative to the extent of this vegetation type within the study area (295 ha). Indirect impacts such as surface cracking from underground mining will impact approximately 88 ha of this EEC/ CEEC.

Table ES3 provides a summary of the summed direct plus indirect impact areas for landcover types not classified as intact native vegetation.

Table ES3: Summary of Direct/ Indirect Impacts of Proposed Stage 2 of the MCP – Other Landcover Classifications

Landcover Type	Direct (ha)	Indirect ha)
Crop/ Plantation	50.4	0.6
Secondary Grasslands and Shrublands	584.79	53.98
Disturbed/ No Natural Vegetation (e.g. roads, rail, claystone mines, dwellings)	20.28	2.36
Total	*655.47*	*56.94*

Threatened Biodiversity

Database, literature and baseline field surveys for EL6288/ the study area identified 31 threatened biodiversity that are considered subject species relevant to the assessment of the MCP, this including 5 threatened flora, 1 EP and 25 threatened fauna. WBYBBRW EEC/ CEEC is also known to occur within the study area and would be adversely impacted by the MCP. There was no threatened aquatic biota listed under the Fisheries Management Act 1994 (FM Act) found or expected to occur in the study area despite database searches (i.e. three species identified as potentially occurring within the area).

Habitats contained within the study area predominantly suit threatened species of dry sclerophyll grassy woodland environs such as those associated with the Western Slopes Grassy Woodlands, with parts of this vegetation class listed as an endangered ecological community (i.e. WBYBBRW EEC/ CEEC). The transition qualities of habitats located at the interface between the Western Slopes Grassy Woodlands of the valley floor and Western Slopes Dry Sclerophyll Forests of the adjoining ridgetops are locally important hence contain substantial biodiversity values.

Impacts on threatened biodiversity that are known or may potentially occur throughout the study area are likely, especially for species that occupy the valley floor such as woodland birds and microchiropteran bats (e.g. Painted Honeyeater, Hooded Robin, Diamond Firetail and Long-eared Pied Bat). This area is also important to the occurrence of WBYBBRW EEC/ CEEC, where the direct impacts of mining (i.e. open cut operations) is at its greatest. Indirect impacts will be largely restricted to ridgetops and associated midslopes where vegetation is predominantly characterised by Western Dry Sclerophyll Forests. In contrast, species such as the Glossy Black-cockatoo and Brown Treecreeper appear to be reliant on the habitats contained throughout this landscape.

Impact Management Strategy

The objective of the impact management strategy is to achieve a “Maintain and Improve” outcome for significant biodiversity values contained within the area impacted by the proposed mine. Impact management is principally focused at the landscape level (e.g. conservation and/or restoration of ecological function), with the purpose being the restoration and/or conservation of sustainable habitat over the long term

This strategy has focused on the following impact management approaches:

- Avoidance of areas of ecologically important values where possible;
- Establish, restore and reinstate functional aquatic (creek), terrestrial and riparian corridors;
- Enhance the ecological values of retained aquatic ecological resources and of native vegetation cover and associated habitats;
- Increase the net native vegetation cover within the locality;

- Conserve fauna habitats through managed salvage and compensatory works (including retention of large woody debris (LWD) for use in creek diversion/rehabilitation activities;
- Establish and enhance wildlife connectivity between conservation reserves and adjoining unreserved native vegetation cover;
- Incorporate specific rehabilitation techniques for use in an integrated rehabilitation strategy designed to restore key ecological function (e.g. grassy woodlands mosaic);
- Undertake actions that may facilitate and/or support the development of long term conservation outcomes in the locality and region; and
- Off-set areas of significant ecological values with dedications to the conservation reserve network.

The strategic framework established for threatened biodiversity at a State and regional level was used to define the detail of the above management strategy, this being DECCs threatened biodiversity 'Priority Action Statements'. Key elements of the impact management strategy are as follows:

- Integrate important ecological values such as those that occur within grassy woodland in an improved condition within the final landscape to 'seed' the future restoration works including revegetation and rehabilitation initiatives. This has been achieved through avoiding selected parts of the study area such creeklines and existing vegetation cover.;
- Revegetate cleared lands that are under the control of MCMs both within and outside the mining footprint to improve the local biodiversity values prior to sequential mining works;
- Establish permanent and maintain temporary movement corridors of sufficient width and ecological condition between Munghorn Gap Nature Reserve and Goulburn River National Park to facilitate regional movements;
- Undertake progressive creek diversion/restoration works to maintain and embellish core creek aquatic ecological function and connectivity;
- Undertake extensive progressive terrestrial and aquatic fauna habitat salvage works throughout the impact areas and restoration works throughout retained landscapes;
- Monitor and manage fauna populations throughout the duration of mining to seek balance between common and sensitive species;
- Undertake progressive mine rehabilitation works that integrate key environmental gradients important to ecological function to embellish and link retained vegetated and revegetated landscapes;
- Take all necessary steps to prevent, control and eradicate listed environmental and noxious weeds from the mine site, particularly known troublesome species of rehabilitated landscapes such as Galena (*Galena pubscens*), Rhodes Grass (*Chloris gayana*) and Coolati Grass (*Hyparrhenia hirta*);
- Undertake a significant roadside environment study to identify the extent, distribution and condition of important ecological values, for example, within the Mid-Western Regional Council local government area. Outcomes such as ecologically sustainable roadside maintenance and targeted management works are likely outcomes from such as study, with the likely beneficiary being WBYBBRW and derived grasslands;
- Establish 'like for like' offsite conservation outcomes for non-threatened vegetation communities and EECs/ CEECs cleared from the impact area. These are to be dedicated to the conservation reserve network; and
- Undertake detailed impact monitoring designed on the principles of a 'Before, After Impact Control' (BACI) monitoring program incorporating ecological research, performance indicators and corresponding alternative management strategies;

Maintain and improve outcomes arising from the above management actions include, but are not restricted to the following:

- An improved knowledge base of regional threatened biodiversity occurrences and habitat condition, thus strengthening strategic land use planning initiatives through the identification of lands with high priority conservation values;
- Increased public awareness of significant environmental issues throughout the Mid-Western Regional Council local government area, and seeking to foster a positive stewardship of other areas of high ecological significance throughout the district;
- Increased certainty of conservation outcomes for threatened biodiversity at the landscape level, particularly for ecological communities that are under represented in the conservation reserve network through impact offsets and dedications to the conservation reserve network;
- Increased native vegetation cover through a combined revegetation and rehabilitation program that is to apply to the majority of mined and unmined cleared landscapes that are under the control of MCMs;
- Increased understanding of biodiversity responses to revegetation and rehabilitation works, thus improve the success of future revegetation and rehabilitation programs designed to establish biodiversity outcomes; and
- Increased understanding of species impact responses, thus leading to improved impact management and rehabilitation techniques.

Conclusions

The assessments and suggested mitigation strategies presented in this EIA permit the conclusion that the proposed development combined with the proposed impact management strategy would result in a ‘maintain and improve’ outcome for threatened biodiversity, aquatic biodiversity and overcleared landscapes at a regional level through offsets and at a local level through revegetation and specific rehabilitation

A local ‘maintain and improve’ outcome can be achieved provided a suite of recommendations for rehabilitating ecological function are implemented. This would be expected to occur within the medium term provided the rehabilitation measures are integrated into early rehabilitation planning supplemented by the recommended offsite revegetation works. In the long term, it is expected that a mature rehabilitated landscape would emerge creating connected areas containing sustainable ecological conditions supporting local biodiversity values including matters ecological significance.

The development of the proposed mine will locally adjust the presence of threatened biodiversity and their habitats, both in terms of space and time. Local impacts will be cumulative and will have substantial lasting influence on local biodiversity lifecycles, and considerable impact management will be required to address this matter. For aquatic ecosystem rehabilitation the re-construction of lost surface water facilities (sub-catchment drainages, creeks and ponded storages) can be restored and even improved, but subtle ecological relationships arising from the present interaction of surface and groundwater resources are unlikely to be achieved unless specific measures are taken to restore some groundwater function to the sub-catchment drainages and diverted creeks.

Onsite impact management works will focus on minimising the long term impacts of mining at a local level by avoiding focal locations (i.e. core or source representations of particular landscapes), reinstating vegetation cover and mosaics, reinstating and managing water resources, controlling weed cover and reinstating wildlife linkages. The extent of the mine impacts for this area inevitably implies a stronger focus on offsite conservation outcomes. Consequently a strategic approach has been taken to meeting the “Maintain and Improve” test through measures such as the dedication of ‘like for like’ ecological communities to the conservation reserve network. Other conservation initiatives include local and regional works that meet the objectives of DECC’s Priority Action Statements for threatened species.

1. INTRODUCTION

This Ecological Impact Assessment (EIA) has been prepared to support the assessment of Stage 2 of the Moolarben Coal Project (MCP), a Part 3A Major Project, which is located in the Murragamba Valley at Ulan, New South Wales (the site is illustrated in **Figure 1**). It has been prepared to specifically address the impacts of mining on terrestrial and aquatic environs in response to the Director-General's Requirements (DGRs) dated the 11 September 2008.

1.1. Project Overview

The MCP is located in the New South Wales western coalfields, where it is situated east of the village of Ulan, approximately 40 km northeast of Mudgee and 25 kilometres east of Gulgong. It shares a common boundary with the approved Wilpinjong Coal Mine to the east and the approved Stage 1 of the MCP to the west. The Ulan Coal Mine is also located nearby to the northwest. The Moolarben coal exploration area (EL6288) covers approximately 110 km^2 and borders the Goulburn River National Park and Munghorn Gap Nature Reserve. The location of the MCP Stage 2 development area is shown in the main Environmental Assessment report.

1.2. Study Objective

The main objective of this report is to describe and quantify the terrestrial and aquatic biodiversity of the study area for assessment against the impacts of a proposed coal mine, thus ascertain the extent of impact management required to achieve a 'Maintain and Improve' outcome for this impact. This involved a review, detailed field surveys, results interpretation and classification of the study area's terrestrial and aquatic biodiversity values against the local and regional biodiversity framework followed by impact analysis. To this extent the guiding principles of various government policies and guidelines were utilised to achieve this objective, such as:

- Working Draft Guidelines Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (DEC 2004);
- State Groundwater Dependent Ecosystem policy guidelines (DLWC 2002);
- NSW DPI Guidelines for the assessment of aquatic habitat (NSW Fisheries 1999); and
- Management of stream/aquifer systems in coal mining developments; Hunter Region (DIPNR 2005).

Threatened biodiversity listings relevant to this assessment include those identified by the *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act) for State matters and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for Commonwealth matters.

1.3. The Study Area

The general location of the study area, as shown in **Figure 1**, lies on the eastern side of the Great Dividing Range on a lowly elevated saddle (500 m AHD) within the Hunter Central Rivers Catchment Management Area (HCR CMA), and is wholly contained within the Sydney Basin Bioregion. The South Western Slopes and Brigalow Belt South bioregions are located nearby to the west and north respectively.

The study area boundary defining the assessment area for Stage 2 of the MCP is illustrated in **Figure 2** (total area: 3,382 ha), an area consisting of approximately 2,354 ha intact native vegetation cover with a residual of 1,028 ha cleared lands (i.e. secondary grassland and shrublands subject to grazing, crops and hardstand such as roads and past claystone mines). It is inclusive of lands predicted to experience both direct and indirect impacts from the proposed mine. For the aquatic ecological assessment, the study area is extended up and downstream for streams that occur within the study area boundary, as aquatic ecological impacts can occur further downstream and aquatic connectivity can be impacted further upstream.

Ecological values examined in this report for this area are listed as follows:

- Vegetation cover and connectivity;

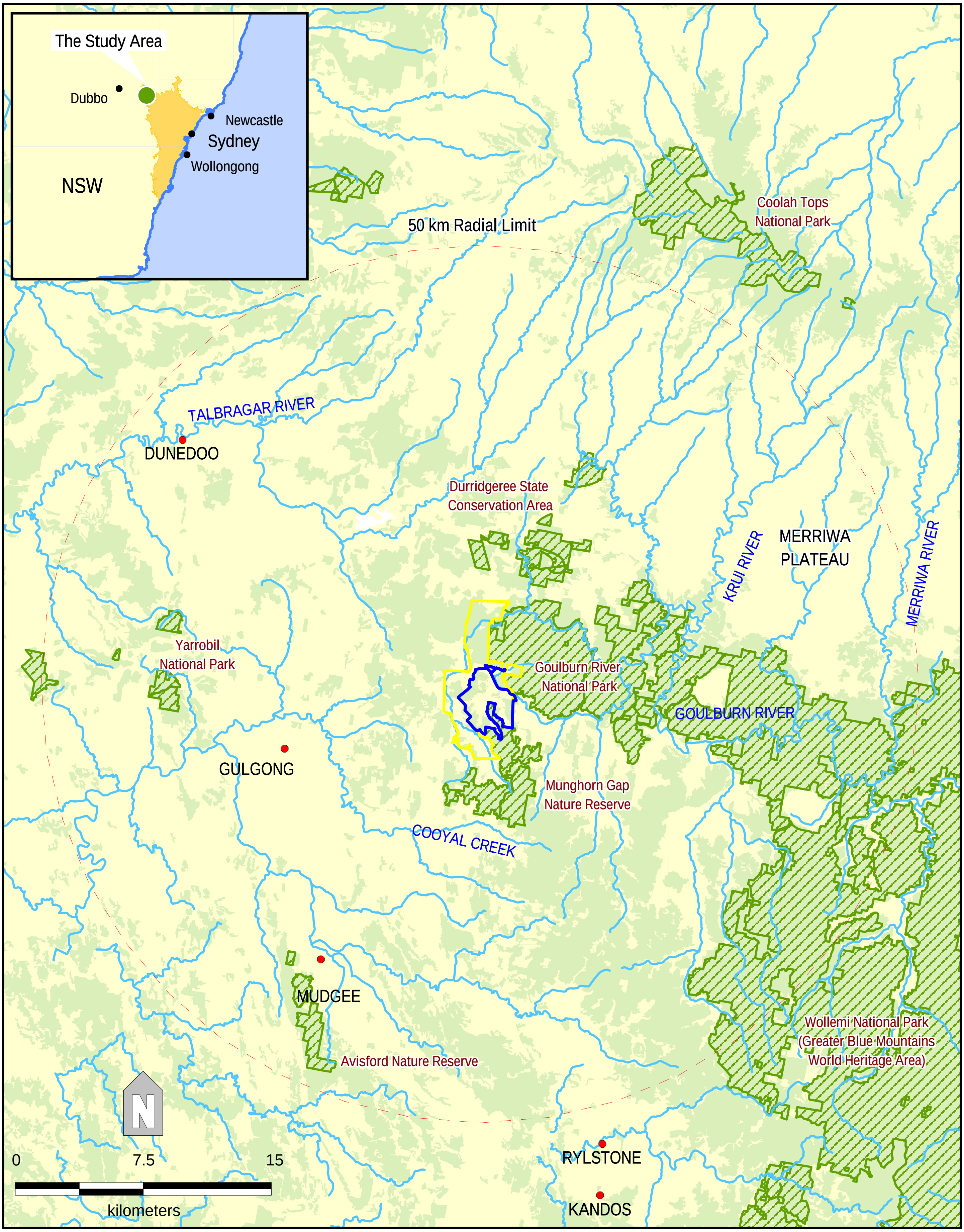


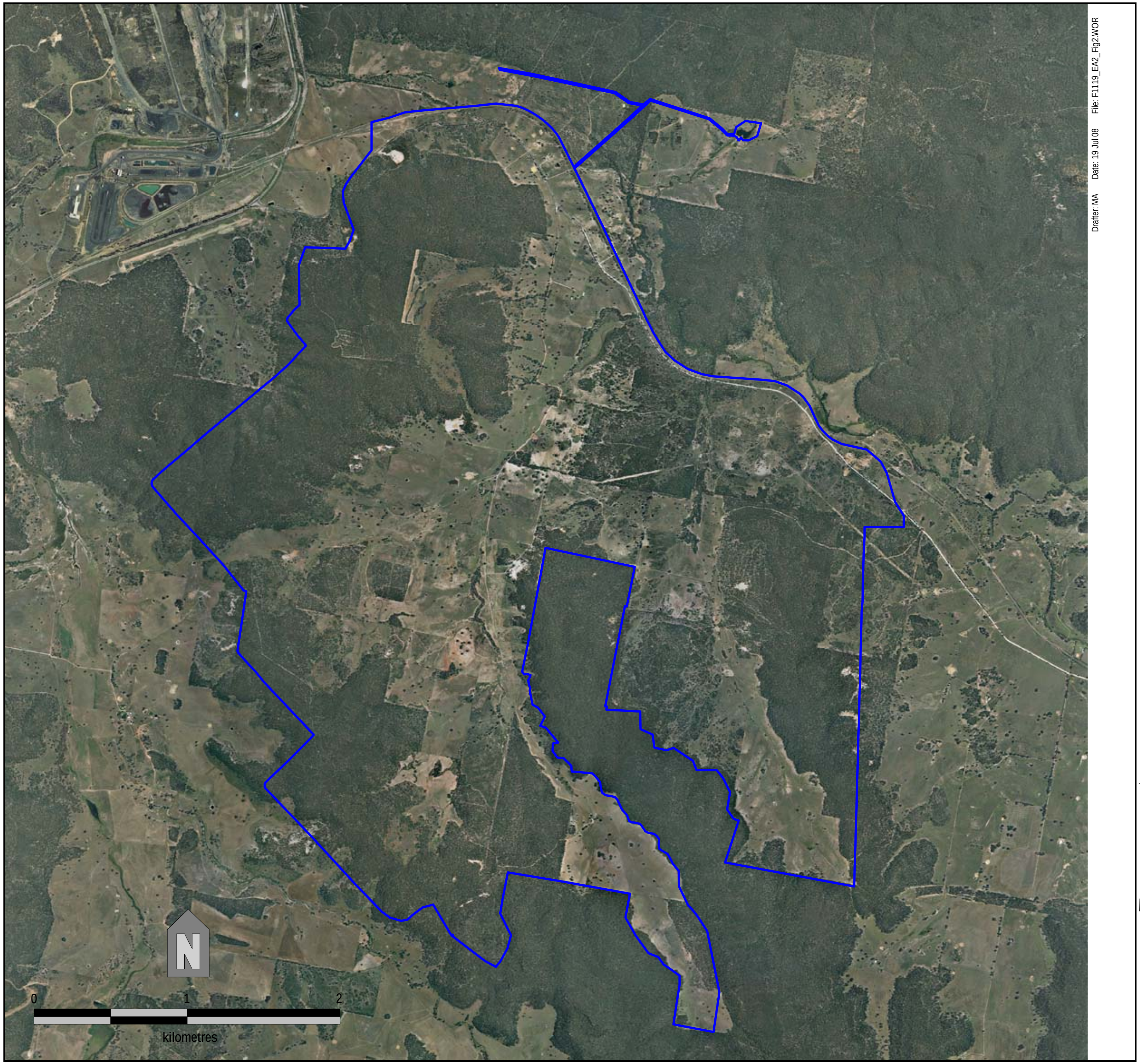
Figure 1

Location of the Study Area

Legend

Waterways	Native Vegetation Cover
Boundary of EL 6288	Conservation Reserves
Study Area	"Treeless" landcover

ECOVISION CONSULTING
PO BOX 26
MUSWELLBROOK NSW 2333
TEL.FAX 02 6543 2318
MOBILE 0401 574 535
MARK@ECOVISION.NET.AU



Legend

Study Area Boundary

FIGURE 2

Study Area Boundary

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- Aquatic ecological habitat connectivity;
- Terrestrial and aquatic taxa and their habitats including exotic species; and
- Relationship between hydrological regimes and biodiversity.

1.4. Background and Report Structure

1.4.1. Background

Identified at the onset of the MCP was the need for thorough ecological studies to classify local biodiversity and define temporal variability throughout EL6288. As such baselines studies were scheduled and completed on a seasonal basis to examine specific ecological parameters such as the flowering periods of White Box and Yellow Box. Baseline studies completed for the approved Stage 1 MCP identified the most beneficial survey seasons for this purpose were spring and summer, which coincides with the breeding times for many flora and fauna species. Autumn is recognised as an important period for various avifauna species, particularly migratory species with late winter relevant to the detection of the Regent Honeyeater and Swift Parrot. For aquatic ecology evaluation the most important variable was available water. Thus aquatic ecological sampling is best scheduled to follow good rainfall in the district.

Subsequent to the definition of the proposed Stage 2 mining footprint a review of the existing baselines seasonal studies was completed to ensure an adequate evaluation of the ecological values contained within the Stage 2 study area. The following works were completed to update the baseline data collected for the approved Stage 1 of the MCP in preparation for the assessment of Stage 2.

- Additional flora quadrats to determine the extent of White Box Yellow Box Blakely's Redgum Woodland within the Murragamba Valley in light of the Critical Endangered Ecological Community listing in May 2006 including the identification of derived grasslands;
- Targeted winter surveys for the Regent Honeyeater, Swift Parrot and other nectar foraging species;
- Spring survey to assess the fauna usage of flowering resources such as Yellow Box and Mistletoe;
- Spring surveys to improve vegetation mapping, improve vegetation descriptions and target threatened orchids;
- Summer survey to further evaluate fauna breeding and foraging values;
- Summer surveys to target threatened grasses and finalise vegetation mapping and descriptions,
- An additional autumn aquatic ecology survey to extend the aquatic ecological database to encompass areas east of Murragamba Creek.
- Targeted searches for recently listed threatened biodiversity such as Ausfield's Wattle; and
- The mapping of tree hollows to reflect the subsequent listing of a key threatening process referred to as "Loss of Hollow-bearing Trees".

These works were completed with the data obtained added to the baseline database compiled for the approved Stage 1 of the MCP.

1.4.2. Structure

The EIA has been structured in accordance with the format specified in **Table 1**.

Table 1: Report Structure

Section	Content
2 Legislation	A list pf relevant legislation.
3 The Proposed Development	Summary description of the proposed development.
4 Study and Assessment Methods	Details of the methods used to review the biological values of the study area and surrounding locality this including the way literature used, the use of spatial databases accessed, manner in which baseline surveys data analysis were completed. These methods are relevant to the sequential preparation of sections 5, 6 and 7.

Section	Content
5 Description of the Study Area	A literature review broadly discussing the local environment. Only published information was used to prepare this section of the report. This provides context for the description of survey results including those completed subsequent to the approved Stage 1 of the MCP. Identifies threatened biodiversity that may potentially be relevant to the study area. Provides context for the baseline surveys.
6 Survey Results	General discussion of the sites ecological character as defined by the baseline data compiled for Stage 1 of the MCP and subsequent studies completed for Stage 2 of the MCP as they relate to the study area
7 Data Analysis	An indepth data analysis of the baseline survey results using statistical means to classify vegetation, fauna values and status of endangered ecological communities of the study area. Descriptions of classification units are also provided for ecological communities.
8 Impact Analysis	A review of the development and its impacts on the study area in terms of the information presented in Section 3 and Section 5, 6 and 7. A preliminary ecological risk analysis is included to assist in the identification of matters of ecological significance relevant to the project.
9 Relevant Matters of Ecological Significance	Discussion of threatened species, EPs, EEC/ CEECs that are of relevance to Stage 2 of the MCP as guided by Sections 5, 6 and 7 and the preliminary ecological risk analysis presented in Section 8
10 Impact Management	Identifies the range of impact management works required to offset the developments impacts within the context of a “Maintain and Improve” philosophy.
11 Impact Assessment	Reviews the developments impacts against relevant matters of ecological significance within the context of the proposed impact management approach.
12 Conclusions	Summary of EIA including a response to various Part 3A matters
13 Bibliography	Resources used to prepare the EIA.

1.5. Compliance with Director General’s Requirements

This report has been prepared to meet the 11 September 2008 Director-General’s Requirements (DGRs) with regard to Environmental Assessment – Ecology for Stage 2 of the MCP and adequacy review comments provided by the delegate of the Director General of Planning provided on 31 October 2008.

Terrestrial biota field surveys were designed and conducted in accordance with the Working Draft Guidelines Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities’ (DEC 2004). Assessment of groundwater dependent ecosystems was undertaken in accordance with the State Groundwater Dependent Ecosystem policy guidelines (DLWC 2002), and assessment of aquatic habitat was undertaken in accordance with the NSW DPI Guidelines (NSW Fisheries 1999a, 1999b).

1.6. Limitations and Bias

This EIA has classified and quantified the biological character of the study area at a landscape level through literature reviews, database searches, field survey and data interpretation. Substantial reliance has been placed on the accuracy of regional databases (i.e. DECCs Wildlife Atlas database and regional vegetation mapping) for the development of the survey approach, with these databases reported to potentially contain omissions and erroneous data. Limitations have been minimised, where possible, by comprehensive terrestrial and aquatic field surveys. Conversely, bias has been introduced in certain circumstances to meet specific objectives set by the DGRs

An understanding of temporal variation resulting from seasonal change and its relationship with the site and study area is based on the extensive seasonal field surveys completed for EL6288(i.e. a minimum of 36 months of routine seasonal survey from spring 2005 to winter 2008), experience of the principal investigators, relevant information contained within local literature, databases and vegetation mapping. In this respect, field surveys were in selective cases biased to maximise data capture of locally occurring threatened biodiversity, particularly those sensitive to the developments impacts.

There were still specific limitations placed on this EIA such as:

- Some limited accessibility with regard to landholder access agreements for particular seasons;
- Unreliability of mass flowering events. Flowering events were mostly gradual across the study area and seasonally biased. Exceptions include mass flowering of White Box (*Eucalyptus albens*) during July-August 2005 and Broad-leaved Ironbark (*E. fibrosa*) during December 2004. This bias may have influenced the detection of some honeyeaters and parrots whose movements are governed to some extent by mass flowering events, *eg* possibly the Regent Honeyeater or Swift Parrot;

- The presence of extensive and complex anthropogenic disturbance regimes and its heterogeneous affect on biological systems; and
- Unreliability of rainfall resulting in limited pooling of water in many of the ephemeral drainages, resulting in aquatic ecological sampling sites being generally located at constructed pools (behind rail or road crossings) and generally at the lower ends of the drainages.

Report Validity

The contents of this report are limited by its focus (i.e. assessment of relevant legislation, associated regulations and guidelines) and information available at time of publication. Government and/ or government authorities periodically review this underlying assessment framework where it may be amended or altered to reflect changes in government policy. Hence, any amendments to the assessment framework arising after the published date of this report may potentially invalidate any of the recommendations. Accordingly, no warranty is placed on the contents of this report where it can be demonstrated that the assessment framework has been amended or changed subsequent to the reports' published date.

2. LEGISLATION AND GUIDELINE FRAMEWORK

2.1. Director Generals Requirements

The following guidelines were deemed relevant by the Department of Planning (DoP) in their DGRs for the assessment of biodiversity matters (see bibliography for full citations):

- Policy and Guidelines – Aquatic Habitat Management and Fish Conservation (NSW Fisheries);
- Policy and Guidelines for fish friendly waterway crossings (DPI Fisheries 1999, 2004, Fairfull and Witheridge 2003);
- Groundwater Dependant Ecosystems Policy 2001 (DLWC 2002);
- State Environmental Planning Policy No. 44 – Koala Habitat Protection; and
- Draft Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act (NSW DECC 2008).

Not identified by the DGRs is reference to the *Working Draft Guidelines Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities' (DEC 2004)*, a guideline that was considered in the preparation of this assessment particularly in reference to the completion of baseline ecological studies (e.g. seasonality surveys).

Other guidelines considered relevant to this assessment that were identified in the DGRs for other non-biodiversity matters include the following:

- Guidelines for Fresh and Marine Water Quality (ANZECC 2000); and
- Rehabilitation Manual for Australian Streams (Rutherford et al 2000).

In addition to the above matters, the DGRs also draw reference to the EPBC Act, this being a law administered by the Commonwealth, where an impact on matters protected by this requiring separate consideration under that Act.

The above guidelines and Acts form the basis for the assessment provided in this report.

2.2. Context Supporting the DGRs

The development is classified as a Part 3A Major Project under the *Environmental Planning and Assessment Act 1979* (EP&A Act). The following provides context for the DGRs relative to biodiversity matters.

2.2.1. EP&A Act

Stage 2 of the MCP has been declared a Part 3A Major Project under the EP&A Act and thus is subject to the assessment protocols prescribed by this part of the Act, with approval for these projects the responsibility of the NSW Minister for Planning.

Matters pertaining to significant impacts on threatened species that arise from proposed development declared as a Major Project are no longer subject to the preparation of a Species Impact Statement (SIS) under the *Threatened Species Conservation Act 1995* (TSC Act) or the *Fisheries Management Act 1994* (FM Act). Notwithstanding, both these Acts provide context for impact assessment of Part 3A Major Projects, as these Acts contain listings of threatened species, populations and ecological communities.

TSC Act

In addition to prescribing the requirements for a Species Impact Statement, the TSC Act contains schedules listing threatened species (i.e. endangered or vulnerable), EPs, EECs and key threatening processes. It also provides for the keeping of a critical habitat register, the granting of licences authorising actions leading to the harm of any threatened species, EP or EEC, the handling of a threatened species, EP or EEC or damage to critical habitat and/or habitat of a threatened species, EP or EEC.

FM Act

In 1999 the *Fisheries Management (Amendment) Act 1994* inserted threatened species provisions into the FM ACT for the protection of threatened aquatic biota and for aquatic habitat protection. The FM ACT is administered by Department of Primary Industries (Fisheries branch) and the conservation aspects of the FM ACT are set out in two NSW Fisheries Policy and Guideline Documents (NSW Fisheries 1999a, 1999b).

2.2.2. Assessment Guidelines

Guidelines that identify matters relevant to the assessment of potential impact on threatened species, populations or ecological communities of proposed development under Part 3A of the EP&A Act have been prepared by the Department of Environment and Conservation (now Department of Environment and Climate Change) and the Department of Primary Industries (DEC 2005).

The *Guidelines for Threatened Species Assessment* identifies the following objectives in regard to conserving threatened biodiversity:

1 "Maintain or improve biodiversity values (i.e. there is no net impact on threatened species or native vegetation).

2 Conserve biological diversity and promote ecologically sustainable development.

3 Protect areas of high conservation value (including areas of critical habitat).

4 Prevent the extinction of threatened species.

5 Protect the long-term viability of local populations of a species, population or ecological community.

6 Protect aspects of the environment that are matters of national environmental significance."

The Guidelines outline a broad five-step process for assessing impacts on threatened species. Note that 'threatened species' refers here to species, populations and communities listed as threatened under the TSC Act or the FM ACT. As this project is being assessed under Part 3A of the EP&A Act, this investigation and report follows the Guidelines where relevant.

2.2.3. Survey Guidelines

Field survey design will have regard for relevant industry standards, this currently being the Working Draft Guidelines *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities*' (DEC 2004). As these are guidelines, various modifications to the survey protocols were applied where justification permits.

2.2.4. Groundwater Dependant Ecosystems Policy 2001

Many statutes can apply to the management of groundwater dependent ecosystems (GDEs). Under the *Water Management Act 2000* (WM Act), the Minister for Land and Water Conservation (now Department of Water and Energy) controls and manages groundwater extraction and use in NSW. The Act is aimed at the sustainable and integrated management of water. It includes principles that must be applied by decision makers and any one else who is exercising functions under the Act. These principles include the following:

- Water sources, floodplains and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded - see section 5(2)(a) of the Act;
- The water quality of all water sources should be protected and, wherever possible, enhanced - see section 5(2)(c) of the Act; and
- Sharing of water from a water source must protect the water source and its dependent ecosystems - see section 5(3)(a) of the Act.

The WM Act is largely administered by the NSW Department of Water Resources (DWE). The WM Act also requires all the State's groundwater sources to be classified according to the extent to which they are at risk, subject to stress, or hold conservation value. In systems classified as high risk, high stress or high conservation value, Minister's plans are required to be established in 2001/2002 for a number of priority systems. These plans will establish the water sharing arrangements for the system, including environmental water rules, arrangements for domestic and stock use and an access (sharing and extraction) regime for licence holders.

The WM Act also requires environmental water rules to be established for all other groundwater systems as soon as practicable after 1 January 2001. These rules will ensure that water is specifically provided to meet the needs of GDEs. The Department licenses private entities and government authorities to extract and use groundwater. The licences can include conditions designed to protect GDEs. A new licensing and approvals system will begin operating in late 2002.

Development and use of land is the one consistent element in the list of potential threats to groundwater. Land use planning legislation and instruments, therefore, provide some control over the uses to which land is put. Land use planning in NSW is administered by the Department of Planning, and local councils under the EP&A Act.

The EP&A Act requires the potential effects on groundwater of proposed developments to be assessed as part of the environmental impact assessment process. It also provides for the preparation of environmental planning instruments which may control, restrict or limit development at local, regional and State levels. The Act applies both to local councils approving private developments and carrying out their own activities. It also applies to State government agencies issuing approvals, including licences for groundwater extraction.

The *Protection of the Environment Operations Act 1997* administered by the DECC is one of the legislative tools for the control of water pollution, including the pollution of groundwater. This Act consolidates previous environmental legislation including the Clean Waters Act, prohibits the pollution of any waters and provides for a licensing scheme. People acting in accordance with a licence have a defence against prosecution for polluting. This Act establishes a tiered structure of offences and penalties for pollution based on the intent of those involved and the severity of the harm caused.

2.2.5. Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prohibits actions that are likely to have a significant impact on matters of national environmental significance (NES) in the absence of an approval for such actions. Matters of National Environmental Significance protected by the EPBC Act include, but are not restricted to:

- Declared World Heritage properties;
- Ramsar wetlands;
- Listed threatened species and communities;
- Listed migratory species;
- Nuclear actions; and
- Actions in a Commonwealth marine area.

It is an offence to carry out an action that will or is likely to have a significant impact on NES matters without first obtaining an approval from the Commonwealth Environment Minister except where an exemption in the EPBC Act applies or the action is assessed in accordance with an approved bilateral agreement. A person who is proposing to carry out an action that may have a significant impact on one of the above NES matters (and which is not the subject of an exception) is required to refer the proposed action to the Commonwealth Environment Minister. The Minister will determine as to whether the project is a "controlled action" (i.e. an action that requires the approval of, or the environmental assessment nominated by, the Environment Minister).

Bilateral Agreements

A key function of bilateral agreements is to reduce duplication of environmental assessment and regulation between the Commonwealth and states/territories. Bilateral agreements allow the Commonwealth to 'accredit' particular State/ Territory assessment processes and, in some cases, State/ Territory approval decisions.

In effect, bilateral agreements allow the Commonwealth to delegate to the states/territories the responsibility for conducting environmental assessments under the EPBC Act and, in certain circumstances, the responsibility for granting environmental approvals under the EPBC Act. Bilateral agreements may also deal with various other matters, such as management plans for World Heritage properties and cooperation on monitoring and enforcement.

On 20 December 2006 the Minister for the Environment and Water Resources (now DEWHA), gave notice that the Commonwealth of Australia had entered into a bilateral agreement with New South Wales. This agreement has the effect of delegating the assessment of EPBC Act matters of NES within the assessment process specified under Part 3A of the EP&A Act (Major Projects). This project has been declared a Part 3A (Major Projects) and will thus be considered within the framework specified by the Bilateral Agreement.

2.3. Legislation Irrelevant to the EIA

In terms of biodiversity matters the following planning laws, policies and guidelines that normally operate in tandem with matters assessed under Part 4 or 5 of the EP&A Act are not relevant to the planning processes involved in the determination of developments classified as Part 3A Major Projects:

- *Native Vegetation Act 2003* and its regulation; and
- *TSC Act*; and
- *FM Act.*

Ordinarily a significant impact on threatened biodiversity declared under Part 4 and/or 5 of the EP&A Act would trigger a requirement for a Species Impact Statement under the latter two Acts. However, such requirements cannot be triggered under Part 3A Major Projects as the pathway for such assessments (i.e. s5A ‘Assessment of Significance’ of the EP&A Act) are bypassed by the Part 3A amendments. Therefore, there is no requirement for the preparation of ‘Assessments of Significance’, with the framework for the projects impact assessment, including those that are significant impacts, defined by the *Guidelines for Threatened Species Assessment* (DECC, 2005).

3. THE PROPOSED DEVELOPMENT

Approval of Stage 2 of the MCP is sought to construct and operate coal mining in Open Cut No 4 and Underground No. 1 and 2 (U/Gs 1 and 2) resource areas together with associated infrastructure.

Stage 2 will operate in conjunction with Stage 1 to constitute the MCP which will operate as a single mining complex comprising three underground and four open cut coal mines with surface facilities comprising coal handling, preparation, run-of-mine (ROM) and clean coal stock piling and rail loading at the currently approved, and to be upgraded by Stage 2 of the MCP.

The Stage 2 application seeks approval to increase production from the whole of the MCP to 13 Mtpa of product coal from a total of 17 Mtpa ROM. Open Cut 4 (O/C4) would have an approved total production of up to 12 Mtpa ROM coal, Underground No 1 (U/G1) of up to 4 Mtpa ROM and Underground No 2 (U/G2) of up to 4 Mtpa ROM coal subject to production scheduling required to comply with the environmental goals of the total approved ROM coal and product coal production.

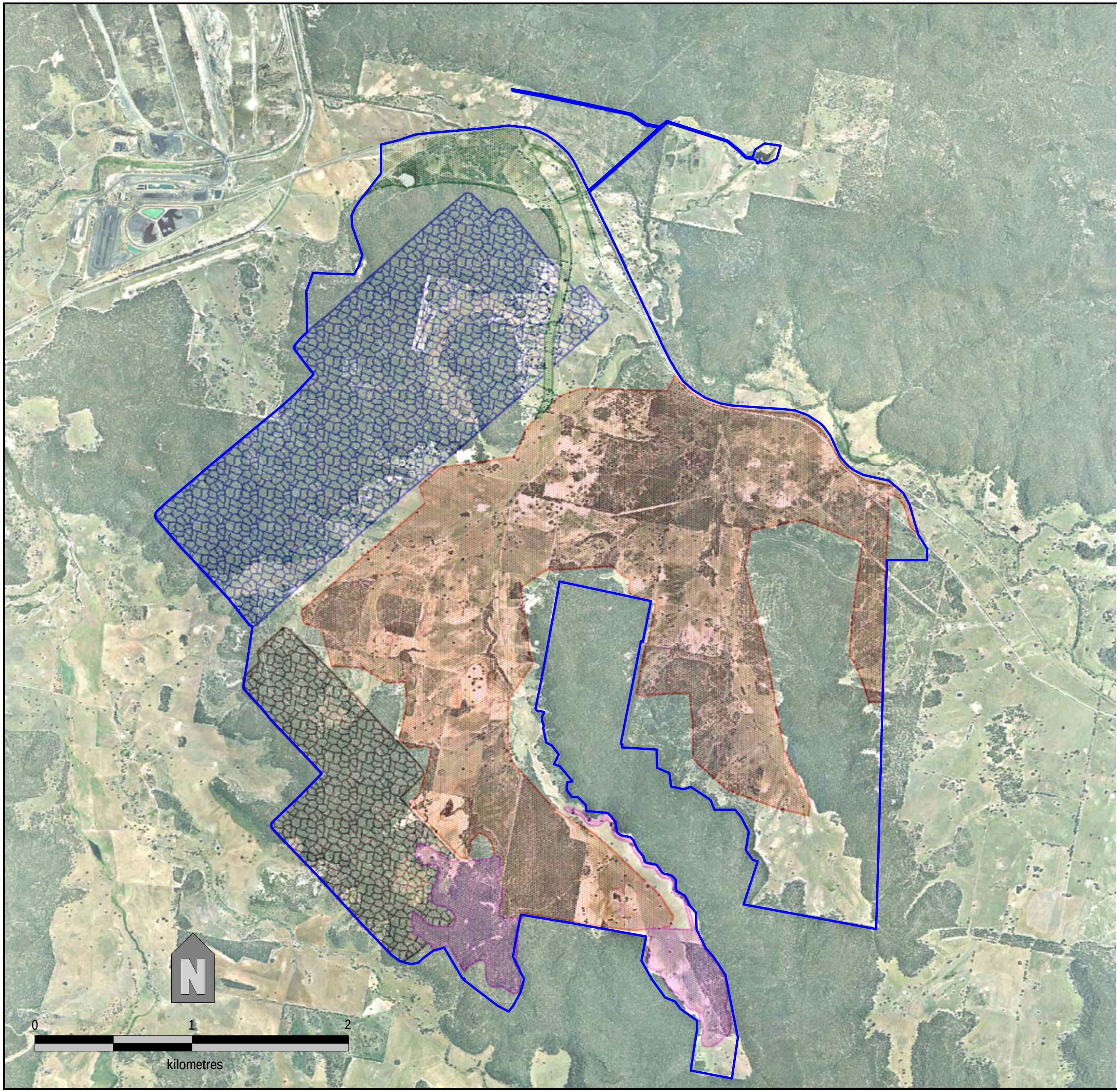
The Stage 2 Application is for:

- Two underground mines (U/G 1 and U/G 2) below the sandstone ridges to produce up to 4 Mtpa ROM coal with associated facilities;
- An open cut mine (O/C4) within the floor of the Murragamba Valley producing up to 12 Mtpa ROM coal with associated facilities; and for,
- Amended operation of the Stage 1 approved Surface Facilities with a capacity to handle 17 Mtpa ROM coal producing 13 Mtpa of product coal; that includes:
    - The upgrade of the Approved Stage 1 CPP and associated handling facilities from 12Mtpa ROM coal to 17Mtpa ROM;
    - The relocation of the Approved Underground No.4 entries south to the Open Cut 1 void; and
    - The upgrade of the Approved Open Cut 1 ROM coal system and conveyors from 8Mtpa to 12Mtpa to accommodate the Stage 2 underground mines.

Figure 3 illustrates the proposed layout of Stage 2.

The underground mines are located below sandstone ridges, whilst the open cut mine is in the floor of the Murragamba Valley and adjoining valley to the east. The Ulan Seam, which ranges from around 11 metres (m) to about 13m in thickness, will be mined with the full seam recovered in the open cut mines by the use of truck and excavator method and a partial section in the underground mines by the use of the longwall extraction method. Both domestic and export thermal coal will be produced.

Further detail of the proposed development is contained within the main Environmental Assessment Report.



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Legend

- Infrastrucutre
- Open Cut No. 4 (O/C 4)
- Underground No. 1 (U/G 1)
- Undergound No. 2 (U/G 2)
- Out of Pit Emplacements
- Study Area

FIGURE 3

Proposed Layout of Stage 2

Moolarben Coal Project

Sources

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4. STUDY AND ASSESSMENT METHODS

4.1. Defining the Study Area Boundary

The main factors involved in defining the study area include the area receiving the greatest impact by the development footprint and those matters identified in **Section 1.3**, these being:

- Vegetation cover and connectivity;
- Aquatic ecological habitat connectivity;
- Terrestrial and aquatic taxa and their habitats including exotic species; and
- Relationship between hydrological regimes and biodiversity.

Additional to this was the consideration of accessible lands such as those under the control of MCMs throughout the term of the baseline studies and the boundaries of the adjoining conservation reserve network.

For the purposes of this assessment, the study area is defined as the proposed mine area, the eastern limit for Stage 1 of the MCP; western limit of the Wilpinjong coal mine and the rail line to the north. Notwithstanding the footprint of the study area, as indicated above, there were substantial field surveys conducted outside this study area (i.e. EL6288) to provide a broad context for the assessment of the development within the study area. This included, for example, aquatic survey locations within the Wilpinjong Creek downstream of the study area.

4.1.1. Aerial Photography Interpretation

Digital orthorectified aerial imagery of 0.5 m spatial resolution was sourced (GeoSpectrum, 2008) for the purposes of reviewing and extending vegetation mapping prepared for Stage 1 of the MCP, other important landscape features such as aquatic environs and for preparing the study area description.

4.1.2. Preliminary Study Area Description

The preliminary study area description had regard for various matters identified within the DGRs, these being but not necessarily restricted to:

- The vegetation types;
- Previous land uses and events;
- Regional boundaries (i.e. catchments, bioregions, geology); and
- Land tenure (i.e. private, conservation network).

This was used to plan and focus detailed field investigations. Preliminary descriptions involved an initial site visit and general review of regional information relevant to the locality.

4.2. Subject Species

The term ‘Subject Species’ applies to listed threatened biodiversity that are known or are likely to be present in the study area and or locality and are likely to be impacted by the proposed development. These have been initially identified by database searches, literature reviews and landscape analysis (i.e. spatial analysis of threatened biodiversity records across relevant vegetation types, geological formations and Mitchell landscapes). The method supporting this analysis is described in the following sections.

4.2.1. Database Searches

A review of recent flora and fauna reports for the locality was completed in combination with database searches. Threatened biodiversity records located within a 30 km radius of the site, as contained within the Wildlife Atlas (DECC, 2008) and Birds Australia (Birds Australia, 2008) databases for the Hunter Central Rivers CMA, were identified for the purpose of defining a threatened biodiversity list of the study area. Similarly, a 30 km point search of the EPBC Act online ‘Protected Matters Database’ (i.e. DEWHA,

2008) was also generated to compliment this database query. A BioNet search was also conducted to identify possible threatened fish species as listed under the *Fisheries Management Act 1994* (FM ACT).

4.2.2. Landscape Analysis

Databases containing threatened biodiversity records (i.e. DECC 2008; Birds Australia, 2008) were spatially analysed against other regional information such as:

- Keith (2004) Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT. NSW Department of Environment and Conservation. Hurstville, NSW;
- GeoScience Australia (2006). Cultural data (vegetation cover) of the Singleton, Tamworth, Dubbo and Gilgandra 1: 250,000 scale map sheets;
- GeoScience Australia (2006). The Geology of New South Wales at 1: 1,000,000 scale; and
- Mitchell (2003). Mitchell Landscapes with per cent cleared estimates, listed by CMA (http://www.nationalparks.nsw.gov.au/npws.nsf/Content/BioMetric_tool).

Threatened biodiversity occurrences and counts were evaluated for each geological formation and Mitchell landscape relevant to the study area to assist in defining the threatened biodiversity of potential relevance. Species not known to occur within the study area or surrounding 50 km radial arc, but are known to occur within regional vegetation types, Mitchell landscapes and/or geological formations that intersect the site were considered.

4.3. Literature Review

Threatened biodiversity identified through literature sources, otherwise overlooked by database searches, have been included as 'Subject Species' (e.g. species that do not have known database records within study area but are known to occur within landscapes and/or vegetation types of the study area). Specific literature sources reviewed in addition to standard references include:

- Watkins J.J., Cameron R.G., Yoo E.K. & Colquhoun G.P. (1999): Gulgong 1:100 000 Geological Sheet 8833, 1st Edition;
- Geo-spectrum (Australia) Pty Limited (2004): Aerial Photography Scale 1:25 000 Run 1 (Frames 0025-0030), Run 2 (Frames 0015-0024) and Run 3 (Frames 0005-0014);
- Kinhill Stearns Engineers (1983): Ulan Coal Mines Stage 2 Colliery Development and Expansion Environmental Impact Statement;
- NPWS (2000): "Goulburn River National Park and Munghorn Gap Reserve: Vegetation Survey for Fire Management";
- NPWS (2003): "Plan of Management for Goulburn River National Park and Munghorn Gap Nature Reserve";
- Resource Strategies Australia (2005): Wilpinjong Coal Project Environmental Impact Statement;
- International Environmental Consultants Pty Limited (2005): Wollar to Wellington 330kV Transmission Line Environmental Impact Statement;
- The first annual environmental monitoring report (AEMR) for the Wilpinjong Coal Project (WCP) released in January 2008 (WCP 2008);
- Ulan Coal Mine annual environmental monitoring reports (AEMRs) summarise the results of annual terrestrial and aquatic fauna assessments which have been prepared for Ulan Coal Mine. There are monitoring data available from 2003 through to 2006 (Mt King Ecological Services 2003, 2004, 2005 and 2006); and
- Additional Ulan Coal Mine AEMRs published on the internet were consulted, but the Flora and Fauna Appendix for the 2007 report has not yet been made available electronically on the Ulan Cole Mine internet site.

4.4. Preliminary Study Area Inspection

A preliminary study area investigation was completed in October 2004 to permit a visual appreciation of the study areas' biological character in conjunction with knowledge gained from literature resources available at the time. This preliminary investigation also provided context for the establishment of the survey approach, design and specifications. For example the effective flora quadrat size was examined together with the characterisation of broad vegetation communities, which were initially conceptualised from remote sensing and literature reviews.

4.5. Terrestrial Field Survey

Terrestrial field survey was conducted in accordance with DECCs working draft *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004). The details of the survey extent are as follows.

4.5.1. Stratification

Survey stratification was used to assist the development of a survey design that considered 'homogenous' features such as geology, topography and 'land cover' (Aerial Photography Inerpreation (API) determined). Preliminary investigations were completed to generally confirm the proposed survey design.

4.5.2. Flora Survey Methods

An investigation of the study areas floristic content and spatial distribution was completed via a sampling regime involving systematic and opportunistic survey methods defined as follows:

<u>*Systematic*</u>: Observations collected within predefined sample areas (i.e. 20 X 20 m quadrats) through a stratified random sampling regime defined by landscapes with relatively homogenous aspect, slope, soil type/ geology, vegetation cover and topographic position. Site selection utilised digital orthorectified imagery, geological, soil and topographic data via a geographical information system (GIS) [MapInfo v8.5]. Sample replicates were used to assist validate stratification and the identification of characteristic species, with increased replicate samples obtained from native vegetation types with large aerial extent. Edges or boundaries between homogenous landscapes were avoided where possible due to potential edge effects.

<u>*Opportunistic*</u>: Observations collected from heterogeneous landscapes such as disturbed areas or boundaries of homogenous landscapes. Opportunistic observations are generally biased by the observer's position within the landscape and the perception of species importance (*i.e.* observer bias). Opportunistic observations include the results of targeted surveys for threatened and/or seasonal species such as ground orchids. These observations were not used to define homogenous vegetation units, however, they assisted defining floristic variability, particularly in disturbed areas or ecotones (i.e. edges).

The combination of these two sampling methods was used to define the floristic character of the vegetation cover and the extent of floristic diversity for the site and study area.

Data Capture

Species observations were collected using the two sampling methods described above. Each observation was described using a set of predefined descriptors (*i.e.* fields) and captured within a field GIS unit. The extent of information collected for each observation is detailed as follows.

Information	Format
Site Number	Systematic methods - Incremental numbers starting from 1 Opportunistic methods – 2000 autumn – 3999 winter – 3999 spring
Co-ordinates	Projection – Map Grid of Australia 1994 (MGA94); Australian Map Grid zone 55; Easting (6 digit number to 4 decimal places); Northing (7 digit number to 3 decimal places)
Date	Day-month-year
Observer's Name	Mark Aitkens
Observation Type	Quadrat, Transect, Opportunistic
Species Identification	Family, Genus and Species Name (Harden 1993, 1994, 2000, 2002)
Braun Blanquet	One digit number: 1 Rare cover < 5%; 2 Common cover < 5%; 3 Cover between 5 and 25%; 4

Information	Format
	Cover between 25 and 50%; 5 Cover between 50 and 75%; 6 Cover between 75 and 100%
Stratum	1 – Tree Canopy; 2 – Midstorey; 3 – Groundcover; 4 – Mistletoe and Vines
Maximum Species Height	Dominant Species – meters (2 digit number with 1 decimal place)
Minimum Species Height	Dominant Species – meters (2 digit number with 1 decimal place)
Maximum Stratum Height	Meters (2 digit number with 1 decimal place)
Minimum Stratum Height	Meters (2 digit number with 1 decimal place)
Stratum Cover	Percent (2 digit number)
Comments	Up to 255 characters.

The information identified in the above table (*i.e.* fields) were collected digitally using specialised software (*i.e.* GBM Mobile v3.11) as a field mapping extension to a desktop Geographical Information System (GIS) (*i.e.* MapInfo v7.5). GBM Mobile v3.11 was supported by a personal digital assistant (PDA) and Bluetooth enabled 20 station Geographical Positioning System (GPS). Hardware components were chosen for their enhanced display capabilities, stability (*i.e.* HP4700) and capability beneath the tree canopy (*i.e.* GlobalSat GPS). A handheld GPS (Magellan Explorist 100) combined with topographical maps (Gulgong 1:25 000; Wollar 1:25 000; Durridgere 1:25 000 map sheets) were used as an alternative/backup, where needed. Accordingly, no datasheets per quadrat sample were created, rather an interactive database that was editable both in the field and on desktop environments.

4.5.3. Fauna Survey Methods

The key assessment requirements for fauna (listed in the DGRs) are threatened species. Further to this, the *Draft Guidelines for Threatened Species Assessment* (DEC & DPI 2005) Step 2 Field Survey and Assessment state:

> "*the objective of the field survey is to ensure that a reliable assessment of the presence or absence of threatened species can be made*".

The target species for this assessment, therefore, are threatened species known to have occurred in the study area, and/or those considered potentially occurring in the study area. Systematic fauna surveys were often conducted in concert with flora sampling sites to assist an integrated characterisation of the study areas' biodiversity and provide spatial information on ecological resources.

Survey methods, seasons and effort

Eight separate seasonal surveys were conducted within the study area from summer 2004 (i.e. December) to spring 2007 (October). Surveys included trapping (i.e. Elliot Type A and B traps, cage traps, hair tubes, harp traps, pitfall traps), spotlighting, recordings (i.e. Anabat II for bats), timed searches (systematic), targeted searches, opportunistic searches, scat searches and call playback. Further details are provided in **Appendix 1**.

Opportunistic records of all species were maintained whilst travelling around the study area, and whilst conducting other surveys, with 'logging' of opportunistic survey areas restricted to data records. However, it can be generally assumed that opportunities surveys occurred at every systematic flora survey location. These included occasional targeted searches as appropriate, *e.g.* for birds and amphibians at selected water bodies.

Surveys within each Stratification Units

Survey techniques involving Elliott trapping, spotlighting, owl call playback, Anabat II recordings, Harp trapping and timed habitat searches were conducted throughout the study area. Survey effort overlapped with the location of flora quadrat sites, where possible, with the spatial extent of these works generally encompassing an area of 1 ha around these locations.

Survey Dates and Weather Conditions

Survey dates and the coinciding maxima – minima temperatures/ total rainfall will be reported along with the survey extent to assist the evaluation of survey effectiveness.

Fauna species identification and nomenclature

Fauna species were identified through visual and aural detection, and through traces, *i.e.* scats, tracks, chew marks *etc*. Fauna surveyors for this project are experienced experts at field identification of native fauna (**Appendix 1**). In addition, various field guides were used to assist with identifications. These are listed in the bibliography at the end of this report. The ultrasonic echolocation calls of microchiropteran bats were recorded using Anabat II Bat Detectors. Analysis of bat calls was undertaken by Mr Michael Welsh during the preparation of documentation for the approved Stage 1 MCP (Moolarben Biota, 2006) and Mr Mark Aitkens. Reference calls used were from Pennag *et al* (2000), the Forests NSW collection, and the personal libraries of Mr Mark Aitkens.

Nomenclature of native fauna species recorded conforms to Strahan (1995) for mammals, Lindsey (1992) for birds, and Cogger (1996) for reptiles and amphibians. Threatened species nomenclature conforms to that used by DECC.

Fauna species determination of status

The conservation significance of native fauna was determined according to schedules of the TSC Act and the EPBC Act.

4.5.4. Access Limitations

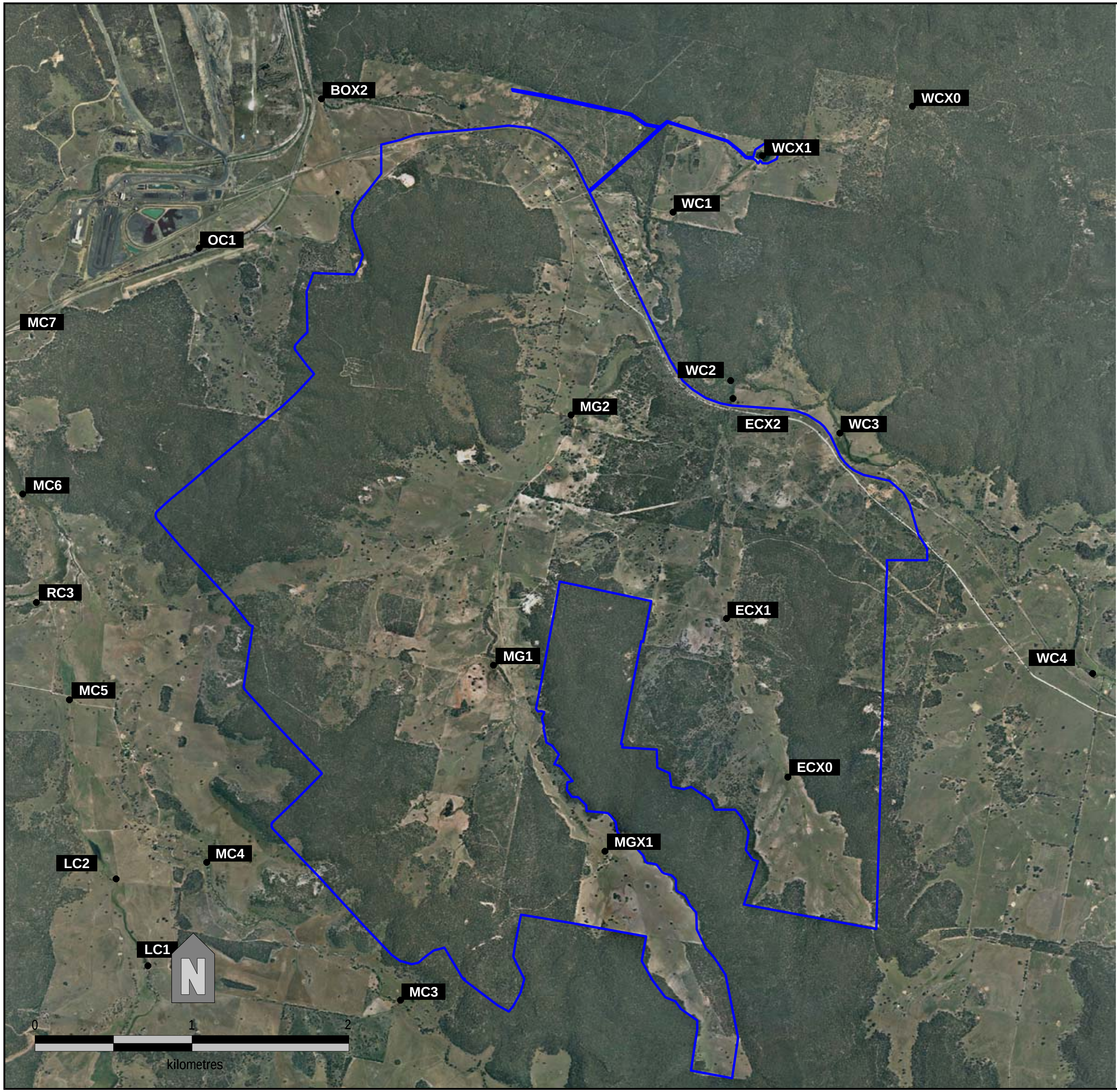
Formal requests for access to relevant properties contained within the study area were prepared and issued in writing to relevant landholders to gain lawful access to these lands for the purpose of completing field inspections and survey, with access provided to the study area for the majority of the time.

4.6. Aquatic Field Survey

The aquatic ecological study incorporated the following field assessment elements:

- An initial aquatic combined specialist scoping study survey was undertaken in October 2004 for the original combined mine plan (and a second combined specialist walkover was undertaken in May 2007). The initial walkover was undertaken to provide a basis for a quantitative aquatic ecology study design, to provide broad indications of potential aquatic ecological impact and to provide constraints and opportunity advice for preliminary plus final mine planning. The second walkover was undertaken to consider aspects of creek diversion for the Stage 2 Assessment.
- Additional field walkover assessments were made of overall aquatic ecological features (including location of possible aquatic groundwater dependent ecosystems (GDEs) - as per DLWC 2002), with walkovers based on analysis of current aerial photography plus topographic maps. An initial walkover of EL6288 was made in October 2004, with subsequent field walkover assessments undertaken during the seasonal aquatic ecology sampling surveys (see below). Final walkover surveys for the present EA were undertaken in May and October 2007, as detailed mine plans and creek diversion plans evolved.
- A field sampling model, utilising 46 sampling sites (including 30 sites for the Stage 1 MCP and 16 sampling sites for the Stage 2 MCP) was designed to separate out possible mining impacts from other catchment associated impacts. The 16 sites for the Stage 2 MCP portion of the proposed total set of sampling sites, derived from the preliminary sampling design are indicated in **Figure 4**.
- The aquatic ecology sites were assessed for overall aquatic habitat condition using a standardised Riparian-Channel-Environment (RCE) ranking scheme (Chessman et al 1997). At each site, the main stream health assessment method targeted aquatic macroinvertebrates, based on the AusRivAS protocol which specifies sampling in spring and autumn. This protocol follows the National River Process and Management Program River Bioassessment Manual methods as adapted for the National River Health Program; now referred to as the AusRivAS method (Turak et al 1999). AusRivAS surveys were supplemented with aquatic plant observations, physical water quality measurements and fish trapping. Searches plus habitat assessments were also made for Platypus and Native Water Rat.

As per AusRivAS protocols, aquatic macroinvertebrate communities are sampled using a 250 µm mesh dip net over as many aquatic 'pool edge' habitat types as could be located within each of the pools along



File: F1119_EA2_Fig4.WOR Date: 19 Nov 08 Drafter: MA

Legend

Study Area Boundary

● Site

FIGURE 4

Aquatic Ecosystem Sampling Sites

ECOVISION CONSULTING

Sources
Copyright Marine Pollution Research (2006)
Copyright GeoSpectrum Australia (2008)
Copyright Moolarben Coal Operations Pty Limited

the defined stream reaches. Net samples are then placed into white sorting trays for in situ live sorting. Live sorting (picking) is undertaken for up to 1 person-hour, also as per the AusRivAS protocol. Following cessation of live picking, further observations are made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms are collected and added to the dip net samples.

In the laboratory, taxonomic identifications for the retained macroinvertebrates from each sample jar (sample site) are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids (which are taken to sub-family). Collembola arthropods (spring-tails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we take them to sub-order classification level where possible. Crustaceans are taken to Family level where suitable keys are available. Ostracoda are left at Class level. The worm like taxa is shown at Phylum or Class level.

At all macroinvertebrate sampling sites at least two fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1 hour) and then retrieved. Fish trapping is supplemented by additional meshing and in-water observations (where possible). Any fish captured in the traps or as part of the macroinvertebrate dip netting are identified *in situ* and released. Any further observations of fish during the pool condition survey are noted with fish species-name only given if the fish can be positively identified.

A Yeo-Kal 911 water quality data logger was used to record pool water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. Basic pool dimensions and condition are recorded as are water flow and general water condition (e.g., colour, presence of algae etc). These latter data are combined with other stream data to produce a stream condition index for the site location. The stream condition index used in this report is one based on the RCE method (Petersen 1992, as reported by Chessman *et al* 1997) for the greater Hunter River catchment.

Aquatic plants were noted and where necessary collected for identification. Searches were made for Platypus and Native Water Rat, and the likelihood of these aquatic mammals being present was assessed by searching for suitable bank conditions, possible burrow sites or feeding stations and inspection of scats.

4.7. Groundwater Dependent Ecosystems

Potential Groundwater Dependent Ecosystems (GDEs) of the MCP study area were identified using the eight-step rapid assessment (DLWC, 2002), with those conforming to this assessment method described below in accordance with its associated broad GDE classification.

The eight-step rapid assessment process contained within *The NSW State Groundwater Dependant Ecosystem Policy* (DLWC, 2002) was used to identify and assess terrestrial, base flow and wetland GDEs within the study area. Assessment of GDE significance was made by examining the species composition, with high value GDEs represented by vegetation containing threatened biodiversity and/or regionally significant species.

Initial GDE identification was done by examining mapped vegetation units (i.e. vegetation formations) against their potential relationship with groundwater. Potential GDEs too small to map were assessed by overlaying the location of all known surface seepages with the native vegetation map for the study area. Wells Environmental Services supplied the location of known water seepages, which were collected during a field investigation with the relevant landholders using a hand held GPS location aid. Seepages coinciding with native vegetation such as ferns, sedges and other moisture affiliated species represent potential GDEs, which were then analysed to determine their status against the policy. Seepages occurring within disturbed agricultural landscapes having no native vegetation content have not been treated as GDEs.

4.8. Data Analysis

4.8.1. Qualitative Analysis - Vegetation

The vegetation of the study area was initially evaluated through community composition comparisons between the results acquired from EL6288 and relevant regional vegetation community profiles such as those defined by Keith (2004), HCR CMA (2006) and BioMetric (DECC, 2008). Regions considered in this analysis include the Hunter Central Rivers, Central West and Hawkesbury Nepean catchment management areas. This initial analysis is recognised as a broad scale overview to provide regional context, with greater resolution obtained thorough the use of objective statistical analytical techniques such as non-metric multidimensional scaling (MDS) non-parametric statistical analyses. This is a qualitative regional scale analysis and as such is less informative than the more detailed site-specific quantitative study undertaken here.

4.8.2. Statistical Analysis – Vegetation

In this assessment, a non-parametric multivariate statistical analysis was used to derive vegetation types from the flora quadrat samples, by clustering these samples according to their degree of similarity. This would allow for the vegetation in the study are to be compared with published classification (e.g. regional vegetation community descriptions and/or legal definitions such as EECs).

A preliminary statistical analysis involved an Agglomerative Hierarchical Clustering analysis of baseline flora data, with the final data analysis involving a Non-Hierarchical Clustering method. Both analyses used the Bray and Curtis/ Two-Step association measures to generate a dendrogram (i.e. classification tree) along with the use of non-metric multidimensional distance scaling (NMDS) techniques to graphically display these results (i.e. ordination plot) for the interpretation of data trends such as environmental gradients.

Software

The systematically collected data was analysed using PATN v3.3, a non-parametric statistical software package based on agglomerative clustering and non-metric multidimensional distance scaling (NMDS) (Belbin, 1989). PATN extracts and displays patterns in complex (multivariate) data, this being a particularly useful analytical technique for understanding ecological data such as vegetation plot data. It has been used in this assessment to aid the categorization of vegetation plot data (i.e. quadrat) for comparative classifications with published vegetation community descriptions.

PATN generates estimates of association (resemblance, affinity, distance) between any set of objects (e.g. quadrats) and their associated variables (e.g. species). PATN then classifies the objects into groups, condenses the information into three dimensions and displays the patterns in the data graphically. PATN also has a range of tools to assist in the evaluation of these patterns.

There are two basic classification techniques used in a PATN analysis, these being:

- Agglomerative Hierarchical Clustering Analysis; and
- Agglomerative Non-Hierarchical Clustering Analysis.

Hierarchical techniques examine and re-examine the association matrix– the relationships between all pairs of objects (or variables) (Belbin, 1989). Agglomerative hierarchical clustering, fusion or classification is traditional in pattern analysis, providing clustering results in the form of dendrograms which are useful in summarizing relationships. However in using hierarchy for each sample it follows that the more objects you have the more difficult it is to comprehend the dendrogram. It is for this reason that datasets with more than 50-100 objects represented within a dendrogram can be difficult to interpret.

Non-Hierarchical Clustering procedures produce groups of objects without a dendrogram, with group clusters intuitively defined by the level of association between these groups. This process optimizes the groups, not the hierarchy. Non-hierarchical techniques operate around the distances (associations) between each object and a set of group centroids and are recommended when the number of objects (or variables for a classification of variables) is greater than 50-100 (Belbin, 1989). Dendrograms are produced by re-analysing the group evaluation data via a Hierarchical Clustering Analysis.

Software Outputs

Dendrograms and ordination plots are the primary outputs from PATN generated associations, with these used to examine the data trends, if any. Dendrograms provide an understanding of how survey sites or group inter-relate (i.e. group clusters). Ordinations provide graphical representations of data spread where the ordination of these associations (i.e. similarity/ dissimilarity) can permit the interpretation of environmental gradients (i.e. factors influencing the distribution or occurrence of biota such as soil fertility or water). Evaluation data for each intrinsic and extrinsic variable were also calculated to aid the interpretation, these including

- Kruskal Wallis statistic (i.e. the higher the value, the more significant the variable in terms of discriminating capacity);
- Principal Component Correlation (PCC) (i.e. multiple linear regression that estimates a line that best corresponds with increasing values of a variable relative to objects);
- R^2 value (i.e. Coefficient of Determination - estimates the proportion of ‘common variation between’ two variables); and
- Monte-Carlo Attributes in Ordination (MCAO) (i.e. A permutation test that examines the reliability of the PCC results (i.e. R^2 value). Values less than 5% or 0.05 indicate a significant correlation for that variable).

The above evaluation data were used to identify intrinsic/ extrinsic variables that ‘reliably’ described the data, which in turn were used to interpret the data (i.e. separate the signal data from the noise). Mechanical intervention such as the removal of "noisy" data (i.e. outlier or non-informative data), was investigated in the classification to improve the signal strength in any data patterns (i.e. to achieve a lower statistical "Stress" value - see below), with data removal only undertaken where necessary. "Noisy" data generally include species and/or attribute variables that have restricted and/or widespread occurrences, as demonstrated by a low Kruskal Wallis and/or R^2 values.

Statistical "Stress" Levels

In the consideration of the results of non-parametric multivariate statistical analysis, the word ‘Stress’ will be used in its technical statistical sense with regard to the validity or interpretability of the statistical analysis. Stress ideally measures the relationship between environmental gradients (i.e. trends) and the sample space (e.g. native plant occurrence and/or abundance within a quadrat), which in the example given allows for the delineation of factors affecting the way plants associate with the landscape and/or each other. Reducing stress within the analysis with minimal mechanical data alterations is a primary objective (i.e. subjectively excluding quadrats and/or species representative of ‘noise’) as this approach seeks an improved relationship and hopefully greater ‘ecological sense'; a better understanding of the reasons determining plant distributions.

This measure is used to determine the validity or interpretability of ordination plots derived from non-parametric multivariate statistical analysis such as Agglomerative Hierarchical Clustering and Non-Hierarchical Clustering methods. It is often the case that an analysis of ecological data will result in a high stress level as signal patterns (i.e. trends) are generally complex (i.e. multidimensional relationships) and/or masked by ‘noisy’ data (e.g. data strongly or overly influenced by intrinsic environmental gradients and/ or extrinsic factors such as fire and disturbance). Notwithstanding, noise always exists in real datasets where the identification of truth is reliant on broad assumptions (Austin, 2002).

In this respect, it is widely accepted that a high stress level is defined by measures exceeding 0.15 with such stress levels indicative of ordination plots that are more random than trend related (Clarke, 1993). In such circumstances minor intuitive mechanical alterations of the dataset may be required (e.g. removal of obvious uninformative outlier data) to improve the interpretability of the analysis. However, in some cases no reliance on high stress data analysis can be drawn as ‘noise’ and/or data disjunctions may represent valid reasons for the resultant ‘random’ ordination plot (e.g. incomplete sampling).

Analysis of Quadrat Data

Data variables or intrinsic data collected for each sample location (i.e. quadrats) include species (i.e. plant) and an associated measure (i.e. cover abundance). Attribute data or extrinsic data for each sample location was evaluated included aspect, landscape position, soil type, geology and location (i.e. data used to interpret but not influence the results of the intrinsic data analysis).

A preliminary agglomerative hierarchical clustering analysis of intrinsic data for each quadrat was completed using the Bray and Curtis association measure and default PATN settings, this being the most appropriate measure for data matrices with a large number of zero data values (Belbin, 1989). The resultant ordination and stress level was examined to determine whether further analysis was required. Based on the number of quadrats included in the analysis (i.e. approximately 200 quadrats) and variables (in excess of 400 species) it was anticipated that a further non- hierarchical clustering analysis would be required as the ordination stress level for the hierarchical clustering analysis is likely to exceed 0.15 (i.e. stress exceeding this value relates to data of questionable goodness of fit).

Analysis initially focused on distinguishing between regional vegetation communities with regard to Keith (2004) that have known/ expected occurrences within or adjacent to the study area (http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/browse_veg.aspx). The Two-Step association measure was used for variables (i.e. species data) for the development of a two-way table defining groups (i.e. similar quadrats) and their components (i.e. species). Vegetation classifications are described from this two-way table.

4.8.3. Fauna Statistics

A statistical analysis of the systematically collected fauna survey data was completed using the Shannon Wiener index for the purpose of comparing fauna composition between vegetation foramtions. The higher the score the greater the species compostion for that vegetation formation. An Eveness score was also calculated, which considered the number of records within each vegetation formation, to provide an indication of the eveness of the data. The closer the Eveness score is to “1” the more even the data spread and was thus used to evaluate the Shannon Wiener index.

A spatial review of key habitat features such as trees with hollows and available water resources was also undertaken. These features were mapped and compared with other survey results such as the distribution of threatened species and vegetation communities including groundwater dependant ecosystems.

4.8.4. Analysis of EEC/CEECs

The vegetation communities as described above form the basis of defining the spatial extent of EEC/ CEEC within the study area. To determining whether a vegetation formation is included within the EEC/ CEEC definition vegetation classifications were examined in this assessment using qualitative methods through resources such as the listing advice for this ecological community and guidelines published by the NSW National Parks and Wildlife Services (NPWS, 2001) and Department of Environment and Heritage (DEH, 2007). Species defining the White Box Yellow Box Blakely’s Redgum Woodland and derived grasslands EEC/ CEEC are specified in State and Commonwealth listings (i.e. Final Determination by the NSW Scientific Committee 2002; Threatened Species Scientific Committee, 2006a).

Species that define EECs/CEECs were summed for each quadrat and were allotted into various classes for consideration against the criteria developed by DEWHA. These classes include:

- Dominant/ characteristic trees (i.e. White Box, Yellow Box, Blakely’s Redgum);
- Non-dominant trees;
- Grasses;
- Shrubs;
- Herbs;
- Important species; and
- Exotics.

These summed results were used in conjunction with other measures to assess the presence and distribution of WBYBBRW EEC/ CEEC.

4.9. Aquatic Biota Data Interpretation

The field site description data were quantified using a modified Riparian, Channel and Environment (RCE) inventory, using the RCE descriptors and scores (1 to 4) developed by Chessman et al (1997) for their study of the greater Hunter River catchment. For this study the RCE categories have been expanded by inserting a zero (null) score for each category to account for totally degraded stream characteristics. The RCE output is a set of scores representing the value of the creek section as aquatic habitat; ranging from 0 for totally degraded habitat to 52 for pristine and suitable aquatic habitat. These scores are also presented as percentages.

The AusRivAS macroinvertebrate data are in the form of taxa presence/absence at sites over time. The data have been summarised into tables showing individual site diversities per site per time which are then used to generate overall seasonal diversities. Given that not all sites are sampled over all times and that sampling conditions have been observed to be particularly variable from season to season, further statistical analysis has not been attempted.

Given the generally degraded condition of many of the sample sites plus the intermittent nature of remaining sites the data have not been subjected to AusRivAS analysis at this stage as it is considered that AusRivAS would not be sensitive enough to allow for meaningful within-site comparisons (as per Walsh 2006). Accordingly, the overall condition of the macroinvertebrate communities at each site have been analysed by assigning Stream Invertebrate Grade Number Average Level (SIGNAL) pollution tolerance scores for each taxa (Chessman 1995) and then computing a site SIGNAL index for each site/sampling period. SIGNAL analysis was found to provide overall more sensitivity for comparisons of degraded sites (Walsh 2006).

SIGNAL (Stream Invertebrate Grade Number Average Level) is an index for pollution tolerance for stream invertebrate animals. It is based on correlation analysis of aquatic invertebrate survey information with water chemical analysis and RCE scores for a wide range of different streams in NSW. Each invertebrate Family has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant). The water chemistry attributes generally used for pollution tolerance analysis are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus.

Once SIGNAL grades are assigned to the individual families found at the site (as binary presence-absence data), a site SIGNAL grade is derived by averaging the scores to provide an indication of the level of 'pollution' in the stream site at that time. Assessing the scores against actual site RCE scores plus against stream water chemistry over time provides a means of understanding which of the environmental variables are most likely to contribute to low scores at the site. Over time the combined assessments can also be used as a measure of site improvement via improved physical habitat conditions (RCE analysis) or improved water chemistry.

Individual taxa SIGNAL grades have been progressively refined since Chessman's' first published lists in 1995 (currently SIGNAL-2 values; Chessman 2003). However, Chessman et al (1997) published a comprehensive study of the macroinvertebrate fauna of the greater Hunter River catchment and provided revised SIGNAL grades for taxa in the Hunter River, termed SIGNAL-HU97. For the present study the HU97 grades as published have been adopted. For taxa where there were no published HU97 grades, published SIGNAL-2 grades have been used. The results tables provide both the HU97 and SIGNAL-2 grades for comparison.

4.10. Impact Analysis

The likely impacts arising from the proposed development were spatially and temporally analysed to establish the impact assumptions for this assessment. Impacts were described using area statements and terms such as ‘direct’, ‘indirect’, ‘temporary’ and ‘permanent’, with the overall classification of these impacts termed ‘Impact Intensity’.

4.10.1. Ecological "Risk" Analysis

The likely impacts attributed to the proposed development were used to identify/ refine the 'Subject Species', as required by DECC in the DGRs. Facilitating this was an ecological "risk" analysis, which conservatively evaluates the impact of the development by taking into consideration the intensity of the impact on a species habitat (i.e. likelihood – see also **Table 2**) and the effect on its occurrence (i.e. consequence – see also **Table 3**). This process of risk evaluation is based on the Australian Standard for risk management (AS/NZS 4360).

The ecological risk analysis was completed by attributing a 'Likelihood' and 'Consequence' label to each of the threatened biodiversity identified through database searches, spatial analysis, literature reviews and field survey. This analysis considered the extent of habitat values within the site, the extent of overlap between this habitat and the developments impacts and the legal status of the species. Threatened biodiversity having a preliminary ecological risk classification exceeding 'low' are considered 'Subject Species' for this assessment, with those classified as having low ecological risk regarded as inconsequential in terms of the development. Note that this analysis also in part validates the extent of field surveys applied to relevant threatened biodiversity identified in this report.

Impact Likelihood

Impact Intensity attempts to define the temporal and spatial extent of direct and indirect impacts on the receiving environment as they relate to threatened biodiversity. For the purposes of the ecological risk analysis, Impact Intensity was translated into a 'Likelihood' label, as defined in **Table 2**.

Table 2: Likelihood Scale

Likelihood Label	Description
A	Impact on known core and/or source habitat (e.g. breeding and foraging habitat)
B	Impact on known secondary and/or sink habitat (e.g. breeding or foraging only)
C	Impact on potential core and/or source habitat (e.g. breeding and foraging habitat)
D	Impact on potential secondary and/or sink habitat (e.g. breeding or foraging only)
E	Impact on habitats other than core/ secondary and/or source/ sink habitat.

Likelihood was calculated by comparing the broad habitat values and landscape attributes of the impact area against those prescribed for relevant threatened biodiversity. Landscape attributes were defined by the methods described in **Sections 4.1 – 4.6**. Broad habitat types, as guided by the literature, were categorised as follows:

- Known natural distributions including survey results;
- Geological preferences;
- Specific habitat requirements (e.g. aquatic environs, seasonal nectar, tree hollows etc);
- Climatic considerations; and
- Topographical preferences (e.g. ridgetops, coastal headlands, midslopes etc).

Impact Consequence

'Impact Consequence' defines the predicted response of a threatened species to impacts arising from the development, this ranging from 'no impact' to 'local extinction'. In the context of this assessment, consequence is directly related to the legal status of a species and is defined as follows in **Table 3**.

Table 3: Consequence Scale

Consequence Label	Predicted Event	Description
5	Locally Extinct	Classification applies to species listed as 'extinct' within the meaning of the TSC Act.
4	Extinction imminent	Classification applies to species listed as 'Critically Endangered' within the meaning of the TSC Act.
3	Extinction within 10 years	Classification applies to species listed as 'Endangered' within the meaning of the TSC Act.

2	Extinction within 50 years	Classification applies to species listed as 'vulnerable' within the meaning of the TSC Act.
1	No foreseeable extinction	Classification applies to species not listed as threatened within the meaning of the TSC Act.

The last classification described as 'no foreseeable extinction' relates to all species not classified as threatened. This is particularly relevant to undescribed species where it is likely there is limited knowledge of the species conservation status.

Subject Species Evaluation

Using the ecological risk analysis to evaluate the likely impact of development on threatened biodiversity permitted for a distinction between threatened biodiversity relevant to the assessment from those that are not (i.e. identification of Subject Species). The ecological risk analysis matrix used for this purpose is shown as follows in **Table 4**.

Table 4: Ecological Risk Matrix

Likelihood Label	Consequence Label				
	1	2	3	4	5
A	High	Extreme	Extreme	Extreme	Extreme
B	Medium	High	Extreme	Extreme	Extreme
C	Low	Medium	High	Extreme	Extreme
D	Low	Low	Medium	High	Extreme
E	Low	Low	Low	Low	Low

From the above table it is clearly apparent that both vulnerable and endangered species are considered 'Subject Species' where known and/or potential habitat is identified. Threatened biodiversity classified as having a 'Low' ecological risk rating are species that are unlikely to be impacted by the development (i.e. no known and/or potential habitat within the impact area), and are hence deemed irrelevant to the assessment.

Extinct species listed on the TSC Act that have historical affiliation with the region are considered on the assumption that knowledge on habitat values is likely to have been limited by an absence of records and/or any targeted research. Similarly, undescribed species likely to be impacted by the development will also receive consideration (i.e. ecological risk classification of A1 – High').

4.10.2. Assessment of Groundwater Dependant Ecosystems

Assessment of GDE significance was made by examining the species composition, with high value GDEs represented by diverse vegetation formations containing threatened biodiversity, regionally significant species and/or 'species 'unique' to the study area or locality.

Initial GDE identification was done by examining mapped vegetation units (i.e. vegetation formations) against their potential relationship with groundwater. Potential GDEs too small to map were assessed by overlaying the location of all known surface seepages with the native vegetation map for this assessment. Interpretations were aided/ enhanced by supporting surface and groundwater assessments conducted within the study area.

4.11. Impact Management

To achieve a 'Maintain and Improve' outcome for this proposed mine it is implied by virtue of the impact area that the impact management approach would occur at varying scales, these being direct local works to minimise disruption to local ecological processes and wider regional works to provide strategic outcomes (e.g. offsets and the like). The following describes the general approach adopted.

4.11.1. Local

A preliminary mine plan was reviewed to broadly delineate mine impacts on the biological environment. Lands containing aquatic and terrestrial ecological values (i.e. source biodiversity) were compared with this preliminary mine plan for the purpose of identifying avoidance areas, this being the primary impact management consideration. How these core landscape values are managed over the duration of mining activity and beyond (e.g. connectivity between rehabilitated landscapes, avoidance areas and adjoining conservation reserves) is the subject of any approval granted for Stage 2 of the MCP and the conditions contained there within. The contents of this report and submissions received by the consent authority (public and private) will be the basis for these conditions of consent.

Broader local issues such as connectivity between proximal conservation areas, riparian corridors (i.e. chain of ponds) and compatibility with other environment management works have formed part of the considerations presented in this report. The integration of research objectives into monitoring works have also been considered such as impact – response relationships, which in turn could enrich rehabilitation science both locally and regionally.

After the cessation of mining, MCMs would seek to have voluntary conservation agreements enforced over the rehabilitated landscape in order to ensure the proposed outcomes for the rehabilitated landscape would continue on post mining should the land not be accepted for dedication to the estate.

4.11.2. Regional

Impacts arising from mining activities that cannot be adequately addressed within the local context will require the consideration of a wider regional context to achieve the ‘Maintain and Improve’ objective. An emphasis will be placed on broad conservation initiatives such as those defined by DECCs threatened biodiversity ‘Priority Action Statements’. Regionally based impact management works will focus on impacts that cannot be satisfactorily managed at a local level. The mechanics and timing of regional impact management will be determined in consultation with the consent authority, relevant government agencies and land holders/ managers

5. DESCRIPTION OF STUDY AREA

5.1. Regional Setting

5.1.1. Bioregions and Catchments

Geographically the study area is located within a transitional zone between the western slopes of the Great Dividing Range and coastal NSW. The Ulan locality is situated in a lowly elevated saddle of the Great Dividing Range (i.e. approximately 500 m elevation), with elevation significantly increasing in both a northerly and southerly direction with the Mudgee – Cassilis district broadly representing the separation between the New England Tablelands and Central Tablelands.

The study area is located wholly within the Sydney Basin Bioregion, although it's location within this bioregion is close by two adjoining regions these being the South Western Slopes and Brigalow Belt South Bioregions. Whilst it is reasonable to expect the biological values of the study area to be reflective of the Sydney Basin Bioregion, influences from the adjoining bioregions is likely.

The study area is located at the western edge of the Hunter Central Rivers catchment management area (HCR CMA), more specifically in the Wilpinjong/ Wollar Creek, upper headwaters sub-catchment of the Goulburn River. The Great Divide is located approximately 10 km to the west the boundary of the greater Macquarie River catchment (i.e. Central West CMA). The Namoi CMA is located approximately 50 km to the north and Hawkesbury-Nepean CMA approximately 75 km to the south. As is the case with the study area's proximity to adjoining bioregions, there is also a close geographical relationship with proximal CMA's to the north, south and west.

Thus it is concluded that the study area has numerous transitional qualities at the regional scale with notable distinguishing characteristics including mid-elevations and bioregional convergence at the extremities of the Hunter River catchment.

5.1.2. Study Area Overview

The study area is located in the western end of the Hunter Valley at the headwaters of the upper Goulburn River catchment, with a large portion of these headwaters contained within the adjoining Munghorn Gap Nature Reserve and Goulburn River National Park. Goulburn River National Park adjoins most of the north-eastern boundary of the study area where it largely conserves dissected sandstone country. Munghorn Gap Nature Reserve represents the narrow vegetated peninsulas that jut into the study area southern boundary, with sandstone pagoda formations being a dominant feature of this area (NSW NPWS 2003). Both of these reserves are listed as National Heritage Areas under the Commonwealth EPBC Act.

The Goulburn River catchment is the largest sub-catchment of the Hunter River covering just under one third of the total Hunter River catchment (of 22,000 km2), with this catchment referred to as the region. The study area is approximately 8 km in length from north to south, and 7 km in width east to west containing an estimated 40 km^2 native vegetation cover. The Murragamba and Wilpinjong Creeks (all upper tributaries of the Goulburn River) drain most of the study area. The Goulburn River remains one of the few unregulated rivers flowing into the Hunter River.

The majority of the study area is characterised as gently undulating agricultural land throughout the valley floor and midslopes, with moderate sized stands of native woodland vegetation retained along the steeper hillsides and ridgelines and along locally important open depressions. Surrounding lands support similar vegetation patterns.

Soils of the valley floor consist of narrow quaternary deposits along the major creeklines adjoining outcropping Permian geological formations. Occasional conglomerate outcrops referred to as 'hard caps' are associated with 'tertiary channels', which occur as localised hills throughout the valley floor. Soils of the midslopes are generally derived from weathered Permian conglomerates and claystones, with the upper slopes typically characterised by Triassic sandstones. The ridgelines tend to have poor soil fertility due to the underlying Triassic geological formation (Narrabeen Sandstones). Basalt outcrops also occur in some areas, which give rise to locally fertile landscapes.

Land uses within the study area and region include agriculture (grazing, cropping), coal mining, extractive industries, waste disposal and transfer, road and rail corridors plus infrastructure, utility corridors (electricity, telecommunication), tourism, recreation and conservation. Grazing is the predominant agricultural activity in the study area. Coal mines are also a feature of the region - the Ulan Coal Mine adjoins the small village of Ulan centrally along the western boundary of the study area and the recently approved and now operating Wilpinjong Coal Project is located immediately to the east. (i.e. directly abutting the eastern boundary of the proposed OC4).

5.1.3. Local Climate

Baseline monitoring of air quality, surface waters, ground waters and acoustical conditions for the MCP study area have been ongoing since December 2004. Having regard to the local topographic, climatic conditions and elongated north-south extent of EL6288, two weather stations were installed, one in the village of Ulan (Met 1) and the other in the southern portion of the area on the Rayner property (Met 2). The area's climatic conditions are summarised as follows:

- Rainfall in the area is variable averaging 610 mm per annum at Ulan. Rainfall occurs throughout the year with a slightly higher seasonal distribution in summer. Intense showers, particularly in summer, characterise much of the rainfall and account for falls of up to 130 mm in 24 hour;
- On an annual basis the most common winds for the area are generally from the west and east with some winds from the northeast and east-northeast near Ulan and from the southwest in the south of the MCP area. This pattern of winds is evident in all seasons with winds from the west being more common in winter and spring;
- Hot weather is experienced in the area from October to April, with average maxima ranging from the high twenties to the low thirties. During the summer months, very hot conditions occur with temperatures ranging from 32^{o}C to more than 38^{o}C are not uncommon during these periods;
- Conditions during the other months of the year are milder, with average winter maxima about 10^{o}C cooler than summer temperatures. Overnight temperatures occasionally drop below freezing point;
- Frosts may occur from mid-April through to September and as late as mid-November. For the Ulan area, the average frequency of frosts is about 45 days per annum;
- The average daily ‘bright’ daylight period in the summer months is 9 hours and in the winter months 6 hours. The average annual evapotranspiration of the Ulan area is about 1730mm;
- The average relative humidity varies throughout the year, the winter months are typically about 20% more humid then in the summer months, most likely due to the hot dry winds during summer. During the daytime humidity varies significantly between 60 to 80% in the mornings and 40 to 60% in the afternoons for summer and winter respectively. There is little change in the relief of the humidity from mornings to afternoons throughout the year; and
- In summary the study area is described as having low variable rainfall patterns of average 610 mm per annum (i.e. recorded at Ulan). The average annual evapotranspiration of the Ulan area is high, at about 1730mm, with the comparatively wide differences between rainfall and evapotranspiration indicating the area to be a considerably dry locality.

5.1.4. Conservation Reserve Network

Stage 2 of the MCP is located at the headwaters of the Goulburn River in the Sydney Basin Bioregion, as shown in **Figure 1**. Nearby conservation reserves include Goulburn River National Park (725 km2 total area) to the north and west and Munghorn Gap Nature Reserve (61.5 km2 total area) to the south. Wollemi National Park (5,014 km2 total area), which forms part of the Greater Blue Mountains World Heritage Area, is approximately 35 km to the southeast of the study area.

Other conservation reserves within the general locality include those contained in the adjoining South Western Slopes Bioregion such as Yarrobil (13 km2), Dapper (5.6 km2), Goodiman (11 km2) State Conservation Areas and Avisford Nature Reserve (26 km2). The Brigalow Belt South Bioregion to the north contains the nearby Durridgere State Conservation Area (54 km2).

5.2. Spatial Database Analysis

The following discusses the review of spatial databases (i.e. geology, soil Landscapes, Mitchell landscapes) relevant to the study area. Assessment at this level is designed to:

1) Provide context for the assessment of the relevant value of the remnant native vegetation within the study area in terms of avoidance strategies; and

2) Assess the integration of the development with relevant regional impact management strategies.

This analysis is necessary to develop a satisfactory 'Maintain and Improve' outcome.

5.2.1. Mitchell Landscapes

Five Mitchell landscapes occur within the study area. **Table 5** summarises the proportional area contained within the study area and residual native vegetation cover throughout the entire extent of each Mitchell Landscape.

Table 5: Mitchell Landscapes of the Study Area

Landscape	Total Area of Mitchell Landscape (km²)	Portion in Study Area (km²)	Percent Cleared*	Estimated Existing Vegetation Cover (km²)
Lees Pinch Foothills	2,051.5	11.4	28%	1,477
Upper Goulburn Valleys and Escarpment	888.5	21.9	48%	462
Gulgong Ranges	1,883.5	6.2	71%	546
Liverpool Range Valleys and Footslopes	4,694.5	0.4	80%	939
Talbragar - Upper Macquarie Terrace Sand	936.55	0.7	93%	66

* According to the Hunter Central Rivers catchment management authority

Of these landscapes the Gulgong Ranges, Liverpool Range Valleys and Footslopes and Talbragar - Upper Macquarie Terrace Sand Mitchell landscapes are overcleared relative to benchmarks set for Mitchell landscapes (i.e. vegetation clearing exceeding 70% is considered overcleared). The Lees Pinch Foothills and Upper Goulburn Valleys and Escarpment Mitchell Landscapes are well represented in the adjoining conservation reserves (Goulburn River National Park and Munghorn Gap Nature Reserve).

5.2.2. Geology of the Study Area

The study area is predominantly characterised by the Permian and Triassic geological formations, these being sedimentary deposits consisting of mudstones, tuff/ chert, conglomerate, siltstones, coal and sandstone. Permian geological stratigraphy is found throughout the valley floor of the study area with the Triassic's largely restricted to the adjoining ridgelines and upper midslopes. A brief description for these formations is as follows:

Illawarra Coal Measures: Conglomerates, claystones, sandstone and coal formed in 'coal' swamp conditions.

Narrabeen Group: . Quartz-lithic to quartzose sandstone, conglomerate, mudstone, siltstone, and rare coal

Mapped/ unmapped occurrences of the Liverpool Range Volcanics geological formation also occur within the study area as scattered basalt outcrops, primarily in elevated positions along the western margin of the study area. These brecciated basalt outcrops give rise to locally fertile red soils, with increased fertility also observed throughout proximal lands located downslope and within connected drainage lines. Also contained within the study area are unmapped tertiary sand deposits (i.e. paleochannels) located centrally between Murragamba and Eastern Creeks south of the Wollar – Ulan Road.

5.2.3. Regional Vegetation Types

Keith (2004) regional vegetation classes mapped as occurring within the Ulan area and which may occur within the study area include those listed in Table 6.

Table 6: Keith (2004) Vegetation Classes within the Ulan Area

Vegetation Class	Native plant species richness	Native overstorey cover (%)	Native mid Storey Cover %	Native Groundcover (grasses) %	Native Groundcover (shrubs) %	Number of Trees with Hollows/ ha
Sydney Hinterland Dry Sclerophyll Forests	32	15-40	10-55	3-10	5-15	3
Western Slopes Dry Sclerophyll Forests	30	8-35	3-35	3-25	3-25	2
Western Slopes Grassy Woodlands	23	10-45	5-60	5-45	2-10	2
North-west Slopes Dry Sclerophyll Woodlands	35	25-40	11-50	5-45	5-30	3

BioMetric (DECC, 2007) specifies various vegetation formations within each of the above Keith (2004) vegetation classes. Due to the transition nature of the study area, many of the following vegetation formations known to occur within the Hunter Central Rivers, Namoi, Hawkesbury-Nepean and Central West CMAs may also occur within the study area (http://www.environment.nsw.gov.au/projects/BiometricTool.htm):

- Black Cypress Pine - Narrow-leaved Stringybark heathy woodland of the Brigalow Belt South;
- Blakely's Red Gum - Yellow Box - Rough-barked Apple grassy woodland of the Capertee Valley;
- Blakely's Redgum – Rough-barked Apple flats woodland of the NSW Western Slopes;
- Blue-leaved Ironbark heathy woodland of the southern part of the Brigalow Belt South Bioregion;
- Central Hunter Grey Box Ironbark Woodland;
- *Eucalyptus fibrosa*/ *Eucalyptus punctata* Woodland/ Open Woodland;
- *Eucalyptus punctata*/ *Eucalyptus dawsonii* Woodland;
- Grey Box - Blakely's Red Gum - Yellow Box grassy open forest of the Nandewar Bioregion and New England Tablelands;
- Grey Box - Narrow-leaved Ironbark shrubby woodland on hills of the Hunter Valley, North Coast and Sydney Basin;
- Grey Gum - Narrow-leaved Stringybark - Ironbark woodland on ridges of the upper Hunter Valley;
- Hunter Narrabeen Footslopes Exposed Ironbark Woodland;
- Narrow-leaved Ironbark - Grey Gum shrubby woodland on footslopes on the upper Hunter Valley;
- Redgum – Apple (183);
- Scribbly Gum - Brown Bloodwood woodland of the southern Brigalow Belt South;
- Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin;
- Upper Hunter Hills Narrabeen Exposed Stringybark – Ironbark Woodlands;
- White Box - Black Cypress Pine - Tumbledown Gum - Mugga Ironbark shrubby woodland in hills of the NSW central western slopes (Benson 272);
- White Box - Blakely's Red Gum - Yellow Box grassy woodland of the NSW South Western Slopes Bioregion (Benson 282);
- White Box shrubby open forest on fine grained sediments on steep slopes in the Mudgee region of the of central western slopes of NSW (Benson 273);
- White Box - Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley, Brigalow Belt South; and
- Yellow Box – Grey Gum – Redgum (190).

5.2.4. Regional Vegetation Cover

It is estimated that approximately 2,750 km^2 native vegetation cover occurs within a 50 km radius of the study area (GeoScience Australia, 2006), representing 35% of the total area within this arc. Approximately a third of this native vegetation cover is contained within conservation reserves (i.e. approximately 925 km^2). Native vegetation cover per geological formation is shown in Table 7 for this area.

Table 7: Proportion of Native Vegetation Cover on Geological Formations within 50km of the study area

Geological Formation (GeoScience Australia, 2006)	Native Vegetation Cover 50km radius (km^2)	Residual Native Vegetation Cover/ geological formation within 50km radius (%)	Native Vegetation Cover within Study Area (km^2)	Proportion of 50km radius Native Vegetation Cover in the Study Area (%)
Narrabeen Group	1433.5	89	11.7	0.8
Pilliga Sandstone	277.8	38	0	0
Illawarra Coal Measures	277.8	43	16.2	5.8
Chesleigh Group	115.8	26	0	0
Mount Knowles Group	86.9	71	0	0
Tannabutta Group	84.4	21	0	0
Purlawaugh Formation	82.1	44	0	0
Ulan Quartz Monzonite	63.9	54	0	0
Coogal Subgroup, Nea Subgroup	39.9	51	0	0
Adaminaby Group	33.2	50	0	0
Liverpool Range Volcanics	28.3	3	0*	0*
Digby/ Napperby Formation	21.0	55	0	0
Gulgong Granite	19.8	6	0	0
Kandos Group	18.9	48	0	0
Tucklan Formation	17.9	13	0	0
Shoalhaven Group	16.8	12	0	0
Crudine Group	16.8	11	0	0
Sand plain 38499	14.0	9	0	0
Mafic volcanic/intrusive	13.8	29	0	0
Alluvium 38485	13.4	2	0.07	0.5
Colluvium 38491	11.0	6	0	0
Rylstone Volcanics	10.7	22	0	0
Felsic to intermediate volcanic/intrusive	10.4	75	0	0
Singleton Supergroup	10.2	65	0	0
Home Rule Quartz Monzonite	7.6	10	0	0
Sediments 39484	7.3	7	0	0
Cunningham Formation	7.3	18	0	0
Tallawang Granite	2.7	53	0	0
Coomber Formation	2.6	2	0	0
Felsic intrusives 42016	2.5	34	0	0
Queens Pinch Group	1.8	3	0	0
Havilah Granite	0.8	15	0	0
Sofala Volcanics	0.5	8	0	0
Mafic intrusives 42182	0.2	2	0	0
Mafic intrusives 42017	0.2	2	0	0
Pyangle Pass Granite	0.1	1	0	0

* Note: There are no mapped occurrences of this geological formation in the study area despite the presence of Tertiary Basalt.

Geological formations of volcanic or igneous origin (e.g basalts and granites) are consistently overcleared presumably in response to the agricultural suitability of these areas. Conversely, there is a relatively high percentage of vegetation cover on lands with sedimentary based geological formations (i.e. low fertility), particularly the Triassic sandstones and conglomerates (e.g. Narrabeen Group). Such vegetation cover is well represented in the conservation reserve network, with more fertile landscapes not so well represented (e.g. Liverpool Ranges Volcanics).

The proportion of native vegetation coverage per Mitchell landscapes with a 50 km radial arc of the study area is indicated in Table 8.

Table 8: Proportion of Vegetation Cover per Mitchell Landscape within 50 kms of the study area

Mitchell Landscape	Native Vegetation* within 50 km (km^2)	Total Native Vegetation*/ Mitchell Landscape within 50 km (%)	Native Vegetation* Study Area (km^2)	Native Vegetation*/ Mitchell Landscape 50 km radius (%)	Native Vegetation* (study area)/ Native Vegetation* (Mitchell Landscape) (%)
Lees Pinch Foothills	612.3	12.3	9.1	41.4	1.5
Gulgong Ranges	377.6	7.6	5.1	69.2	1.4
Upper Goulburn Valleys and Escarpment	243.0	11.0	13.5	52.6	5.5
Talbragar-Upper Macquarie Terrace Sand	52.1	3.1	0.05	78.8	0.1

* Note: Estimate derived from spatial analysis of Mitchell Landscapes and vegetation cover GeoScience (2006).

Table 8 indentifies each of the Mitchell Landscapes contained within the study area as having a proportionally higher extent of native vegetation cover within 50 km of the study area relative to their overall extent. Both the Gulgong Ranges and Talbragar-Upper Macquarie Terrace Sand Mitchell Landscapes are overcleared Landscapes, with native vegetation cover located on these landscapes within the study area considered important but not significant (i.e. significant if greater than 5.0% cover). However, it is considered that the occurrence of 5.5% native vegetation cover on the Upper Goulburn Valleys and Escarpment Mitchell Landscape within the study area represents a significant proportion of this landscape.

5.3. Literature Review

5.3.1. Floristic Biota

Flora surveys and impact assessment were completed in 1983 to support an EIS assessing the impacts of an expansion to the existing Ulan coal mine. Seven vegetation types were identified during that survey, with a summary of these provided in Table 9.

Kinhill Stearns Engineers (1983) prepared studies to support the further development of the Ulan Coal Mine soon thereafter the gazettal of the EP&A Act, with flora and fauna impact assessments relating to the schedules of the *National Parks and Wildlife Act 1974*. At that time, none of the species or communities found within the surveyed area was a listed threatened species, with subsequent changes to the legislation and threatened species listings starkly contrasting with this earlier planning context. The report indicates WBYBBR EEC was likely to occur within communities 3, 4, 5 and possibly 7.

Table 9: Vegetation Communities of the Ulan Coal Mine area (1983)

#	Vegetation Name	Description
1	Woodland (Ridgetops)	Canopy dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*), Blue-leaved Stringybark (*E. agglomerata*), Dwyer’s Redgum (*E. dwyeri*), Caleys Ironbark (*E. caleyi*), Brown Stringybark (*E. eugenoides*) and Black Cypress Pine (*Callitris endlicheri*). Understorey consisting of *Melaleuca uncinata, Hakea dactyloides, Acacia brownii, Grevillea sericea, G. floribunda, Persoonia linearis, Oxylobium ilicifolium, Cassinia laevis.*

#	Vegetation Name	Description
2	Woodland – Open Forest (Talus Slopes)	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Forest Redgum (*E. tereticornis*), Dwyer's Redgum (*E. dwyeri*), Brown Stringybark (*E. eugenoides*) and Blakely's Redgum (*E. blakelyi*). Understorey consisting of *Casuarina littoralis, Acacia linearifolia, M. uncinata, Hakea dactyloides, C. endlicheri, Persoonia linearis, Cassinia laevis.*
3	Cleared (mainly valley floor)	Canopy dominated by scattered Rough-barked Apple (*A. floribunda*). Understorey consisting of *Acacia linearifolia, Cassinia laevis* and groundcover native grasses (e.g. *Stipa, Danthonia*).
4	Cleared (Valley floor)	Canopy dominated by Yellow Box (*E. melliodora*) and Rough-barked Apple (*A. floribunda*). Understorey consisting of *Acacia linearifolia, Cassinia laevis* and grasses.
5	Open Woodland (Talus Slopes–Partly Cleared)	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Brown Stringybark (*E. eugenoides*), Yellow Box (*E. melliodora*) and Rough-barked Apple (*Angophora floribunda*). Understorey consisting of *Acacia linearifolia, Cassinia laevis* and grasses.
6	Open Woodland (Talus Slopes–Partly Cleared)	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Dwyer's Redgum (*E. dwyeri*) and Blakely's Redgum (*E. blakelyi*). Understorey consisting of *Casuarina littoralis, Acacia linearifolia, A. polybotrya, C. endlicheri.*
7	Open Woodland (Valley Floor)	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Inland Scribbly Gum (*E. rossii*), Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*). Understorey consisting of *C. littoralis* and *A. linearifolia.*

Vegetation mapping by the NPWS established for Goulburn River National Park definitions for at least 14 vegetation communities as defined in the following table.

Table 10: Vegetation Communities of the Goulburn River National Park (NPWS, 2000)

#	Vegetation Name	Description
1	Ironbark Open Forest on Sandstone	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Blue-leaved Ironbark (*E. nubila*), Broad-leaved Ironbark (*E. fibrosa*), Stringybark (*E. sparsifolia*) and Black Cypress Pine (*C. endlicheri*) with a shrubby understorey. Sheoak (*Allocasuarina gymnanthera*) dominates the shrub stratum. Occurs on ridgetop plateaus with shallow to skeletal soils.
2	Sheltered Open Forest Complex	Canopy dominated by Grey Gum (*E. punctata*), with canopy associates of varying abundance including Redgum (*E. blakelyi, E. tereticornis*) and Stringybark (*E. sparsifolia / E. agglomerata*). Shrub stratum well developed. Located on protected slopes and gullies and is widespread.
3	Exposed Open Woodland	Open woodland canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Caley's Ironbark (*E. caleyi*), Broad-leaved Ironbark (*E. fibrosa*) and Black Cypress Pine (*Callitris endlicheri*) with a shrubby understorey. Canopy associates of varying abundance include Bloodwood (*Corymbia amphistomatica*), Inland Scribbly Gum (*E. rossii*) and Grey Gum (*E. punctata*).
4	Narrow-leaved Ironbark Open Forest	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*) and Rough-barked Apple (*A. floribunda*), with canopy associate including Grey Gum (*E. punctata*). Shrub stratum poorly developed. Grassy/ herb rich groundcover dominates understorey.
5	Slaty Gum Open Forest	Canopy dominated by Slaty Gum (*E. dawsonii*) and Grey Box (E. *moluccana*). Canopy associates include Narrow-leaved Ironbark (*E. crebra*), Broad-leaved Ironbark (*E. fibrosa*), Brown Stringybark (*E. eugenoides*) and Black Cypress Pine (*C. endlicheri*). Limited occurrence on Narrabeen clays.
6	Open Forest on Pilliga Sandstone	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Broad-leaved Ironbark (*E. fibrosa*) and Brown Bloodwood (*C. trachyphloia*). Shrub stratum well developed. Occurs on ridgetops and plateaus.
7	Apple Alluvial Open Forest	Canopy dominated by Rough-barked Apple (*A. floribunda*), with canopy associates of varying abundance including Narrow-leaved Ironbark (*E. crebra*), Box's (*E. melliodora, E. albens*) and Redgum (*E. blakelyi, E. tereticornis*). Inland Scribbly Gum (*E. rossii*) and Grey Gum (*E. punctata*) occur in sandier soils with a more pronounced shrub stratum.

#	Vegetation Name	Description
8	Munghorn Sheltered Open Forest	Found on broad depressions, stream banks and sandy alluvial deposits. Canopy dominated by Grey Gum (*E. punctata*), Blue-leaved Stringybark (*E. agglomerata*), Stringybark (*E. sparsifolia*) and Black Cypress Pine (*C. endlicheri*). Shrub stratum well developed. Located on sheltered slopes and gullies.
9	Low Open Forest – Scrub Complex	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Broad-leaved Ironbark (*E. fibrosa*), Stringybark (*E. sparsifolia*) and Bloodwood (*C. amphistomatica*). Shrub stratum well developed including *Hakea, Callitris*, *Melaleuca* and *Allocasuarina*. Occurs on ridgetops and plateaus in the Wollar Creek catchment.
10	Scribbly Gum Woodland (Valley Floor)	Canopy dominated by Inland Scribbly Gum (*E. rossii*), in association with Ironbarks and Bloodwoods. Shrub stratum well developed. Occurs on broad sandy flats in the Wilpinjong area.
11	White and Grey Box Woodlands	Canopy dominated by Box (*E. albens* and *E. moluccana*). Canopy associates include Yellow Box (*E. melliodora*), Blakely's Redgum (*E. blakelyi*) and Fuzzy Box (*E. conica*). Understorey grassy, except for some basalt areas where White Cypress (*C. glaucophylla*) may occur. Located on basalt caps and basalt derived alluvial flats.
12	Callitris Alluvial Open Forest	Canopy dominated by Black Cypress Pine (*C. endlicheri*) on deep alluvial sands. Canopy associates include Grey Gum (*E. punctata*) and Rough-barked Apple (*A. floribunda*). Understorey consisting of *Acacia linearifolia* and grasses.
13	Dry Rainforest in Sandstone Gorges	Canopy dominated by Figs (*Ficus* sp.) and Grey Myrtle (*Backhousia mytifolia*). Emergent canopy includes Grey Gum (*E. punctata*) and Brown Stringybark (*E. eugenoides*). Shrub stratum well sparse. Located on protected south facing gullies along creek lines.
14	River Oak Riparian Forest	Canopy dominated by River Oak (*Casuarina cunninghamiana*) on sandy alluvial soils. Shrub stratum generally absent.

Communities 7 and 11 may in part be classified as belonging to the WBYBBRW EEC as they both contain one or more of the characteristic canopy dominant and a grassy/ herbaceous understorey.

Resource Strategies (2005) prepared an EIS for the proposed Wilpinjong Coal Project located adjacent to the study area's eastern boundary. The associated flora study identified a number of vegetation communities, as shown in the following table**.**

Table 11: Vegetation Communities within the Wilpinjong Coal Project (Resource Strategies, 2005)

#	Vegetation Name	Description
1	Yellow Box – Blakely's Redgum Woodlands	Canopy dominated by Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*). Canopy associates of varying abundance including Rough-barked Apple (*A. floribunda*) and/or Grey Box (*E. moluccana*). Blakely's Redgum (*E. blakelyi*) dominates wetter creeklines with Rough-barked Apple (*A. floribunda*) occurring on the periphery.
2	Coast Grey Box Woodlands	Canopy dominated by Grey Box (*E. moluccana*). Canopy associates include Narrow-leaved Ironbark (*E. crebra*), Rough-barked Apple (*A. floribunda*) and Black Cypress Pine (*C. endlicheri*). Occurs upslope of community 1, in drainage lines and gentle slopes of valleys.
3	Rough-barked Apple Woodland	Canopy dominated by Rough-barked Apple (*A. floribunda*), with canopy associates including Narrow-leaved Ironbark (*E. crebra*) and Black Cypress Pine (*C. endlicheri*). Occurs on slopes, rises and hills of the valley floor.
4	Narrow-leaved Ironbark Forest	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*) and Black Cypress Pine (*C. endlicheri*). Canopy associates include Rough-barked Apple (*A. floribunda*), Red Stringybark (*E. macrorhyncha*) and Caley's Ironbark (*E. caleyi*). Occurs on gravely soils of the lower slopes.
5a	Grassy White Box Woodlands	Canopy dominated by White Box (*E. albens*). Canopy associates include Grey Box (*E. moluccana*) and Black Cypress pine (*C. endlicheri*). Permian clay hills, north-facing colluvial footslopes of sandstone ranges.
5b	Shrubby White Box Woodlands	Canopy dominated by White Box (*E. albens*). Canopy associates include Grey Box (*E. moluccana*), Narrow-leaved Ironbark (*E. crebra*), Rough-barked Apple (*A. floribunda*) and Black Cypress pine (*C. endlicheri*). East, south and west facing lower and mid slopes of

#	Vegetation Name	Description
		sandstone ranges, dry elevated flats on sandstone ranges.
6	Sandstone Range Shrubby Woodlands	Canopy dominated by Narrow-leaved Ironbark (*E. crebra*), Blue-leaved Stringybark (*E. agglomerata*), Broad-leaved Ironbark (*E. fibrosa*), Stringybark (*E. sparsifolia*), Grey Gum (*E. punctata*), Slaty Gum (*E. dawsonii*) and Black Cypress Pine (*C. endlicheri*). Occurs on the upper slopes and ridges.
7	Cleared Agricultural Land	N/A. Occurs on the Permian soils of the valley floor.
8	Secondary Shrubland	*Acacia ixiophylla*, *A. implexa, A. linearifolia Bursaria spinosa*, *Cassinia quinquefaria*. Recently cleared lands of the sandstone range footslopes.

While 403 flora species were found within the Wilpinjong study area, none were listed as threatened at the time of publication (Resource Strategies, 2005). However, two regionally significant species were recorded during the survey, these being *Boronia angustisepala* and *Gonocarpus longifolius*. Both are listed as rare nationally in *Rare or Threatened Australian Plants* (ROTAP) (Briggs and Leigh, 1996). Neither species was recorded within the area to be disturbed by the Wilpinjong mine, with their occurrence restricted to the upper slopes of the Sandstone Range Scrubby Woodlands vegetation community.

In addition, one potential new species of Yellow Buttons, *Chrysocephalum* sp. was recorded in Sandstone Range Scrubby Woodlands vegetation community in the south-west of the Wilpinjong project area. Similarly, it is reported that this species of uncertain taxonomic identity will not be adversely impacted by the Wilpinjong mine (Resource Strategies, 2005).

International Environmental Consultants (2005) assessed within the context of an EIS the proposed Wollar to Wellington 330kV power line. A Species Impact Statement (SIS) prepared in support of the EIS (Cumberland Ecology, 2006) addressed a variety of issues pertaining to threatened species and endangered ecological communities. A portion of this transmission line traverses the study area along Wilpinjong Creek, with vegetation classifications noted along this length of the powerline easement described in Table 12.

Table 12: Vegetation Communities of the Wollar to Wellington 330kV transmission line (2005)

#	Vegetation Name	Description
1	Black Cypress Pine - White Box	Canopy dominated by Black Cypress Pine (*C. endlicheri*) and White Box (*E. albens*). Canopy associates include Tumbledown Redgum (*E. dealbata*). Understorey sparsely shrubby with *Hibbertia obtusifolia* and *Cassinia* sp. Occurs on granite-derived soils
2	White Box – Inland Grey Box	Canopy dominated by Box (*E. albens* and *E. microcarpa*). Canopy associates include Blakely's Redgum (*E. blakelyi*) and Rough-barked Apple (*A. floribunda*). Understorey grassy, with shrubs less than 5% cover.
3	Black Cypress Pine – Tumbledown Redgum	Canopy dominated by Black Cypress Pine (*C. endlicheri*) Box and Tumbledown Redgum (*E. dealbata*). Understorey shrubby, with grasses such as *Aristida* spp. common throughout. Located on granitic hilltops.
4	Black Cypress Pine – Broad-leaved Ironbark	Canopy dominated by Black Cypress Pine (*C. endlicheri*) and Broad-leaved Ironbark (*E. fibrosa*). Other canopy associates include Inland Scribbly Gum (*E. rossii*), Dwyer's Redgum (*E. dwyeri*), Narrow-leaved Ironbark (*E. crebra*) and Blue-leaved Stringybark (*E. agglomerata*) and with a shrubby understorey containing Sheoak (*A. gymnanthera*). Occurs on ridgetop plateaus with shallow to skeletal soils.
5	River Redgum Riparian Forest	Canopy largely absent. Occurs along creeklines.

Also completed were detailed surveys for the uncommon Narrow-leaved Goodenia (*Goodenia macbarronii*), a small annual herb found mostly in moist drainage lines on clays and shale derived alluviums. Other species considered potentially occurring within the transmission easement that were assessed in the SIS include the Capertee Stringybark (*Eucalyptus cannonii*), *Bothriochloa biloba*, *Dicantheum setosum* and *Zieria obcordata*.

From the above local studies and from the studies conducted for Stage 1 of the MCP, the following general vegetation descriptions apply to the MCP Stage 2 study area.

Valley Floor and Riparian Corridors

Woodland and open forest vegetation throughout the predominantly cleared valleys are generally restricted to remnants located along creek lines and road corridors. Some areas of remnant vegetation also exist as isolated patches within the agricultural landscape. Many of these remnant woodlands and forests are floristically variable due to geological and soil moisture influence, with some being characterised by Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*). Woodlands dominated by Rough-barked Apple (*Angophora floribunda*) are commonly found along the creek lines, often in association with Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*). The adjoining sandy terraces that overlie the Permian geological formation also host monotypic communities dominated by Rough-barked Apple (*A. floribunda*). More clayey soils support Grey Box (*E. moluccana*) dominated communities.

Midslopes

Located on the drier midslopes are highly weathered landscapes consisting of low to moderately fertile soils derived from claystones, colluvial deposits and/or eroded basalts. The various soils support woodlands dominated by a variety of eucalypts including Ironbarks, Grey Box (*E. moluccana*) and Slaty Box (*E. dawsonii*) with a sparsely grassy understorey diverse shrub mid stratum.

Immediately upslope of this vegetation, near the footslope of the adjoining plateaus and their midslopes, are ironbark forests dominated by a combination of Narrow-leaved Ironbark (*E. crebra*) and Broad-leaved Ironbark (*E. fibrosa*). Black Cypress Pine (*C. endlicheri*) is equally as common and occasionally forms a co-dominant canopy species. Other canopy species may include Mugga Ironbark (*E. sideroxylon*), Red Stringybark (*E. macrorhyncha*), Narrow-leaved Stringybark (*E. sparsifolia*) and Grey Gum (*E. punctata*) with their presence dependant on topographic position and soil type.

Steep mid slopes with claystone derived soils in general are comparably fertile relative to the adjoining sandstone/ conglomerate derived soils. This landscape supports vegetation dominated by White Box (*E. albens*), particularly on western to southwest facing slopes. The shrub understorey is predominantly characterised by species of the Epacridaceae family (i.e. sclerophyllous prickly species). The groundcovers are equally as sparse and consist of grasses and herbs.

Ridgetops

The majority of the ridgelines throughout the locality are vegetated on soils with poor fertility due to the underlying Triassic geological formation (Narrabeen Sandstones). Two tree canopy dominants occur throughout this landscape, these being Scribbly Gum (*E. rossii*) and Broad-leaved Ironbark (*E. fibrosa*). Shale enriched sandy soils are generally characterised by Ironbarks such as Narrow-leaved Ironbark (*E. crebra*) and Broad-leaved Ironbark (*E. fibrosa*). Grey Gum (*E. punctata*) and Stringybark (*E. sparsifolia*) also occur in association with these species. The predominantly shrubby understorey of this broad vegetation class is mostly dominated by prickly sclerophyllous species such as *Acrotriche rigida.* Black Cypress Pine (*C. endlicheri*) also occurs as an associate canopy species with the Ironbark dominated vegetation or as canopy dominant where the sandy soils are shallow to skeletal.

Shallow sandier infertile soils generally support woodland vegetation dominated by Scribbly Gum (*E. rossii*) and Narrow-leaved Ironbark (*E. crebra*), particularly in the northern parts of the study area. Rocky outcrops throughout these landscapes support localised occurrences of mallee dominated by Dwyer's Redgum (*E. dwyeri*) and various heath species. Creek lines within these landscapes are generally characterised by Scribbly Gum (*E. rossii*) and Parramatta Redgum (*E. parramattensis* ssp. *parramattensis*), particularly in the first order ephemeral drainage lines. Semi-permanent creeklines are generally supportive of Scribbly Gum (*E. rossii*), Rough barked Apple (*A. floribunda*) and Blakely's Redgum (*E. blakelyi*). Rocky outcrops upslope of these creek lines often support associations containing Blue-leaved Stringybark (*E. agglomerata*).

Basalt derived soils are dominated by scattered White Box (*E. albens*) with rich grass and herb diversity and few shrubs, which contrasts with adjoining vegetation types.

5.3.2. Fauna Biota

The seasonally based field surveys conducted between December 2004 and July 2008 recorded 256 fauna species, including 37 mammals (8 introduced species), 170 birds (3 introduced species), 32 reptiles and 17 amphibians (Moolarben Biota, 2006 and this study).

The study area contains fauna species associated with a diverse range woodland types that occur on the tablelands, western slopes and sub coastal districts. The proximity of the study area to the coast (i.e. approximately 200 km) has not inhibited the occurrence of fauna species with sub coastal distributions, which is due in part to the relatively low elevation of the Great Dividing Range at this location (i.e. approximately 500 m AHD). Similarly, many fauna species exhibiting distributions throughout the western slopes of the Great Dividing Range also exist within the study area (Moolarben Biota, 2006).

Fauna of the Ridgelines

In general, native vegetation of the ridgelines is relatively continuous and undisturbed consisting mostly of woodlands on infertile soils derived from Triassic sandstone geological formations. These conditions have biased fauna composition with bird species being the most regularly observed fauna group throughout the dry ridgetop woodlands and forests due to their highly mobile capabilities (i.e. high movement for sustainable foraging). The Birds Australia (2008) database for the Hunter Central Rivers CMA indicates the presence of 268 species throughout the Narrabeen geological formation representing approximately 87% of the non-marine/ wetland bird species within this region. However, local communiuty composition for reptiles, mammals and amphibians were comparatively lower (Moolarben Biota, 2006).

Birds throughout this part of the study area are typical of dry sandstone environments of limited water and foraging resources. Birds are typically small, wide ranging generalist species capable of utilising patchily distributed resources. Commonly observed species included the Striated Pardalote, Rufous Whistler, Superb Fairy-wren, Eastern Spinebill, Red Wattlebird, Black-faced Cuckoo-shrike, Eastern Yellow Robin, Brown Treecreeper, Olive-backed Oriole and Grey Shrike-thrush. Many of these species often formed roving cohorts throughout the shrub and sub-tree canopy. Larger bird species were also regularly seen throughout this area including the Glossy-black Cockatoo and Yellow-tailed Black Cockatoo (Moolarben Biota, 2006). Owls also occur throughout this landscape including the Boobook Owl, Powerful Owl (Moolarben Biota, 2006) and Masked Owl (Birds Australia, 2008).

The dry, rocky terrain has limited ground habitat complexity for mammals and amphibians. These harsh dry environments were generally suited to reptiles including Bearded Dragon, Mountain Dragon, Copper-tailed Skink, Stone Gecko and Red-naped Snake. However, rock cover suitable to sheltering reptiles was sporadic and unexpectedly limited in the south, with the limited extent of this habitat feature throughout this area substantially influencing local reptilian distributions (Moolarben Biota, 2006).

Ground mammals generally consisted of large wide ranging species such as Red-necked Wallaby, Eastern Grey Kangaroo and Echidna. Few smaller mammals such as Antechinus were observed despite intensive trapping. Arboreal species included Sugar Glider, Common Ringtail and Common Brush-tail Possums, with the latter comparatively abundant (Moolarben Biota, 2006).

Fauna of the Valley Floor

A varied disturbance history occurs throughout this landscape for the locality and the Hunter Central Rivers CMA including agriculture (grazing, cropping), coal mining, extractive industries, waste disposal and transfer, road and rail corridors plus infrastructure, utility corridors (electricity, telecommunication), tourism and recreation, resulting in habitat loss, fragmentation and simplification. The natural regeneration of native vegetation is also evident in selected areas that have been largely excluded from local land uses. The impact of land clearing and agriculture on native vegetation cover and fauna habitats throughout this area has led to a predominance of generalist coastal and western fauna species such as the Red-browned Treecreeper, Bar-shouldered Dove, Brown Falcon, Nankeen Kestrel, Red-rumped Parrot, Red-capped Robin, Zebra Finch, Dusky Woodswallow, Striped Honeyeater, White-plumed Honeyeater, White-winged Triller, Singing Bushlark, Emu, Spiny-checked Honeyeater, White-browed Babbler, Galah, Eastern Rosella, Pied Currawong, Australian Magpie, Australian Raven, Richards Pipit, Willie Wagtail and various Thornbills (Birds Australia, 2008).

Isolated patches of relatively diverse fauna communities are mostly restricted to the larger less disturbed vegetation remnants and vegetated edges of the adjoining midslopes. These areas consist of species common to the disturbed landscapes, as previously described, in addition to various sensitive woodland species such as Diamond Firetail, Restless Flycatcher, Speckled Warbler, Southern Whiteface, White-winged Triller, Crested Shrike-tit, Jacky Winter and Rufous Songlark (Moolarben Biota, 2006). Locally, the Permian geological formation appears to represent source habitat for species such as Barn Owl, Black-chinned Honeyeater, Fuscous Honeyeater, Stubble Quail, Plum-headed Finch and Southern Whiteface (Birds Australia, 2008).

Reptiles other than common wide ranging species such as Lace Monitor, Red-bellied Black Snake, Brown Snake and Bearded Dragon were generally absent from the cleared parts of the valley floor. Increased species richness occurred only in isolated patches were suitable shelter habitats was sufficiently high and/or complex such as isolated rock outcrops associated with the Marangaroo conglomerates. Reptiles were frequently encountered north of the Ulan – Wollar Road where ground habitat such as rock cover was relatively high (Moolarben Biota, 2006).

Fauna of the Midslopes

Midslope vegetation consists of Sedimentary Ironbark Forests and Box Woodlands (i.e. Shrubby White Box Woodland). Fauna assemblages within the Sedimentary Ironbark Forests, which also dominated the adjoining ridgelines, were similar to those throughout the dry sclerophyll woodlands north of the Ulan Wollar Road. However, bird species observed in greater abundance throughout this part of the Study Area include Brown Treecreeper, Glossy Black-cockatoo, Rock Warbler, Sacred Kingfisher, Pallid Cuckoo and Weebill (Moolarben Biota, 2006).

Reptiles, amphibians and mammals were infrequently observed throughout the Sedimentary Ironbark Forests due to the limited availability of suitable foraging and shelter resources. However, the vegetation of this landscape offered the highest density of arboreal mammals such as the Common Ring-tail and Brush-tail Possums. Amphibian species were primarily restricted to the Banjo Frog, a burrowing species specialised in surviving dry environments (Moolarben Biota, 2006).

Honeyeaters were most commonly encountered throughout the Box Woodlands, either on the valley floor or adjoining midslopes. Frequently observed resident honeyeaters include Noisy Friarbird, White-naped Honeyeater, White-headed Honeyeater, Yellow-faced Honeyeater, White-eared Honeyeater, Red Wattlebird, Eastern Spinebill and Spiny-cheeked Honeyeater. Infrequent seasonal species included the Painted Honeyeater, Stripped Honeyeater and Singing Honeyeater. Roaming through the shrubbier Box Woodlands on the midslopes were bird cohorts including various thornbills, Weebill, Golden and Rufous Whistler, Jacky Winter and Grey Shrike-thrush (Moolarben Biota, 2006).

Fauna Habitat

A range of broad fauna habitat classes occurring throughout the locality provide opportunity for a range of faunal activity. Habitat classes are listed as follows:

- Woodland and open forest tree canopy dominated by Eucalypt species of dry sclerophyll environs;
- Open to dense shrublands Asteraceae (Daisy's) and Mimoisodaceae (Wattles);
- Sparse to open groundcovers dominated by grasses and woody herbs of dry environs;
- Semi-permanent to ephemeral open/closed depressions dominated by a mix of native and exotic sedges and herbs; and
- Exotic grasses and herbs of disturbed cleared environs.

Microhabitat features characterising these general habitat classes are listed as follows:

- Tree Canopy including nectar/ pollen, branches and hollows;
- Sparse to moderate distribution of fallen timber and bark;
- Isolated rock outcrops and bush rock;

- Isolated accumulations of waste including household items, corrugated iron and masonry; and
- Ephemeral to semi-permanent streams and pools of water.

Notably absent from the locality are wet sclerophyll forests and wetlands, which represent important habitat values for specific fauna species such as reptiles.

Presented below is a description of the local fauna habitats relative to fauna classes.

Reptilian Habitat

Reptiles commonly use rock outcrops or loose surface rock as a shelter resource, which is largely absent from the valley floor due primarily to the unfavourable geological setting (i.e. Permian formation) and agricultural activities. The absence of these habitat features disadvantages many small shelter dependent reptiles such as the Striped Skink (*Ctenotus robustus*), Copper-tailed Skink (*Ctenotus taeniolatus*), Yellow-faced Whip Snake (*Demansia psammophis*) and Dwyer's Black-headed Snake (*Suta dwyeri*). These species were more reliably found in the northern half of the study in association with exfoliated rock outcrops. Nocturnal species such as Geckos are also found throughout the particularly rocky areas include Southern Leaf-tail Gecko (*Phyllurus platurus*), Stone Gecko (*Diptodactylus vittatus*), Wood Gecko (*Underwoodisaurus millii*) and Velvet Gecko (*Oedura leseurii*).

However, the presence of scattered fallen timber partially compensates for this absent habitat feature, with isolated/ remnant reptile populations tied to the availability of this habitat. Common species that utilise leaf litter and fallen timber are more common throughout the locality and include species such as Boulenger's Skink (*Morethia boulengeri*) and Three-toed Skink (*Anomalopus leukartii*). Wider ranging species that also occupy these habitats include the Shingle Back (*Tachydosaurus rugosus*) and Eastern Blue-tongue Lizard (*Tiliqua scincoides*).

Arboreal species such as the Barred Skink (*Eulamprus tenuis*) and Wall Skink (*Cryptoblephrus virgatus*) are expected to occur throughout the locality due to the presence of suitable shelter sites associated with roughbarked trees (i.e. ironbarks) and tree hollows. Velvet Gecko (*Oedura leseurii*) is also found within the tree canopy.

In contrast to the valley floor, the ridgetops provide a greater density of bush rock suitable for shelter sites. Most of the suitable bush rock resources are located in the northern half of EL6288, with evidence of bush rock removal noted alongside tracks leading into this area. Reptile activity is notably high throughout the northern half including four species of gecko, a variety of skinks and at least one snake. However, the southern half of EL6288 exhibits differing vegetation cover and surface rock, with much of this landscape generally of limited value to reptiles (i.e. blocky rock rather than thin sheets or exfoliations). In this respect, cliff line species such as White Skink (*Egernia whitii*) and Cunninghams Skink (*Egernia cunninghami*) were observed in preference to the above listed species.

Amphibian habitat

The locality is typically characterised by dry terrestrial environs, permanent closed depressions (e.g. farm dams) and ephemeral open depressions (e.g. streams). Species locally suited to these largely dry terrestrial conditions include burrowing amphibians such as the Banjo Frog (*Limnodynastes dumerilii* ssp. *dumerilii*), Ornate Burrowing Frog (*Limnodynastes ornatus*) and Painted Burrowing Frog (*Neobatrachus sudelli*) with these species notably common on the valley floor nearby soils characterised by deep sands (e.g. Redhills). The Brown Toadlet (*Psuedophryne bibronii*) was also observed in these conditions.

The Smooth Toadlet (*Uperoleia laevigata*) and Eastern Toadlet (*Crinia signifera*) were common to closed depressions. 'Tree' dwelling species are also common throughout the locality, particularly in areas where a permanent water supply exists (i.e. farm dams) and/or human habitation. The Peron's Tree Frog (*Litoria peronii*) is perhaps the most common arboreal amphibian species of the locality along with the Green Tree Frog (*Litoria caerulea)*.

Avifauna habitat

Foraging resources for nectivores are abundant during the summer/ autumn period with the plant genus Eucalyptus, specifically White Box (*E. albens*), Yellow Box (*E. melliodora*) and Mugga Ironbark (*E. sideroxylon*) being a particularly important contributors to avian foraging resources. Honeyeaters and small shrubland-heath avifauna species such as thornbills and wrens are regularly observed throughout the shrubby midslopes and adjoining lower slopes. Other species also observed within these habitats include Whistlers, Noisy Friar Birds, Pied Butcherbird and Noisy Miner.

Woodlands characterised by Scribbly Gum appeared to preferentially support woodland species such as the White-crowned Babbler, with the grassier Box - Ironbark Woodland seemingly more important to the Grey-crowned Babbler. Both these species generally favour dry forest and woodlands, particularly those undergoing natural regeneration, as it appears small trees and tall shrubs are essential for nesting sites and complex ground cover for foraging.

Grassy woodlands of the lower slopes appear to strongly favour honeyeaters such as the White-plumed Honeyeater, Little Lorikeets and Noisy Friarbirds with Noisy Miners and Fuscous Honeyeaters also present but not dominating. A mosaic of flowering trees and other resources such as insects appear to represent important factors in the spatial movements of nectivorous birds throughout this landscape.

Hollow bearing trees promote a wide array of avifauna activity. Common hollow dependant species found within the locality include the Kookaburra and Brown Treecreeper. Owls and various large parrots/ cockatoos will exhibit a patchy local distribution primarily governed by the presence of large tree hollows, a habitat feature of locally rare occurrence due to the effects of extensive detrimental anthropogenic processes of the area. Other important factors involved in the distribution of these larger hollow tree specialists include the availability of foraging resources, with the Powerful Owl requiring the presence of proximal arboreal mammal populations and Glossy-black Cockatoo requiring proximal stands of Sheoak and water. Survey of the study area and Wildlife Atlas records (DECC, 2008) seemingly support this view.

Mammal Habitat

Mammalian habitat of the locality can be separated into three distinct types, these being:

- Woodlands and forest;
- Shrubland; and
- Open grasslands.

Local woodlands and forest consist of natural vegetation of varying structural complexity and floristic diversity. While both these habitat types have been exposed to disturbance regimes, they continue to provide habitat for mostly arboreal and flighted mammals. Two regionally common arboreal species, these being the Brush-tailed Possum (*Trichosaurus vulpecular*) and Ringtail Possum (*Pseudocheirus peregrinus*), occur within the locality with the latter species mostly restricted to denser vegetation types. The occurrence of Sugar Glider (*Petaurus breviceps*) and Squirrel Glider (*Petaurus norfolkensis*) is also widespread, albeit fragmented. The latter species has been observed within the Moolarben Creek catchment (Moolarben Biota, 2006).

Ground-dwelling species are rare in the locality and are restricted to the generalist introduced House Mouse (*Mus musculus*). Habitat features such as scrap metal, scattered fallen timber, exotic grasses, shrubs and herbs also provide shelter habitat for these introduced rodents, with densities of these species particularly high nearby settlement. The Yellow-footed Antechinus (*Antechinus flavipes*) on the other hand has restricted distribution where it is found in complex rocky habitats in the north of the study area. Similarly, the Common Dunnart (*Sminthopsis muria*) appears to be restricted to larger Box - Ironbark remnants.

Medium sized mammals such as the Wallaroo (*Macropus robustus*) and Red-necked Wallaby (*Macropus rufogriseus*) are common in the less disturbed woodlands and forests. The Eastern Grey Kangaroo (*Macropus giganteus*) is abundant in the grassy woodlands and adjoining disturbed cleared lands and derived grasslands. European Fox (*Vulpes vulpes*) and Rabbits (*Oryctolagus cuniculus*) are common throughout the locality, particularly along disturbed vegetation boundaries and adjoining cleared/ secondary grasslands.

The woodland and forest habitats also provide substantial areas of habitat for microchiropteran bats. The small insectivorous microchiropteran bats are frequently observed/ recorded within the locality, with both cave and tree hollow roosting species represented. Microchiropteran bat species frequently recorded in the locality include the Chocolate Wattled Bat (*Chalinolobus morio*), Gould's Wattled Bat (*C. gouldii*), Large Forest Bat (*Vespadelus darlingtonii*) and Free-tail Bats (*Mormopterus* spp.). Rarer species such as the threatened Eastern Free-tail Bat (*Mormopterus norfolcensis*), Long-eared Bat (*Nytophilus timorensis*), Eastern Bentwing Bat (*Miniopterus schreibersii*), Pied Bat (*Chalinolobus picatus*) and Large-eared Pied Bat (*Chalinolobus dwyeri*) have also been recorded locally.

5.3.3. Aquatic Biota

The following EISs and Mine Monitoring reports were consulted to provide relevant aquatic biota species lists for the upper Goulburn River study area:

- Wilpinjong Coal Project EIS (May 2005), Specifically Volume 4 - Appendix HD, Aquatic Ecology Report. Bio-analysis (2005) undertook a single seasonal study of fish, macroinvertebrates and aquatic plants at a number of sites within the potentially impacted catchments draining to Wilpinjong Creek plus in Wilpinjong Creek. The report noted that there were springs and saline groundwater seepages in the study area but did not conclude that there were any groundwater dependent ecosystems (GDEs) associated with these features. There is some overlap between the Bio-analysis (2005) upper Wilpinjong Creek sites and the Moolarben lower Wilpinjong Creek sites (WC4);
- The first annual environmental monitoring report (AEMR) for the Wilpinjong Coal Project (WCP) was released in January 2008 (WCP 2008) and the first assessment of stream health monitoring was scheduled for spring 2007. However, as noted in the WEC (2008) report, this first sampling event was cancelled due to high flow events in the sampling sites. Accordingly there is no additional aquatic biota information available since the original EIS work reviewed above;
- Ulan Coal Mine annual environmental monitoring reports (AEMRs) summarise the results of annual terrestrial and aquatic fauna assessments which have been prepared for Ulan Coal Mine by Mt King Ecological Services since 2003. Aquatic ecology monitoring includes one monitoring site in Ulan Creek and five sites in Goulburn River, two upstream and three downstream of the Ulan Creek confluence. Whilst these sites are remote from the present MCP study area, they provide additional locality data for comparing the aquatic biota of the two main upper Goulburn River sub-catchments (i.e. Ulan Mine located in the upper Goulburn River sub-catchment and the Stage 2 MCP study area located in the Wilpinjong/Wollar Creek upper sub-catchment). There are monitoring data available from 2003 through to 2006 (Mt King Ecological Services 2003, 2004, 2005 and 2006), and Mt King Ecological Services (2004) provides a comparison of aquatic ecological data from the 2003/2004 surveys with earlier surveys undertaken during studies for the Ulan Mine MLA80 Development Application and Environmental Impact Statement (Kinhill 1998). There is no discussion of GDEs;
- Additional Ulan Coal Mine AEMRs published on the internet were consulted for further aquatic ecology information, but the AREM report for 2007 contained no aquatic ecology monitoring results and the Flora and Fauna Appendix for the 2007 report has not yet been made available electronically on the Ulan Coal Mine web site; and
- The Environmental Assessment for the recently approved MCP mining operations in the Moolarben Creek/Goulburn River sub-catchment (MCP Open cut Mines 1 to 3 plus Underground 4) prepared by Wells Environmental Services (2006), contains aquatic ecological assessments of creeks plus sections of Goulburn River upstream plus downstream of the Ulan Coal Mine workings, i.e. also in the upper Goulburn River sub-catchment (Moolarben Biota (2006); Appendix 11 in Wells Environmental Services 2006).

The following documents were consulted but did not provide any specific aquatic ecological information:

- Plan of Management for Goulburn River National Park and Munghorn Gap Nature Reserve (NPWS 2003); provides some overall indications of plant and animal communities with references to 'abundant fish life and platypus' but with no reference to fish lists or data sources; and
- Wollar to Wellington 330 KV Transmission Line EIS (International Environmental Consultants 2005); provides references to creek crossings but no assessment of aquatic biota and no reference to listed aquatic biota.

Literature review for aquatic ecology was supplemented by 'local knowledge' by asking individual landowners regarding particular sightings of animals in creeks. With regard to possible platypus and native water rat sightings, the consensus was that neither species is known within the Wilpinjong Creek catchment area within the study area. Platypus is reported from Goulburn River downstream of the Wollar Creek confluence within the National Park (see also Grant 1991). Locals also stated that platypus are known from across the divide in the Cooyal Creek catchment and native water rat were known from the creeks and rivers around Gulgong and Mudgee.

5.4. Vegetation Remnants

The study area can be partitioned into two main landscapes these being the valley floor (i.e. Permian geological formation) and ridgelines (Triassic geological formation). Anthropogenic landuses have had greater prevalence throughout the valley floor when compared with the adjoining ridgelines, this is due primarily to the restricted occurrence of arable fertile lands. The valley floor is predominantly characterised by rural landuses supporting livestock grazing, communications, electricity plus road and rail corridors, extractive industries and mining related development. Native vegetation remnants are consequently more numerous and smaller throughout this landscape. Vegetation of the adjoining ridgelines is expansive and connected, with substantial interface between study area vegetation and local conservation reserves.

Native vegetation of the study area covers approximately 2,354 ha or 70% of the pre-European extent, an estimate excluding secondary grasslands and shrublands (i.e. 921 ha), cropped lands (i.e. 54 ha) and chronically disturbed vegetation/ no vegetation cover (i.e. 53 ha). Approximately 43 disconnected remnants averaging 2.1 ha (i.e. total 88 ha) of open woodland to forest structure occurs within the valley floor with none exceeding 37 ha in area. Valley floor remnants connected with the adjoining ridgeline landscape are largely restricted to the perimeter of the valley (i.e. along Permian outcrop), with the exception of a large connected remnant at the central northern/ northern parts of the study area. The balance of native vegetation cover is found within 11 remnants totalling 2,266 ha, of which 3 account for the majority, with the majority of these remnants located within the Upper Goulburn Valleys and Escarpment Mitchell Landscape.

5.5. Connectivity

5.5.1. Terrestrial

Connectivity between the larger vegetation remnants of the study area's ridgelines is predominantly intact, with the exception of isolated clearings associated with ridgetop basalt caps. Dissecting ridgeline connectivity is the extensively cleared valley floor, with linkages between intact vegetation cover often exceeding 500 m. Anthropogenic (human) land use intensity is the main reason for vegetation severance, with the majority of local bushland remnants connected by riparian corridors.

Ridgeline vegetation remnant size and connectivity is well preserved, especially when compared to the overcleared valley floor. It is within the valley floor that vegetation is highly fragmented as both anthropogenic landuses and ridgetop are considered barriers to genetic flow. The extensive development of agricultural pursuits, past extractive industries, road, rail and utilities corridors plus coal mining (i.e. Ulan, Wilpinjong and approved MCP Stage 1) has consequently resulted in a substantial decline of secondary/ core habitats for many declining and threatened species, particularly those reliant on fertile landscapes such as the valley floor.

5.5.2. Streams and Aquatic GDEs of the Study Area

Several field surveys were undertaken over the course of the combined studies for this and the Stage 1 MCP EA (see Moolarben Biota 2006), to provide a basis for a quantitative aquatic ecology study design, to provide some indications as to potential aquatic ecological impact and to provide constraints and opportunity advice for preliminary mine planning. The two main creek sub-catchments directly impacted by proposed open-cut operations (Murragamba and Eastern Creeks) were further sub-divided into four sub-sections each, for more detailed description an upper catchment two mid catchments and a lower catchment. The approximate boundaries of these creek segments are indicated on **Figure 5**.

The study area incorporates a portion of the upper catchment of Wilpinjong Creek which is a tributary of Wollar Creek. Wollar creek drains to the Goulburn River some 45 km downstream from Ulan (see NSW CMA 1:25000 topographic maps Wollar 8833-2-N and Durridgere 8833-1-S). The proposed open-cut mining area is located in three sub-catchment drainages to Wilpinjong Creek from the south and there are some mining associated infrastructure works in the Wilpinjong Creek upper catchment;

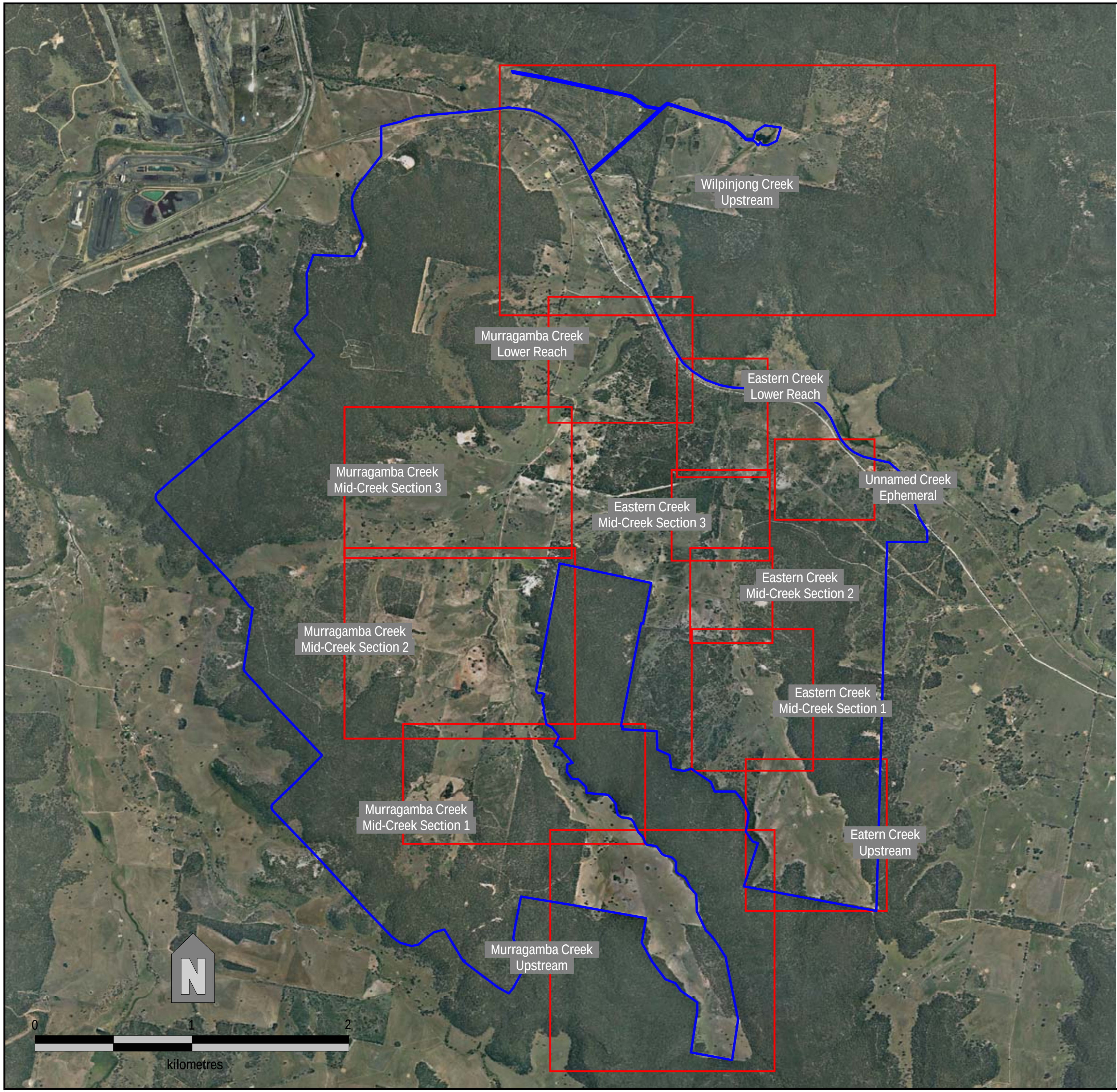
- Wilpinjong Creek is some 26 km long from its headwaters in the Goulburn River National Park (at 510 m elevation) to the confluence with Wollar Creek (at 340 m elevation). Wollar Creek drains to Goulburn River (at 300 m elevation), some 12 km downstream of the Wilpinjong Creek confluence.
- Murragamba Creek is some 9 km long with its headwaters (at about 620 m) in Munghorn Gap Nature Reserve. The creek drains to Wilpinjong Creek at an elevation of 410 m, some 9 km downstream from the headwaters of Wilpinjong Creek. In the upper two-thirds of the sub-catchment the creek is generally located towards the eastern side of the valley with short steep drainages from the escarpment to the east and longer gentle drainages from the ridge to the west.
- Open-Cut 4 extends into the next un-named sub-catchment to the east of Murragamba Creek (conventionally referred to as the "Eastern Creek" in this report). Eastern Creek is 5.5 km long with its headwaters at around 550 m elevation and its confluence with Wilpinjong Creek at 410 m. It drains to Wilpinjong Creek about 1 km downstream from the Murragamba Creek confluence. As for Murragamba Creek, the creek in the upper part of the sub-catchment is located towards the eastern side of the valley, which short steep drainages from the escarpment to the east and longer gentle drainages from the ridge to the west.
- Open-Cut 4 extends further east from the Eastern Creek sub-catchment to the boundary of the Wilpinjong Coal Mine Exploration Area. The eastern section of Open-Cut 4 is bounded to the north by Wilpinjong Creek and to the south by the ridge which forms the eastern side of Eastern Creek. There are several very short drainages of about 1 km length draining north from the ridge to Wilpinjong Creek through this easternmost portion of the Open-Cut 4.

5.5.3. Aquatic Connectivity

From the preliminary study it was determined that most of the creeks and drainages in the study area are ephemeral or intermittent and there are few creeks with permanent (or even semi-permanent) riffle areas. It was also determined that, owing to the ephemeral nature of observed springs and seeps within the study area, there would be few, if any Aquatic GDEs of significance within the study area. That is, the main (aquatic) contribution of groundwater within the study area would appear to be as base-flow to the main creeks (Murragamba, Eastern and Wilpinjong Creeks).

The surveys of the drainages leading from the vegetated basalt cap hill tops to Murragamba Creek and to Eastern Creek indicated that there was very little, if any, creek structure in these upper drainages:

- The drainages to these creeks from the ridge lines to the east of each creek were very short and steep and there were no surface aquatic ecological features at all. There were however some indications of seepages (green flushes of pasture grass or boggy areas in tilled lands) on the lower slopes above the creek lines; and
- For the drainages to these creeks from the ridge lines to the west of each creek there were no surface aquatic ecological features for drainages on the ridges themselves and none on the immediate ridge slopes above the creek valleys (although there were occasional short sections of incised drainage lines where gradients were steeper). There was no obvious creek structure connection between these sections over the lesser grades.



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Study Area Boundary

Creek Section

FIGURE 5

Creek Segments of the Study Area

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In the main, rainfall onto the vegetated basalt cap ridge tops would appear to be dispersed over multiple drainage paths due to the extreme fracturing of the surface rock, which would also appear to slow down the drainage and probably aid local infiltration to the sandy soils.

As a consequence, the drainages down-slope from the vegetated basalt cap hill tops to Murragamba Creek and to Eastern Creek are also not well defined (in terms of the provision of aquatic habitat). The drainage swales generally have in-line dams built along the drainage paths and, for the most part, the land between dams has been cleared and tilled and supports mainly pasture grasses. Some drainage lines can be discerned by remnant lines of trees or by patches of sedges.

Further, whilst there were springs and saline ground seepages observed in both the Murragamba and Eastern Creek sub-catchments, in the main these were degraded or modified by intensive agricultural activities or were dug out to provide in-line stock watering dams (see Aquaterra 2008) for more detail/descriptions of springs in the study area). Other than the spring fed in-line dams, most other groundwater seeps provided little or no significant habitat, either via surface water flow or via hyporheic zones:

- There were proportionally more springs along the longer slope drainages flowing east into Murragamba Creek than from the shorter slope drainages from the western ridge;
- There was also proportionally more spring activity in the lower Murragamba Creek sub-catchment (last 3 km length above the confluence) than in the upper sub-catchment, with springs generally close to the creek line (i.e., within 500 m each side to the creek line);
- There was proportionally more spring activity in the upper two-thirds of the Eastern Creek sub-catchment, with scattered areas of boggy ground which supported mixed sedges and pasture grasses. Spring activity was generally evenly spaced around the creek line and generally located close to the creek line. Most of the areas of seepage were located in cleared, and in some cases tilled lands, and many of the observed springs had associated spring-fed stock watering dams established downstream; and
- There was one permanent spring at the top of the catchment in Eastern Creek which was directed into a small ornamental pond with an extensive seepage area downstream (spring 60 in Aquaterra 2008). The pond supported a complete aquatic ecological assemblage of aquatic plants plus macroinvertebrates but no fish. This pond would meet the classification of an aquatic GDE except that the pond would appear to have been constructed.

There were spring seepages observed along portions of the banks of both Murragamba and Eastern Creeks, but almost all were impacted by tilling or creek bank erosion. The one exception was a series of seepages along the lower Eastern Creek western bank along the creek section within 1 km upstream of the Wollar Road culvert. In one section this seepage supported both fully developed GDE herb and sedge plant communities and there was direct seepage to the creek. Other spring seepages in this location were intercepted by in-line dams.

5.6. Current Impacts Affecting Study Area

The study area has experienced extensive anthropogenic impacts over a substantial time period, as summarised in Table 13.

Table 13: Study Area Lands Uses and Events

Impact	Area of Impact (%)	Notes
Clearing	30	Approximately a third of the study area is cleared of intact native vegetation cover, with most of this clearing restricted to the valley floor and lower to central midslopes below the Triassic outcrop. Areas subjected to clearing are predominantly covered by a mix of cosmopolitan native and exotic species, with shrub/ tree regrowth restricted to areas of marginal agricultural suitability. There has been extensive clearing of riparian vegetation from surface drainages down the valley slopes, around the main creeks in their upper catchment slopes and much of the valley riparian vegetation along the two main creek lines has been cleared or thinned.
Vegetation modification	20	Approximately 610 ha of native vegetation cover has been modified by past land uses (i.e. agriculture), as evidenced by structural changes in vegetation cover away from natural conditions (e.g. derived grasslands, shrublands andopen woodlands), which occur mostly throughout the valley floor. A high degree of floristic variability occurs throughout this area in response to complex interactions between natural and anthropogenic environmental gradients (e.g. natural/ altered soil fertility; exotic plant density; grazing vs time/ climate fluctuations; altered soil moisture), with pioneer native such as Sifton Bush often characterstic of these area.
Fire	5	There is limited evidence of fire activity in selected parts of the site. Fire within the site appears to be associated with non-natural regimes (unauthorized). Fire activity across the entire study area appears to be minimal, as the majority of the large land holdings are controlled by few property owners with limited interest in fire usage (i.e. focus being livestock grazing/ no landuse activity).
Agriculture	50	Livestock grazing is a widespread activity across the valley floor of the study area, with livestock generally regulated in low densities particularly in recent years (i.e. drought). Red soil country at the western boundary of the study area (i.e. basalt) is periodically grazed with recent grazing activity largely excluded from these areas (i.e. .evidence of regrowth and low weed cover). Scattered crops occur in isolated pockets of elevated soil fertility, particularly throughout landscapes downslope of basalt outcrops. Timber collection for pit props (historical) and more recently firewood collection is also evident. Grazing activities plus tilling of soils has been undertaken over much of the slope drainages and over the alluvial flats around the two main creeks with a resultant replacement of much creek structure with gentle undulating drainage swales supporting pasture grasses. These activities have also resulted in the loss of groundwater seepage ecosystems which have been replaced by boggy areas supporting pasture grasses and sedges or by in-line (interception) dams.
Rubbish Deposition	<5	Deposition of rubbish material has been a restricted but common activity in close proximity to selected residences. Refuse consists of wood, metal and other general farm machinery and waste. There are some instances of large scale deposition of rubbish into creek lines, particularly associated with areas of accelerated creek erosion in Murragamba Creek.
Exotic flora and fauna	30-50	Elevated densities of exotic flora occur primarily throughout the valley floor, with elevated exotic plant species richness on the midslopes and ridgetops restricted to areas of higher fertility such as basalt outcrops. Weed species diversity is greatest within heavily grazed areas on clays and near creeklines, with common grassland species proliferating throughout the cleared areas. The introduced pest fish species (Plague Minnow) is found throughout the three main creek systems. Pigs, foxs, cats, dogs, rabbits, mice, goats all occur within the study area
Roads, Rail, Power	2	Infrastructure including road, rail and power transmission occurs within the study area. The Wollar to Ulan Road is the only main road of the study area, where it passes through the northern parts of the study area. Increased traffic and associated road kills are likely to be occurring as a consequence of traffic generated from the adjoining Wilpinjong coal mine to the east. Rail passes along the northern edge of the Wollar to Ulan Road, with its impact largely being the displacement of native vegetation and point source for exotic plants. The Wollar to Wellington power transmission easement also passes through the northern half of the study area, with the associated easement to be maintained as a treeless landscape.
Creek Erosion & Sedimentation		As a consequence of clearing and agricultural practices some of the remaining slope creek drainages plus sections of the two main creeks have been subjected to increased surface water flows and accelerated sediment transport, which, with loss of riparian vegetation has accelerated creek erosion which has then been further exacerbated by stock damage leading to greater rates of erosion. Increased sediment loads dumped into the creeks has resulted in the conversion of some portions of creek bed from gravel to fine sediment and sand, has infilled creek lines plus filled the deeper pools thus limiting drought refuge potential of these pools. Increased agricultural derived sediment transport has also altered creek water quality, with elevated nutrient loads plus elevated turbidity and suspended solids resulting in excessive algae growth at some times plus high fluctuations in dissolved oxygen levels in isolated pools.

The following plates provide a contrasting account of some of the above commentary.

Plate 1: The cleared expanse of the lower Murragamba Creek near the Old School

Plate 2: Native Vegetation Cover Near Ulan Wollar Road

5.7. Initial Threatened Biodiversity Analysis

The following provides the results of the desktop threatened biodiversity analysis and identifies threatened biodiversity potentially relevant to this assessment.

5.7.1. Threatened Flora

Database searches combined with baseline field survey results identified 30 threatened flora/ EPs with known or potential occurrence within the study area (DECC, 2008; DEWHA, 2008). **Table 14** lists the species, the total number of database records within the HCR CMA and those contained within relevant Mitchell Landscapes and geological formations. The distribution of threatened species within and/or nearby the study area is shown in **Figure 6**.

Table 14: Summary of Threatened Flora Species

Common Name	Scientific Name	TSC Act	EPBC Act	Database Records†			
				30 km	Mitchell	Geology	Total
	*Cynanchum elegans**	E	E	0	2	3	32
Hoary Sunray	*Leucochrysum albicans var tricolor***		E	1	1	0	1
	Ozothamnus tessellatus*	V	V	8	8	9	9
Ausfield's Wattle	***Acacia ausfieldii***	V	-	2	1	0	2
Flockton Wattle	*Acacia flocktoniae*	V	-	1	1	1	1
Weeping Myall of the Hunter Catchment	*Acacia pendula*	E2	E	1	1	1	16
	Kennedia retrorsa*	V	V	0	17	17	17
	*Swainsona recta**	E	-	0	0	0	0
Cannons Stringybark	***Eucalyptus cannonii******	V	-	3	3	3	3
River Redgum of the Hunter Catchment	*Eucalyptus camaldulensis*	E2	-	2	0	0	68
	Eucalyptus scoparia	E1	V	1	0	0	1
	Eucalyptus pumila	V	V	0	1	9	12
	Homoranthus darwinioides*	V	-	4	4	4	4
Tiger Orchid of the Hunter Catchment	*Cymbidium canaliculatum*	E2	-	0	14	0	17
Painted Diuris	***Diuris tricolor (syn D. sheiffiana)****	V	V	3	5	4	23
	Diuris pedunculata	E1	E	0	2	0	4
	*Digitaria porrecta**	V	V	0	0	0	0
Silky Pomaderris	*Pomaderris sericea**	V	-	1	0	1	1
Scant Pomaderris	***Pomaderris queenslandica***	E1	-	0	18	18	21
Denman Pomaderris	***Pomaderris reperta***	E1	CE	0	17	17	17
	Prostanthera discolor*	V	V	8	6	7	8
	Prostanthera cineolifera	V	V	0	1	1	1
	Prostanthera cryptandroides*	V	V	0	8	10	15
	Prostanthera stricta	V	V	0	8	8	8
	*Philotheca ericifolia**	V	V	0	0	0	1
	Commersonia rosea	E1	-	0	5	5	5
	Lasiopetalum longistamineum	V	V	0	13	13	13
	Rulingia procumbens	V	V	0	2	2	2
Austral Toadflax	*Thesium australe**	V	V	0	0	0	3
Wollemi Pine	*Wollemia nobilis**	E1	E	n/a	n/a	n/a	n/a

* Identified by EPBC Act Protected Matters Search

** Known to occur locally

† DECC (2008)

The consideration of potential subject species involved a review of local database records (i.e. 30km of the study area), total number of records for the region (i.e. HCR CMA), and affinities with relevant Mitchell landscapes and geology formations. Species of particular interest are identified in bold in the above table but do not necessarily represent the final subject species list.

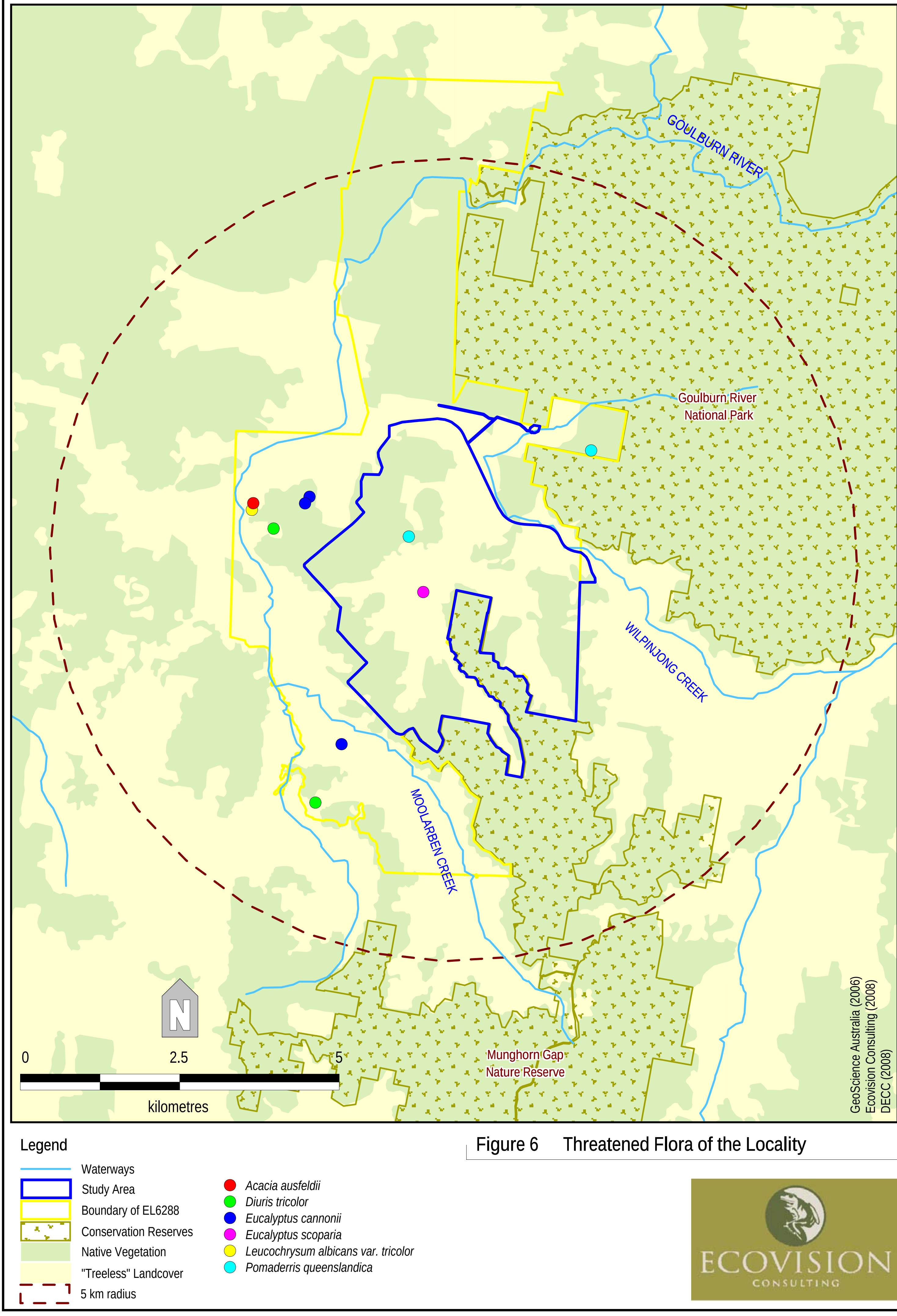

Figure 6 Threatened Flora of the Locality

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5.7.2. Threatened Fauna

Database searches identified 36 threatened fauna species within known or potential occurrence within the study area (DEC, 2008; Birds Australia, 2008; EPBC Protected Matters Report, 2008). **Table 15** lists the species the total number of database records within the HCR CMA, relevant Mitchell Landscapes and geological formations. Threatened species with occurrences nearby and/or within the study area are shown in **Figure 7**.

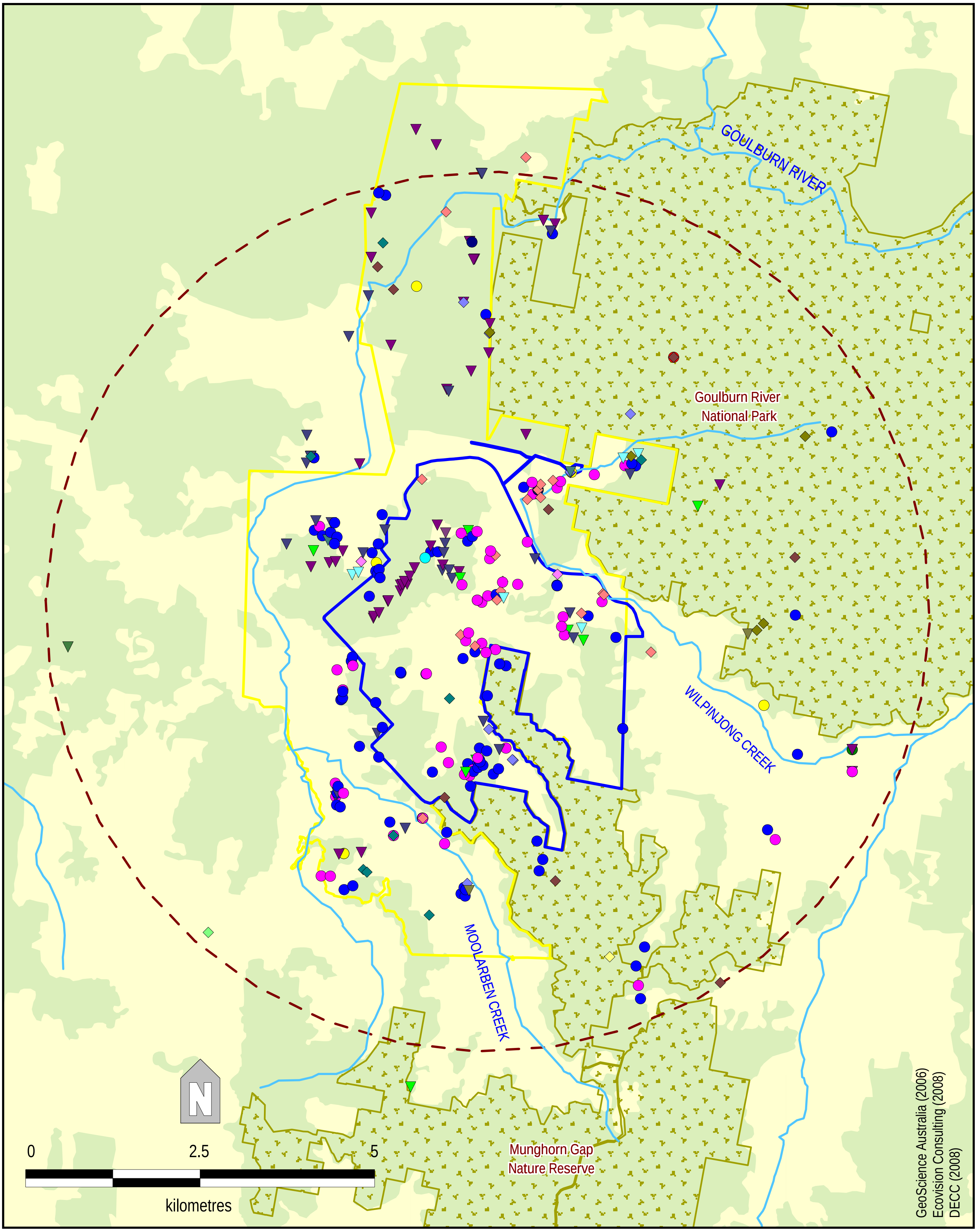
Table 15: Summary of Threatened Fauna Species

Common Name	Scientific Name	TSC Act	EPBC Act	Database Records†			
				30 km	Mitchell	Geology	Total
Booroolong Frog*	*Litoria booroolongensis*	E1	E	0	0	0	6
Giant Barred Frog	*Mixophyes iteratus*	E1	E	1	0	15	24
Worm Skink	*Aprasia parapulchella*	V	V	1	0	1	1
Collared Whip Snake	*Suta flagellum*	V	-	1	0	0	1
Sydney Broad-headed Snake*	*Hoplocephalus bungarioides*	E1	V	0	0	0	0
Mallee Fowl*	*Leipoa ocellata*	E1	E	1	1	0	1
Square-tailed Kite	*Lophoictinia isura*	V	-	10	2	2	15
Bush Stone-curlew	*Burhinus grallarius*	E1	-	1	1	13	141
Australian Painted Snipe*	*Rostratula australis*	V	V	0	0	0	2
Gang-gang Cockatoo	*Callocephalon fimbriatum*	V	-	19	10	113	178
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	V	-	60	104	255	609
Swift Parrot*	*Lathamus discolor*	E1	E	2	0	8	50
Superb Parrot*	*Polytelis swainsonii*	V	V	0	0	0	0
Turquoise Parrot	*Neophema pulchella*	V	-	55	16	47	102
Barking Owl	*Ninox connivens*	V	-	1	2	18	63
Powerful Owl	*Ninox strenua*	V	-	32	9	132	414
Masked Owl	*Tyto novaehollandiae*	V	-	1	0	0	0
Gilberts Whistler	*Pachycephala inornata*	V	-	1	0	0	0
Brown Treecreeper	*Climacteris picumnus*	V	-	147	164	60	323
Speckled Warbler	*Pyrrholaemus sagittatus*	V	-	79	86	86	240
Painted Honeyeater	*Grantiella picta*	V	-	15	9	4	17
Black-chinned Honeyeater	*Melithreptus gularis gularis*	V	-	37	13	39	120
Regent Honeyeater*	*Anthochaera phrygia*	E1	E	86	20	23	77
Hooded Robin	*Melanodryas cucullata*	V	-	33	39	13	45
Grey-crowned Babbler	*Pomatostomus temporalis*	V	-	9	34	25	319
Diamond Firetail	*Stagonopleura guttata*	V	-	54	59	23	91
Spotted-tailed Quoll*	*Dasyurus maculata*	E1	E	0	2	35	992
Koala	*Phascolarctos cinereus*	V	-	8	6	43	693
Squirrel Glider	*Petaurus norfolkensis*	V	-	1	6	150	460
Brush-tailed Rock-wallaby*	*Petrogale penicillata*	E1	V	1	12	80	139
Large-eared Pied Bat*	*Chalinolobus dwyeri*	V	V	8	18	66	109
Little Pied Bat	*Chalinolobus picatus*	V	-	1	4	4	4
Eastern Bentwing Bat	*Miniopterus schreibersii*	V	-	2	9	103	359
Eastern Long-eared Bat*	*Nyctophilus timoriensis*	V	-	6	8	25	30
Large-footed Myotis	*Myotis adversus*	V	V	1	0	0	0
Yellow-bellied Sheath-tailed Bat**	*Saccolaimus flaviventris*	V	-	0	2	4	26

* Identified by EPBC Act Protected Matters Search

** Known to occur locally from local studies (i.e. no databased records).

† Birds Australia (2008) and DECC (2008) for the HCR CMA west of Cessnock (i.e. eastern extent of Narrabeen geology)



Legend

Waterways	Barking Owl	Greater Longeared Bat	Glossy Black Cockatoo
Study Area	Brown Treecreeper	Grey-crowned Babbler	Black-chinned Honeyeater
Boundary of EL6288	Diamond Firetail	Hooded Robin	Painted Honeyeater
Conservation Reserves	Eastern Bentwing Bat	Koala	Regent Honeyeater
Native Vegetation	Gang Gang Cockatoo	Large-eared Pied Bat	Speckled Warbler
"Treeless" Landcover	Gang-gang Cockatoo	Little Pied Bat	Square-tailed Kite
5km radius	Giant Barred Frog	Masked Owl	Squirrel Glider
	Gilbert's Whistler	Powerful Owl	Yellow-bellied Sheathtail Bat

Figure 7 Threatened Fauna of the Locality

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Species identified in bold in **Table 15** represent species that may potentially be considered Subject Species. Of particular interest are the threatened woodland birds such as the Regent Honeyeater and Painted Honeyeater, with a substantial quantum of regional records located within 30 km of the study area. Overall the theme deduced from the above table is the high representation of threatened woodland birds and selected microchiropteran bat species, particularly those that have western distributions.

5.7.3. Threatened Aquatic Biodiversity

Preliminary literature review has comprised searches of the Environment Australia, NSW DECC and NSW DPI (Fisheries) databases for specific details on possible threatened species, ecological communities and key threatening processes:

- Bionet – a search of records for the Goulburn River from the NSW Government's Bionet database (data updated July 2008). This search yielded no records for fish so a broader search was made for the Hunter River, which provided some fish data for the total Hunter River catchment. There were no threatened aquatic species listed;
- EPBC Protected Matters - a search using Environment Australia's EPBC protected matters search tool (data updated July 2008). This search yielded no threatened aquatic species (fish, invertebrates or aquatic plants);
- Morris et al (2001) provides a review of threatened and potentially threatened freshwater fishes of coastal New South Wales and the Murray-Darling Basin. This report was consulted to check whether there were any potentially threatened freshwater fishes which could occur in the study area; and
- Recent aquatic ecological surveys for the upper Goulburn River (see Section 4.3) were also inspected for threatened species information or occurrences and no aquatic species listed under the FM ACT or EPBC Act were reported or expected.

In summary, there are no threatened aquatic plants, fish or macroinvertebrate species or populations for the upper Goulburn River plus sub-catchments listed, either under the threatened species provisions of the Commonwealth EPBC Act or under the threatened species provisions of the FM Act. The DPI (Fisheries) database did not provide any fish data from the upper Goulburn River. There were no threatened species listed in recent (2006 and 2007) aquatic surveys undertaken for Ulan and Wilpinjong Mines.

5.7.4. Ecological Communities

One community listed as endangered is known to occur within the study area this being White Box Yellow Box Blakely's Redgum Woodland (i.e. TSC Act) or White Box Yellow Box Blakely's Redgum Woodland and derived grasslands (i.e. EPBC Act), with the latter a critically endangered listing.

5.7.5. Recovery Plans

Recovery plans potentially relevant to the preparation of this EIA include the following:

- Recovery Plan for the Bush Stone-curlew (February 2006);
- Draft Recovery Plan for the Barking Owl (February 2003);
- Recovery Plan for the Red Goshawk (October 2002);
- Recovery Plan for the Bush Stone-curlew (February 2006);
- Recovery Plan for the Yellow-bellied Glider (February 2003);
- Draft Recovery Plan for the Koala (February 2003); and
- Recovery Plan for the Large Forest Owls (October 2006).

5.7.6. Key Threatening Processes (TSC Act, FM Act & EPBC Act)

Key threatening processes potentially relevant to the preparation of this EIA include the following:

- Removal of large woody debris from New South Wales rivers and streams;

- Alteration of habitat following subsidence due to longwall mining;
- Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams;
- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands;
- Degradation of native riparian vegetation along New South Wales water courses;
- Predation by the plague minnow (*Gambusia holbrooki*);
- Clearing of Native Vegetation;
- Competition and grazing by the feral European rabbit;
- Exotic vines and scramblers;
- Invasion of native plant communities by exotic perennial grasses;
- Loss of Hollow-bearing trees;
- Predation of feral cats;
- Predation by the European fox;
- Removal of dead wood and dead trees; and
- Human-caused climate change.

5.7.7. Threat Abatement Plans

Threat abatement plans potentially relevant to the preparation of this EIA include the following:

- Predation by the red fox (*Vulpes vulpes*); and
- Removal of large woody debris from NSW rivers and streams.

5.8. Groundwater Dependant Ecosystems

Shallow groundwater of high water quality can support terrestrial vegetation, such as forests and woodlands, either permanently or seasonally as a Groundwater Dependant Ecosystem (GDE). Typically these GDEs occur in coastal locations either on deep sands, around wetlands or alongside rivers and large creeks. However, examples of inland GDEs may include River Redgum on floodplains, hanging swamps or valleys on the tablelands or artesian mound springs. A number of different types of GDEs have been described such as:

- Terrestrial;
- Base flow in streams;
- Aquifer and cave ecosystems; and
- Wetlands.

With regard to listed GDEs, DWE (2008) indicates that there are alluvial aquifer systems in the Wollar-Wilpinjong Creek system but the mapped systems show the Wilpinjong alluvials to be downstream of the study area (i.e. they are downstream of the Planters Creek confluence - the limit of the study area). DWE (2008) also does not indicate any significant GDEs in the study area and only one GDE ('The Drip' on the Goulburn River just downstream of the Ulan-Cassilis Road crossing) is currently the only named terrestrial GDE in the upper Goulburn River sub-catchment.

In relation to the floristic assessment of the study area, only terrestrial, base flow and wetland GDEs are likely. Whilst the Draft Water Sharing Plan (DWE, 2008) does not show any recognised GDEs for the Wollar Creek subunit of the Goulburn Extraction Management Unit, the report says that a full list of potential GDEs will be listed on the DWE GDE register and as a precautionary approach, will be considered by DWE staff in the assessment of any works approvals in the plan area.

6. FIELD SURVEY RESULTS

6.1. Survey Dates and Weather Conditions for Terrestrial Surveys

6.1.1. Flora

Systematic and opportunistic surveys were completed in accordance with the guiding principles of DECC's working draft *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004) from spring 2004 (i.e. October) to winter 2008 (i.e. July). Survey times are broadly defined as follows:

- Summer 2004 (22 quadrats);
- Autumn 2005 (24 quadrats);
- Winter 2005 (19 quadrats); and
- Spring 2005 (51 quadrats).

The flora survey extended beyond the systematic fauna survey period (i.e. ending spring 2005), with additional survey times defined as follows:

- Summer 2005 (22 quadrats);
- Autumn 2006 (7 quadrats);
- Winter 2006 (1 quadrats);
- Spring 2006 (26 quadrats);
- Spring 2007 (25 quadrats); and
- Winter 2008 (14 quadrats).

Coinciding with these systematic flora surveys was targeted/ opportunistic surveys for both flora and fauna species.

6.1.2. Fauna

Systematic surveys were completed between summer 2004 (i.e. December) and spring 2005 (i.e. November). Targeted and opportunistic surveys occurred during this period and through to winter 2008 (i.e. July), with weather conditions for these latter non-systematic surveys not recorded.

Systematic Surveys

A summer survey was conducted from the 5th to 11th of December 2004. Weather conditions varied from mild to hot (15-30°C) during the day and were generally mild to warm (18-25°C) in the evening. Rain periods occurred regularly between fine clear weather, with thunderstorms on two evenings. Full details provided in **Appendix 1**.

Two autumn surveys were conducted from the 30th of March 2005 to the 8th of April 2005. Day time weather conditions were good for surveying, with temperatures mostly 20-25°C and an occasional day in the high 20's. Most days were still or with a light breeze. Evenings were generally warm (15-20°C), dropping to around 15°C overnight, with the occasional cool night (13-17°C), dropping to 5-10°C. No rain except for a very few patches of fine drizzle. No moon during the nocturnal surveys.

A winter surveys was conducted between the 28th of June 2005 and 10th of July 2005, with a short break in the middle due to inclement weather. Weather conditions were cool to mild (5-18°C) during the day and cool (4-10°C) during the evening. The first few days experienced heavy rain. After the break, weather was mostly fine with some rain periods.

An early spring survey was conducted between the 5th and 17th of September 2005. Weather conditions varied from cool to warm (8-26°C) during the day, and cool to mild (5-17°C) during the evening. The first part of the survey period was mostly fine, whilst the latter part was mostly cloudy to overcast, with regular light drizzle and rain, and gusty winds.

A late spring surveys was conducted between the 4th and 18th of November 2005. Weather conditions varied during this period, with some days reaching 30°C and other cooler days only 15°C. Overnight temperatures varied from 10-15°C. Heavy rain preceded the survey making the region very green. Some heavy rain also occurred during the surveys, which encouraged frogs to call. The moon was out for some nights, but on most nights the moon was hidden by cloud.

Targeted

Following the completion of systematic surveys, additional targeted surveys were completed to compliment the systematic survey to increase survey coverage, particularly for nocturnal birds (e.g. owls) and microchiropteran bats. Opportunistic surveys for diurnal birds, particularly for threatened species, were completed at every flora quadrat site. These surveys generally coincided with the extended flora survey period.

6.2. Flora

6.2.1. Survey Extent

Detailed systematic flora surveys were restricted to the lands enclosed within the boundaries of EL6288, with 211 quadrats completed for this area. For the study area a total of 85 quadrats were completed targeting key features of landscape expressed within both remnant vegetation cover and disturbed lands. Biodiversity searches of ecotones and disturbed boundaries were also completed to compliment the quadrat sampling methods. Survey locations were randomly selected within stratification units with bias toward areas of direct impact (i.e. open cut operations and infrastructure).

Figure 8 identifies the flora survey locations by season and year for the study area and immediate surrounds (i.e. part of EL6288). Notable on this figure is the increased survey intensity throughout the valley floor relative to the more continuously vegetated ridgetops and upperslopes. This was a deliberate survey strategy cast in response to two factors these being:

- Systematic survey of the Triassic sandstones yielded repetitious predictable results. It is assumed that this artefact of survey is linked to the ‘massive’ nature of the sampled geological formation, where variability in the geological strata is minimal; and
- On reporting these results to DECC during a project meeting for Stage 1 it was acknowledged that the repetitious results were consistent with their understanding of this geological formation. For this reason, combined with higher expected impacts for the valley floor, DECC recommended that ongoing surveys should have increased focus on the lower slopes and valley floor.

Notwithstanding, opportunistic surveys were completed throughout this area targeting specific threatened species habitats. Ongoing systematic surveys throughout the elevated landscapes were generally restricted to other geological formations such as basalt caps.

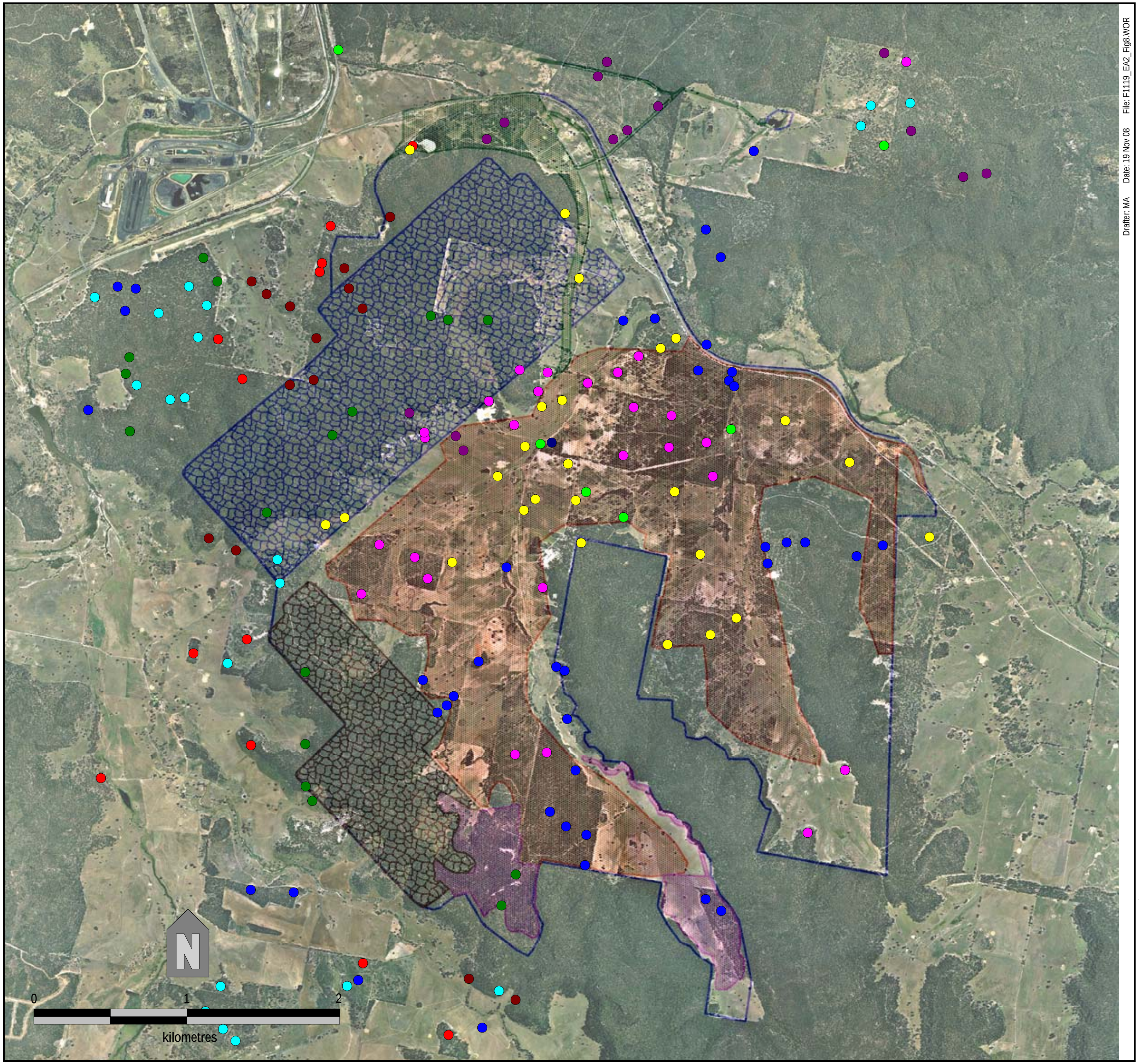
6.2.2. Vegetation of the Site

General Observations

Seasonal based field surveys conducted over 33 months between October 2004 and July 2008 for EL6288 identified 503 plant species consisting of 429 natives and 74 exotics (Moolarben Biota, 2006; Ecovision Consulting unpubl. Data, 2008), with species lists provided in **Appendix 2**. Various broad vegetation communities were defined, as shown in **Figure 9**, these being:

- Secondary Grasslands and Shrublands;
- Western Slopes Dry Sclerophyll Forest;
- Western Slopes Grassy Woodlands; and
- ‘Murragamba’ Sands Woodlands.

Sub-formations were also defined for each of these vegetation classes, which are characterised by one or more of the following tree canopy dominants: Broad-leaved Ironbark (*Eucalyptus fibrosa*), Grey Gum (*E. punctata*), Grey Box (*E. moluccana*), Yellow Box (*E. melliodora*), White Box (*E. albens*), Narrow-leaved Ironbark (*E. crebra*), Blakely’s Redgum (*E. blakelyi*), Inland Scribbly Gum (*E. rossii*) and Rough-barked Apple (*Angophora floribunda*). Less common tree canopy species that typically form associates with the dominant tree canopy species include Slaty Gum (*E. dawsonii*), Blue-leaved Stringybark (*E. agglomerata*),



Legend

- Autumn 2005 (24)
- Autumn 2006 (7)
- Spring 2005 (51)
- Spring 2006 (26)
- Spring 2007 (25)
- Summer 2004 (22)
- Summer 2005 (22)
- Winter 2005 (19)
- Winter 2006 (1)
- Winter 2008 (14)

Study Area Boundary

Infrastructure

Open Cut No. 4

Underground No. 1

Underground No. 2

Out of Pit Overburden

FIGURE 8

Flora Quadrat Locations

Sources
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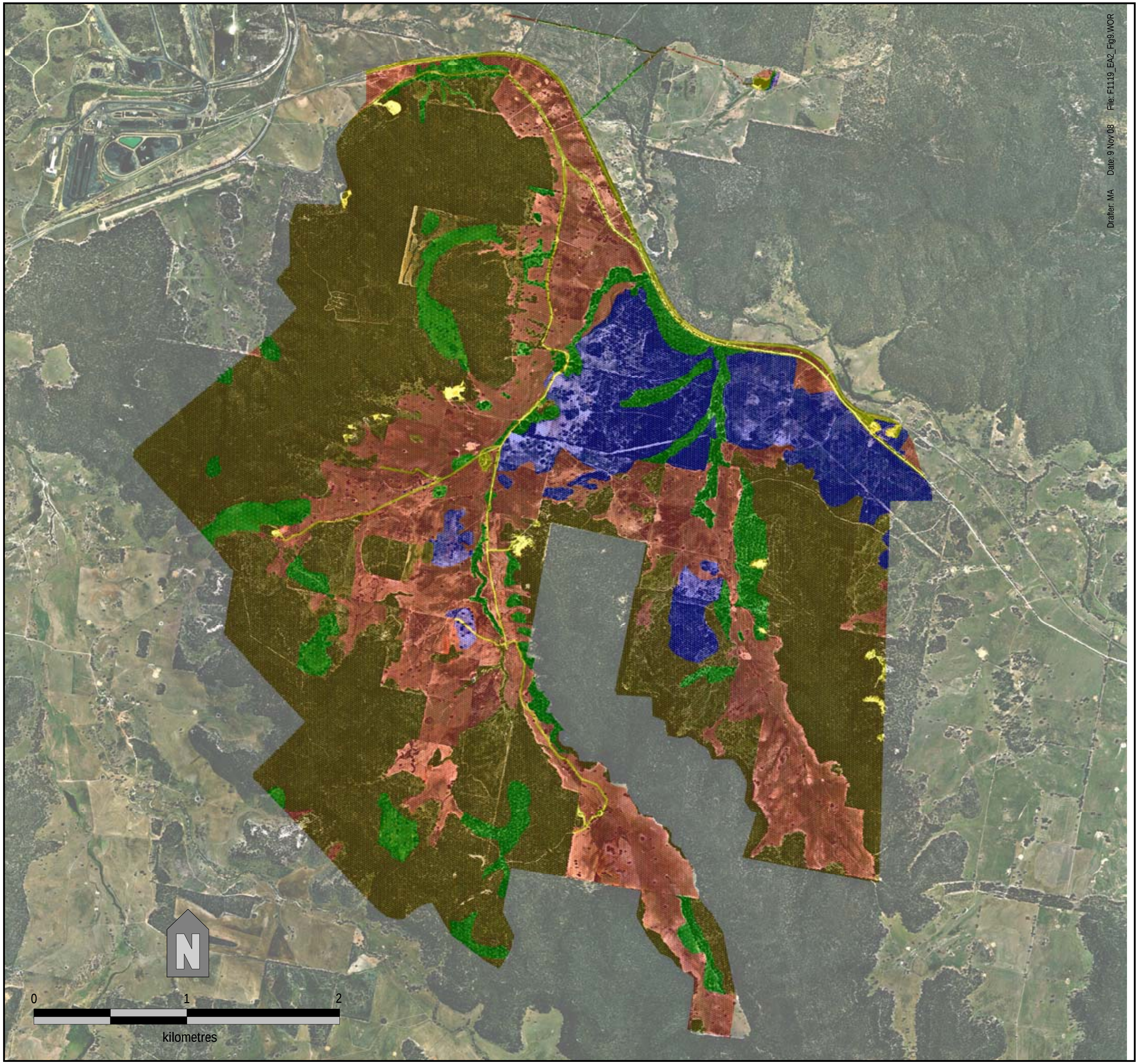

Legend

- Disturbed/ No Natural Vegetation
- Secondary Grasslands and Shrublands
- Murragamba Sands Woodland
- Western Slopes Dry Sclerophyll Forest (Keith, 2004)
- Western Slopes Grassy Woodland (Keith, 2004)

FIGURE 9

Distribution of Broad Vegetation Classes with regard to Keith (2004) classifications

Sources

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Narrow-leaved Stringybark (*E. sparsifolia*) and Red Stringybark (*E. macrorhyncha*) (Moolarben Biota, 2006). Details of these sub-formations are provided in the **Section 7.0**.

Soils with naturally low fertility, which are found mostly on the Triassic geological formation (i.e. midslopes and ridgelines), are generally shrubby (i.e. 20-50% cover) with species such as Sifton Bush (*Cassinia arcuata*), Beard Heath (*Leucopogon muticus*), *Acrotriche rigida*, Hop Bush (*Dodonaea* spp.) and Wattles (*Acacia* spp.). Black Cypress Pine (*Cypress endlicherii*) commonly occurred throughout this landscape as a tall shrub (4-8m) and occasional low tree (approximately 10 m). The woody herbaceous groundcover stratum was generally sparse and contained few grasses (Moolarben Biota, 2006).

Soils with comparatively higher soil fertility, which occur mostly throughout the valley floor and lower midslopes, are generally less shrubby than the adjoining midslopes and ridgelines (5-40% cover), with increasing shrubbiness associated with transitions between these two landscapes. Shrub species commonly occurring throughout these landscapes typically include Sifton Bush (*C. arcuata*), Beard Heath (*L. muticus*), *Styphelia triflora* and Wattles (*Acacia* spp.), with Black Cypress Pine (*C. endlicherii*) also frequently observed on conglomerate derived soils. The groundcover stratum was generally grassier, particularly within isolated areas of high soil fertility such as basalt caps and adjoining downslope lands (Moolarben Biota, 2006).

Parts of the valley floor also consists of isolated narrow Quaternary deposits along major creeklines, which favours the formation of Box - Redgum woodlands. Soils throughout the adjoining terraces are generally derived from the Permian geological formation, which gives rise to woodlands consisting of Box - Ironbark. Occasional conglomerate outcrops referred to as impermeable 'tertiary paleochannels' also occur as localised hills throughout the valley floor, which favours the formation of Ironbark and Scribbly Gum Woodlands. Agricultural pursuits within the locality are mostly restricted to this landscape, particularly where Box – Redgum and Box – Ironbark Woodlands once existed (Moolarben Biota, 2006).

Impoverished soils of the lower and central midslopes are generally derived from Permian conglomerates and claystones mixed with material eroded from the adjoining Triassic sandstones. These areas consist mostly of Ironbark – Stringybark dominated vegetation on the conglomerates and shrubby White Box (*E. albens*) on the steeper west facing claystone outcrops. Ridgelines and upper slopes tend to have skeletal soils of low fertility derived from the underlying Triassic sandstone formation. Broad-leaved Ironbark (*E. fibrosa*) and Black Cypress Pine (*C. endlicherii*) dominate this topographical landscape in the south, with ridgetop vegetation throughout the northern parts of EL6288 consisting mostly of Scribbly Gum (*E. rossii*) and Black Cypress Pine (*C. endlicherii*) (Moolarben Biota, 2006).

Basaltic rocky outcrops overlying Triassic sandstones have scattered occurrences throughout the elevated parts of the study area. These localised geological formations permit the occurrence of grassy woodlands once dominated almost exclusively by White Box (*E. albens*) but now largely cleared (Moolarben Biota, 2006).

6.3. Fauna

6.3.1. Survey Extent

Systematic targeted sampling techniques were employed during the diurnal survey periods such as visual/audible observations (timed quadrats), scat/physical searches and habitat evaluation. Nocturnal surveys involved callplayback (e.g. owls), ultrasonic echolocation (e.g. Anabat II apparatus), Spotlighting and trapping (e.g. Harp and Elliott Scientific). Passive surveys employed include hair tubing, pit fall traps, habitat evaluation (e.g .tree hollow mapping). Surveys were often completed in association with flora survey sites for further analysis. Field survey locations are shown in **Figures 10 - 13**. **Appendix 1** provides details of the fauna survey.

6.3.2. Habitat Values

Trees with Hollows

Hollows develop in the trunk and branches of trees following consumption and decay of internal heartwood by fungi and invertebrates, primarily termites (Wilkes 1982, Mackowski 1984 in NSW Scientific Committee, 2007). In *Eucalyptus* species, decomposition of heartwood typically begins in the stem at an

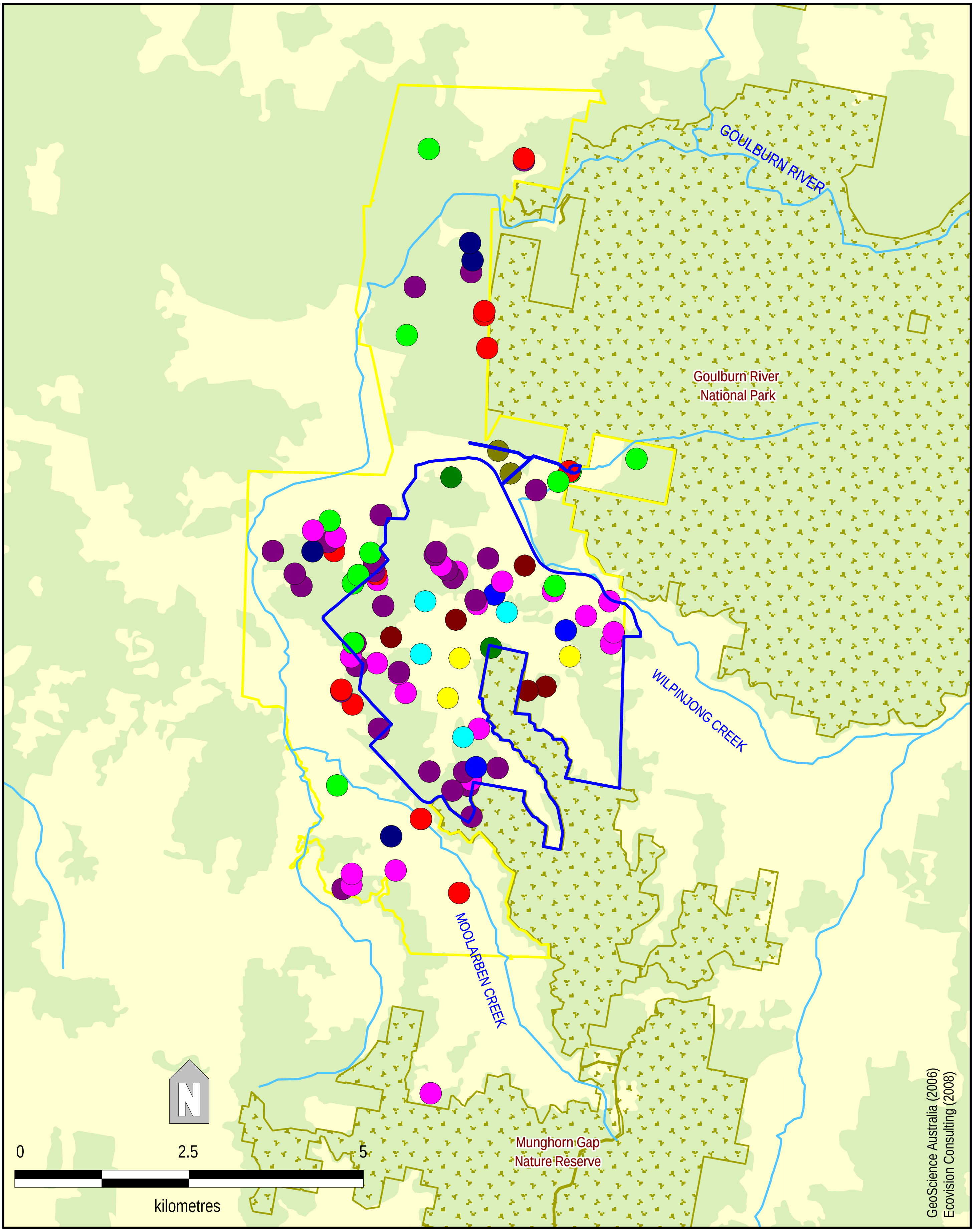

Figure 10 Fauna Survey - Bird Census

Legend

Waterways	Summer 2004	(5)	Late Spring 2005	(4)
Study Area	Autumn 2005	(13)	Spring 2006	(4)
Boundary of EL6288	Winter 2005	(31)	Spring 2007	(5)
Conservation Reserve	Late Winter 2005	(23)	Winter 2008	(2)
Native Vegetation	Early Spring 2005	(13)	Spring 2008	(1)
"Treeless" Landcover	Spring 2005	(3)		

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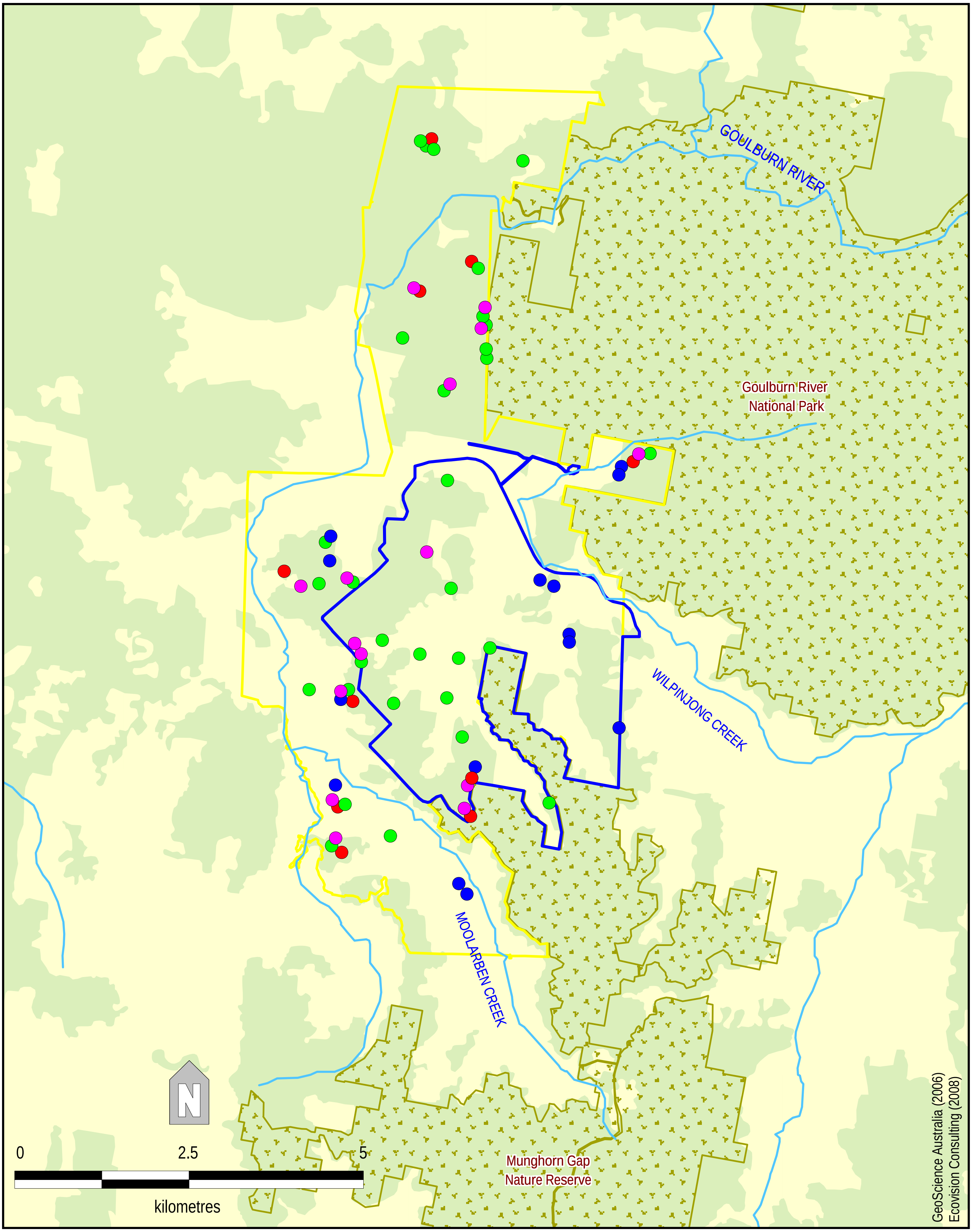

Figure 11 Fauna Survey - Reptile, Frog and Habitat Search

Legend

- Waterways
- Study Area
- Boundary of EL6288
- Conservation Reserve
- Native Vegetation
- "Treeless" Landcover

- Habitat Assessment (10)
- Herpetological Search (31)
- Pitfall Trap (14)
- Scat tracks traces (15)

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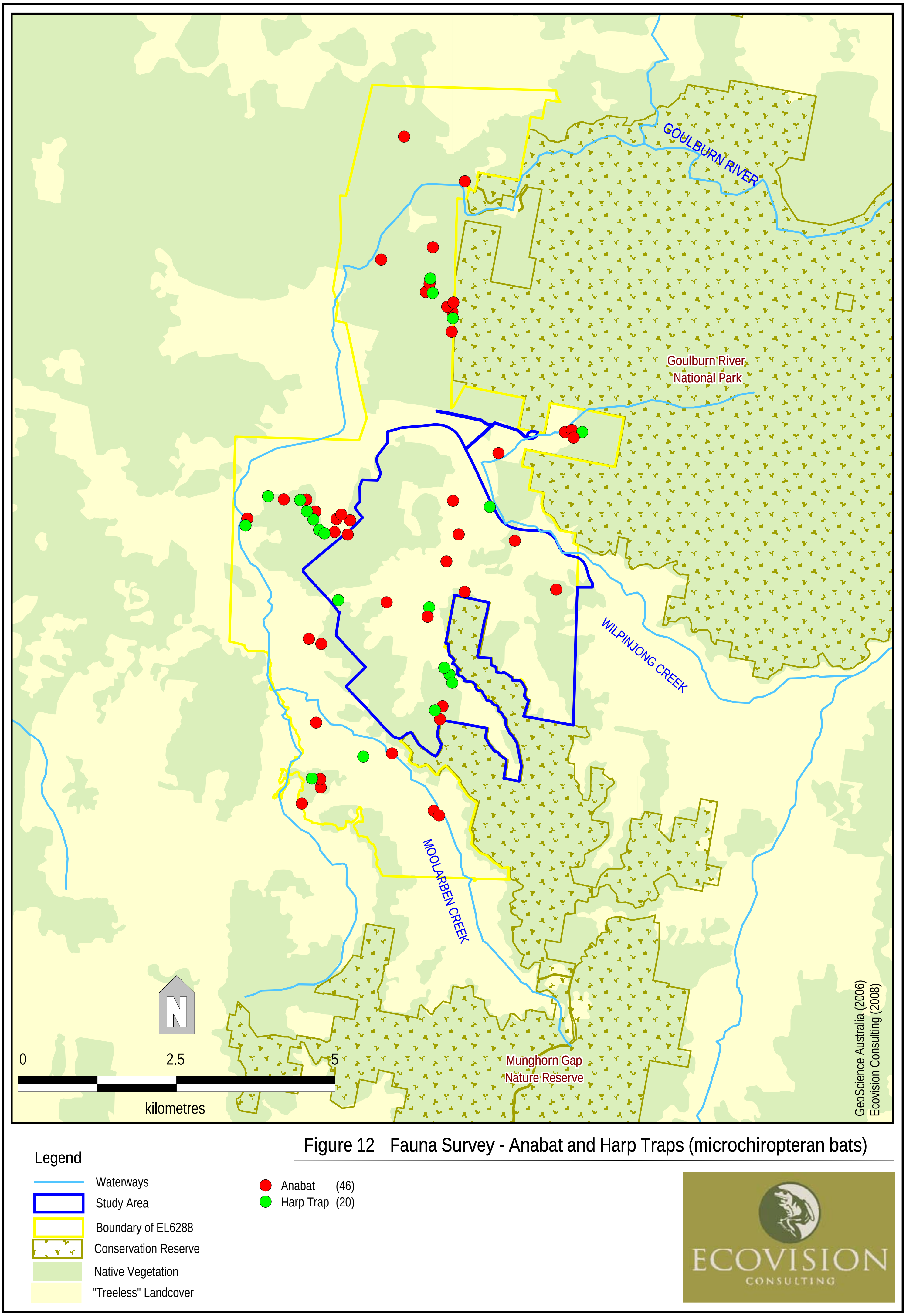

Figure 12 Fauna Survey - Anabat and Harp Traps (microchiropteran bats)

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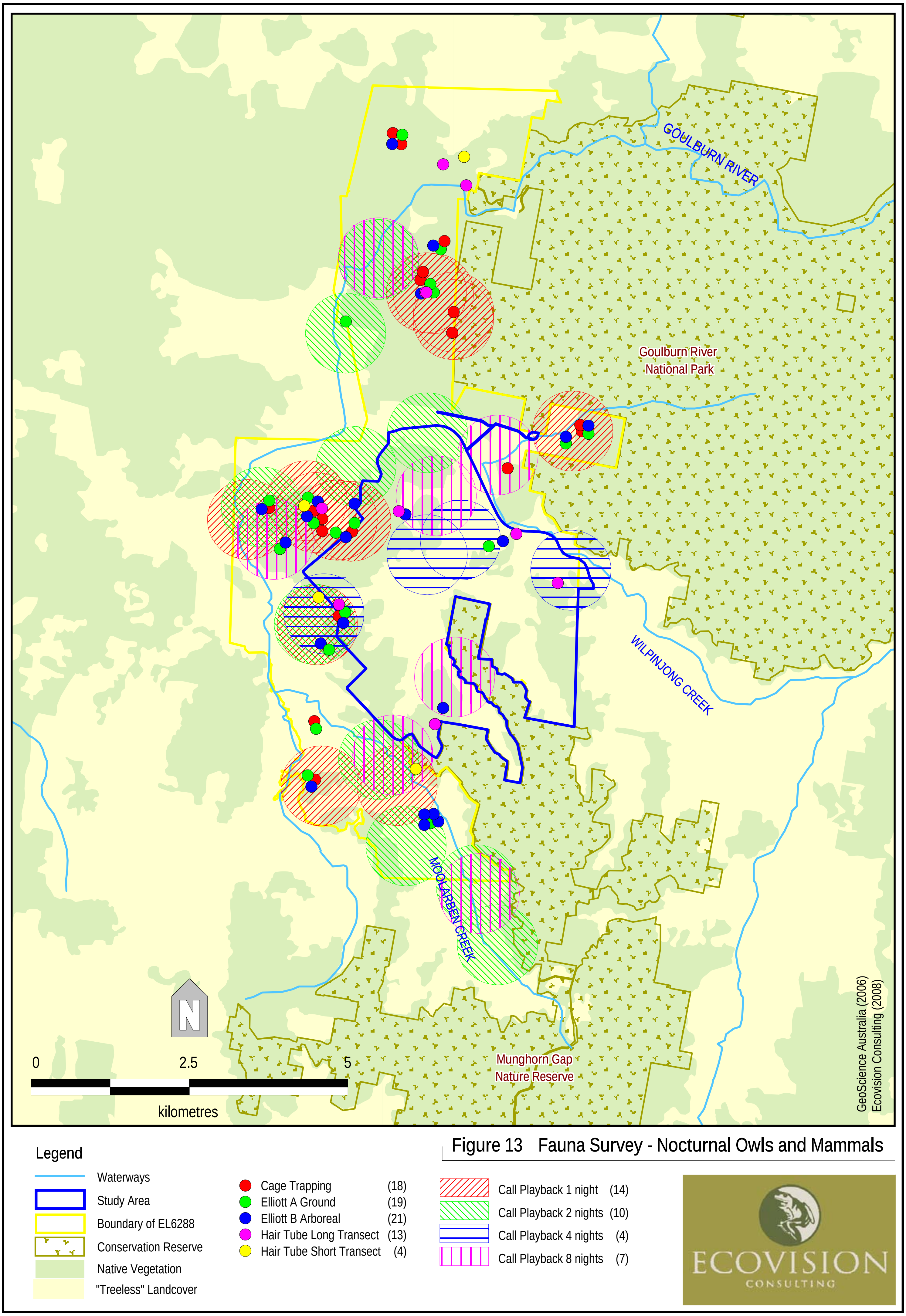


Figure 13 Fauna Survey - Nocturnal Owls and Mammals

early age and extends slowly into the larger branches of mature trees (Greaves and Florence 1966; Mackowski 1984 in NSW Scientific Committee, 2007). Internal cavities develop after this decayed material collapses, and access is provided by breakage of branches or the stem. Hollow entrances are more common in larger trunks and branches because damage is less likely to be occluded by growth of external sapwood (Marks *et al.* 1986 in NSW Scientific Committee, 2007). Fire damage can also expose heartwood to decay or create cavities (Inions *et al.* 1989 in NSW Scientific Committee, 2007). In Australia, active excavation by vertebrates is not an important process in hollow formation.

In agricultural landscapes hollow-bearing trees typically persist as isolated mature individuals in cleared paddocks or in small fragmented vegetation remnants (Bennett *et al.* 1994, Gibbons and Boak 2002 in NSW Scientific Committee, 2007). Such trees frequently suffer from poor health (e.g. 'dieback') and have a shorter lifespan than in forested landscapes (Yates and Hobbs 1997, Saunders *et al.* 2003, Reid and Lansberg 2000 in NSW Scientific Committee, 2007). Eventual loss of current hollow-bearing trees, and a lack of recruitment of younger trees to replace them, will result in a large decrease in the hollow resource over the wide geographic area covered by agricultural landscapes in the medium term (Saunders *et al.* 2003, Vesk and Mac Nally 2006 in NSW Scientific Committee, 2007).

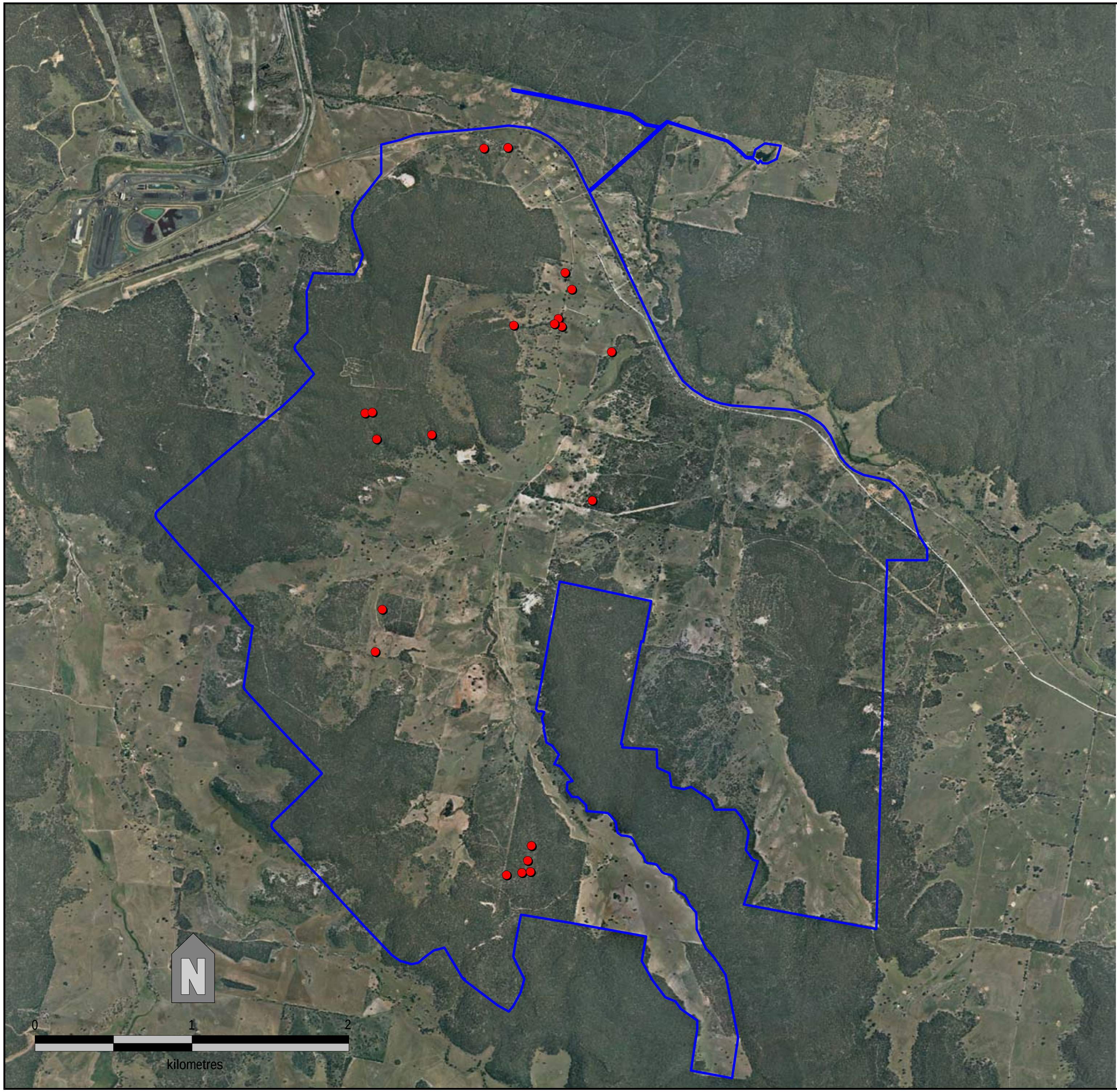
Targeted surveys conducted throughout the study area, with a particular focus on the valley floor and midslopes identified few trees with hollows, with **Figure 14** identifies the location of trees known to contain hollows. This result is consistent with tree hollow densities for agricultural landscapes where trees with hollows are often rare due to the reduced occurrence of trees (i.e. land clearing; stifled recruitment), particularly of a mature age class (i.e. mature aged trees support hollow development). The greatest density of tree hollows on the valley floor is associated with vegetation dominated by Blakely's Redgum (*E. blakelyi*), a vegetation formation that has been sparingly cleared thus containing some of the oldest trees of this landscape.

A greater density of tree hollows was observed in the upper midslopes below Triassic rocky outcrops. Mature Grey Gum (*E. punctata*) reliably provided tree hollows, a result considered directly related to the absence of land clearing events throughout this infertile agriculturally undesirable landscape. However, the absence of tree hollows in Broad-leaved Ironbark (*E. fibrosa*), a co-dominant species, was also noted and is perhaps related to past timber harvesting for 'pit props' in the Ulan mine. Such activity has now ceased, with maturing Broad-leaved Ironbark (*E. fibrosa*) specimens likely to produce tree hollows in time.

An opportunistic observation at dusk identified two Glossy-black Cockatoos perched at the entrance of a large tree hollow contained within a mature Grey Gum (*E. punctata*). This tree is located in close proximity to dense clusters of Sheoak foraging material, other trees with hollows and water resources. For these reasons it is speculated that this landscape is particularly important to the lifecycle of the Glossy-black Cockatoo. Other species that may rely on this landscape for breeding lifecycles include the Brown Treecreeper, despite this species showing a preference for foraging within the adjoining valley floor landscape.

Whilst Box species generally contain high tree hollow density, the experience within the study area is not necessarily consistent with this assumption. Scattered mature White Box (*E. albens*) located on the mid to upper slopes provide isolated tree hollow occurrences, however, the more common Grey Box (*E. moluccana*) and Slaty Box (*E. dawsonii*) offer few to no tree hollows. Both these species are associated with the more arable valley floor landscape are have been heavily cleared for agricultural purposes. Notwithstanding these observations some fauna appear to have adapted to these conditions. Observations of the Red-rumped Parrot using hollows within fence posts are indicative of the scarcity of tree hollows.

The restricted spatial occurrence of tree species that sponsor higher tree hollow densities is likely to have a strong influence on the distribution of fauna reliant on these habitat features. Competition for these roosts is likely, with species more tolerant to disturbance likely to be the winners (i.e. small parrots such as the Red-rumped Parrot and Eastern Rosella). This in part could explain the absence of Turquoise Parrots from the study despite there being a high observation count for this species within the locality (i.e. 30 km radius), with the presence of feral cats in the catchment also considered a negative influence.



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Legend

Study Area

Tree with hollow(s)

FIGURE 14

Known Locations of Trees with Hollows

Sources
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Plate 3: 'Fence post' hollow with juvenile Red-rumped Parrot at base

There is currently limited evidence of exotic avifauna within the study area, however, should the populations of exotic bird species increase (e.g. the Indian Myna and Common Starling) there could be a devastating effect on the tree hollow availability thus naïve fauna occupation. The influx of exotic birds is likely to happen irrespective of mining activities, although may be enhanced by such developments, and will thus require active suppression to minimise the long term affects of competition over limited resources. Moreover, the study area seems to be important to migratory species that use tree hollows such as Woodswallows, with the seasonal influx of these species representing additional stress on local habitat availability.

Fallen Timber

Fallen timber is a restricted and limited resource throughout the study area, with most occurrences restricted to steeper inaccessible lands and/or areas where mature trees exist. The limited occurrence of this habitat resource is attributed to land clearing and followup timber removal for firewood. The highest occurrence of fallen timber is found throughout the dry sclerophyll forests in contrast to the grassy forests and woodlands where land clearing, cropping and grazing have continuously diminished its percentage cover. Plate 4 exhibits a fallen log thus illustrating the importance of this habitat feature in creating habitat 'roughness'.

Flowering Trees and Shrubs

Flowering shrubs and trees that offer foraging habitat for locally occurring nectivorous fauna populations are mostly restricted to the plant families Myrtaceae (i.e. gum trees), Epacridaceae (e.g. prickly sub-shrubs) and Proteaceae (e.g. grevillea and banksia). The ridgetops are rich with summer flowering eucalypts such as Broad-leaved Ironbark and Grey Gum, both of which are capable of producing high quantities of nectar. Also widespread throughout this landscape are fleshy fruits on Geebung (*Persoonia linearis*). Few other foraging resources exist, except for woody fruits which are discussed in the next section.

The midslopes immediately above and below the interface between the Triassic - Permian interface is a diverse landscape characterised by dry undulations and ridgespurs on clays mixed with sheltered ephemeral streams and open depressions on sand clays. This diversity is matched with a wide array of foraging resources common to both the ridgetops and valley floor.

Plate 4: Fallen log in Eastern Creek adjacent to a natural spring

A greater diversity of eucalypts exists throughout the midslopes, with species additional to those of the ridgetops including White Box (*E. albens*), Grey Box (*E. moluccana*), Mugga Ironbark (*E. sideroxylon*), Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*) although many of these are of low abundance. The addition of these species increases the temporal availability of nectar resources, particularly in the case of White Box (*E. albens*) where flowering generally coincides with late autumn and winter. Honeyeaters are particularly advantages by this landscape, with other wide ranging insectivorous species also utilising this landscape during flowering periods.

Occurring on trees located throughout the upper midslopes is a large quantity of Mistletoe (*Amyema* spp.), with this landscape perhaps containing the highest mistletoe density. Trees and shrubs important to mistletoe occurrence include Box, mostly Grey Box (*E. moluccana*), and Narrow-leaved Wattle (*A. linearifolia*). Box Mistletoe (*Amyema miquellii*) and Grey Mistletoe (*Amyema quandang* subsp. *quandang*) are respectively associated with the above mentioned host species. The Striped Honeyeater and Spiny-cheeked Honeyeater are both intrinsically linked with these foraging resources as is the Mistletoe Bird.

Shrubs of the midslope landscape considered important to nectivorous species include various epacrids such as Fiver-corners (*Styphelia triflora*). Moving downslope towards the open drainage lines the landscape becomes more associated with insect populations and small fleshy fruits such as those produced by bush cherry (*Exocarpus* spp.) and Native Cranberry (*Astroloma humifusum*). It is considered that increased 'roughness' in this landscape, which is sponsored primarily by shrubs and ironbark species, encourages the presence of insectivorous fauna species (i.e. increased insect diversity).

The lower slopes and streams are dominated by various box species and Rough-barked Apple (*A. floribunda*), producing scattered but rich seasonally abundant nectar resources. Banksia (*Banksia marginata*) will produce substantial nectar resources during later winter early spring, which coincides with many breeding nectivores. Five Corners (*S. triflora*) is also prominent in this landscape.

Woody Fruits and Seeds

The study area provides a localised abundance of woody fruit resources from a few plant species. Sheoak including the Drooping Sheoak (*Allocasuarina verticillata*) and *Allocasuarina gymnanthera* are common on the steep claystone midslopes and shallow sandy Triassic plateaus respectively, with isolated occurrences of the latter located throughout the footslopes of the Triassic ridgelines. Both these species are critical to the foraging activities of the Glossy-black Cockatoo, with density, age and proximity to nesting areas all important factors.

Scattered occurrences of *Hakea dactyloides* on the ridgelines provide foraging resources for other parrot species such as the Sulphur-crested Cockatoo, Yellow-tailed Black Cockatoo and Gang Gang Cockatoo. Wattles particularly the species *Acacia linearifolia* are also important foraging resources as the woody seeds produced are not only nutritious but also in high quantities in dense patches. The majority of these resources are restricted to the ridgelines, upper slopes and footslopes, with few woody fruit resources of significance located in the valley floor.

Grass seed resources important to species such as the Diamond Firetail are mostly restricted to fertile landscapes such as the basalt caps, streams and basalt influenced slopes of the valley floor. Species diversity appears greatest on the basalt caps, However seed productivity is probably greatest in proximal connected downslope environs.

Water Resources

Critical to the occurrence and survival of many local fauna populations is the occurrence of water resources throughout the landscape. Factors such as permanency and spatial occurrence are particularly important given the high evapotranspiration rates and impoverished nutritional values of the study area (i.e. implying high energy costs for movement). **Figure 15** identifies the location of important water resources such as natural seeps, bores, dams and creeks where available water periodically exists.

Current water resources are widespread, with many exhibiting permanent to semi-permanent occurrence. Many claystone outcrops have been historically mined with residual landscape features promoting water retention within resultant closed depressions. Natural springs also occur throughout the study area, with some of these springs remaining as natural seepages but with the majority feeding purposely built farm dams. Streams also provide some semi-permanent water resources in ‘chain of pond’ arrangements, with pond formation reliant on outcropping bedrock conditions.

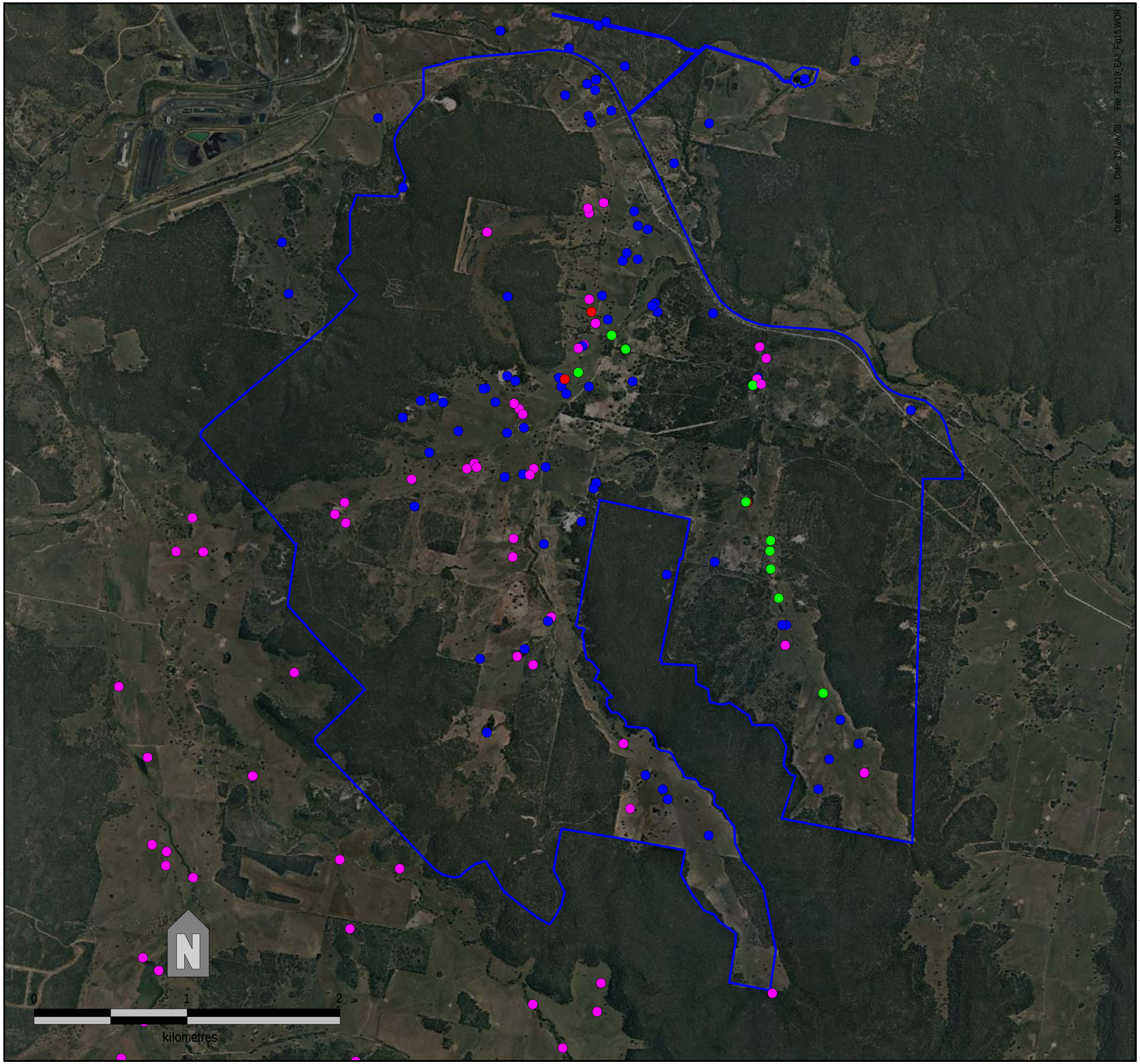
These water resources are critical to parrot populations, particularly the Glossy-black Cockatoo, with this species reliant on water resources in close proximity to nest sites. The Diamond Firetail is also heavily reliant on the occurrence of water presumably to aid the digestion of its seed diet. The frequency of water resources is important to reduce the energy cost of movement, with sparse limited resources potentially reducing the carrying capacity of the landscape for many of the observed species.

6.3.3. Fauna Observations

The description of local faunal assemblages in **Section 5.3.2** as observed from previous local studies are relatively consistent with observations collected from the study area (**Appendix 3**). However, baseline studies detected a wide range of threatened fauna species occurrences throughout the study area, with some populations appearing to have greater abundances than those expressed elsewhere in the Ulan district. The following description of fauna observations is accordingly biased to this fauna group.

Common within Scribbly Gum and Narrow-leaved Ironbark dominated vegetation, which is widespread throughout the northern half of EL6288, is the Glossy Black Cockatoo presumably due to the elevated availability of Sheoak foraging resources and tree hollow roosts. Whilst observed in lower densities throughout the south, the Glossy Black Cockatoo also appears to favour Broad-leaved Ironbark – Black Cypress Pine Forest where foraging resources, potential roosts (i.e. Grey Gum) and watering points (i.e. uplands dams) are irregularly available in close proximity to each other.

Also noteworthy for the Scribbly Gum and Narrow-leaved Ironbark Woodlands is the presence of Large-eared Pied Bat, Eastern Long-eared Bat and Powerful Owl, with the former requiring cave roosts and latter two requiring large tree hollows as part of their lifecycles. It is speculated that very mature (senescent) Scribbly Gum is responsible for Eastern Long-eared Bat roosts, with taller hollow bearing trees in gully heads (i.e. Grey Gum) likely to be important for the Powerful Owl. Elsewhere these species have limited occurrence.



Legend

- Bore
- Creek
- Dam
- Spring

Study Area

FIGURE 15

Location of Water Resources

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The grassy woodlands and shrubby forests of the valley floor contain populations of the Brown Treecreeper, Speckled Warbler and Diamond Firetail. The former two species have been predominantly observed near the margins of native vegetation cover and/or the footslopes of the adjoining ridgelines. However, in contrast the Diamond Firetail appears to prefer the lower grassier slopes and creeklines where ample breeding, foraging grounds and water resources prevail.

As expected, the Black-chinned Honeyeater appears to occupy at least two distinctly differing vegetation types these being Grassy White Box Open Woodland on Basalt (i.e. winter nectar) and Broad-leaved Ironbark vegetation formations (i.e. summer flowering). It is also anticipated that the latter vegetation formation would provide an alternative foraging area during periods of drought (i.e. poor nectar flow) in the form of lerps (i.e. leaf insects).

The vegetation of riparian environments and adjoining lower slopes appears to be locally important for threatened microchiropteran bats, including both cave and tree roosting species. The Little Pied Bat, Large Bent-wing Bat and Yellow-bellied Sheath-tail Bat all have concentrated occurrences within Yellow Box and Blakely's Redgum dominated vegetation. The Large-eared Pied Bat has also been detected foraging throughout this landscape. Roosts sites are likely to be restricted to mature Blakely's Redgum specimens.

The Painted Honeyeater and Grey-crowned Babbler have scattered occurrences throughout the study area, with the former having more predictable reasoning for its distribution pattern. The Painted Honeyeater principally forages on Mistletoe, with spring-summer time migration to the Ulan locality for breeding coinciding with mass mistletoe flowering events primarily on Grey Box. Few records of the Grey-crowned Babbler have been collected from the study area suggesting this species is rare in the locality. Reasons for the uncommon status are probably linked to reduced shrub understorey complexity, vegetation fragmentation, remnant size and competition.

The seemingly high and disproportionate presence of threatened fauna species throughout the cleared lands of EL6288 and adjoining interface with intact vegetation, rather than wholly within tracts of intact native vegetation, could be argued to be an artefact of visibility (i.e. capacity to observe species) rather than habitat value. Notwithstanding, it is recognised that the more fertile overcleared landscapes historically represent core habitat for many of these threatened species, with the key threatening process 'Land Clearing' being the primary driver of species becoming threatened. Thus what could be deduced from these observations is that the current habitat values of the cleared lands do not necessarily inhibit threatened species activity, with observed activity being a function of continued habitat availability.

The distribution of the Hooded Robin throughout the study area supports this concept, as the majority of records were repeatedly collected from a few locations situated in close proximity to grassy woodland remnants particularly fertile landscapes (i.e. basalt and derived soils). These observations are considered important in the context of this impact assessment as the development of a meaningful impact management approach needs to demonstrate a high degree of certainty in its desired outcomes.

6.4. Aquatic Biota

As described in **Section 5.3.3**, a total of 16 aquatic ecology sampling sites were selected for detailed sampling of aquatic biotic assemblages and water quality. **Figure 4** identifies the location of the aquatic sampling sites. The sites were assessed for overall aquatic habitat condition using a standardised Riparian-Channel-Environment (RCE) ranking scheme. At each site, the main Stream Health assessment method targeted aquatic macroinvertebrates, based on the AusRivAS protocol which specifies sampling in spring and autumn.

Aquatic field surveys were undertaken in spring 2004, autumn and spring 2005, summer 2006 and spring 2007 **(**Table 16**)** with some additional walk-over surveys in autumn 2008. Survey intensity varied between 4 and 10 sites per season, with 15 sites having sufficient water available for macroinvertebrate sampling at least once. In summary, 24 visited sites from the total 39 visited sites had sufficient water available for sampling over the sampling period.

Table 16: Moolarben Coal EA2 Aquatic Ecology Site Sampling Dates Dec 04 to Oct 07

Creek	Site	Easting	Northing	Season and Sample Date						No. of	Comments
				Sp 04	Au 05	Sp 05	Su 06	Au 06	Sp 07	Samples	
Upper Wilpinjong (above Murragamba Ck)											
	WCX0	767006	6426631	*	*	*	*			0 of 4	Generally dry
	WCX1	765601	6426168				16/01/06			1 of 1	Splitters Dam
	WC1	764763	6425640	**	**	27/09/05	**	**		1 of 5	
Murragamba Creek											
	MGX1	764125	6419663					*	29/10/07	1 of 2	Ploughed under
	MGX2							*	29/10/07	1 of 2	
	MG1	763082	6421403	*		28/09/05	17/01/06			2 of 3	Erosion gully
	MG2	763809	6423743	15/12/04	18/05/05	22/09/05		08/06/06	29/10/07	5 of 5	Road crossing
Middle Wilpinjong (Murragamba Ck to 'Eastern Creek')											
	WC2	765303	6424064	15/12/04	**		**	**		1 of 4	
Eastern Creek											
	ECSpring								30/10/07	1 of 1	
	ECX0	765838	6420356						30/10/07	1 of 1	Ploughed under
	ECX1	765263	6421840						30/10/07	1 of 1	Generally dry
	ECX1.5								30/10/07	1 of 1	
	ECC1								30/10/07	1 of 1	
	ECX1.75								30/10/07	1 of 1	
	ECX2	765300	6424025			27/09/05	17/01/06	08/06/06		3 of 3	Road crossing
Lower Wilpinjong ('Eastern Creek' to Spring Flat)											
	WC3	766325	6423575								No access
	WC4	768691	6421326			28/09/05	17/01/06	*	31/10/07	3 of 4	
Number of Samples per Survey				2 of 5	1 of 4	5 of 6	4 of 7	2 of 7	10 of 10		
Notes:	* No water available for sampling, ** Insufficient water for sampling									24 of 39	

The full results of the RCE analysis are shown in **Appendix 4** Table 5.1 and are summarised in Table 17and Table 18 below.

Table 17: Moolarben Coal EA2 Aquatic Ecology RCE Scores

RCE Category**	RCE Scores			RCE percent			Median Attribute of Sample Sites
	M	X	SE	M	X	SE	
Land-use pattern	3	2.6	0.1	75	66.2	3.7	Mixed native vegetation and pasture/exotics
Width riparian strip	3	3.0	0.2	75	75.0	6.1	Between 5 and 30 m
Completeness of riparian	2	1.9	0.3	50	48.5	7.6	Breaks at intervals of 10-50 m
Riperian Vegetation	3	3.0	0.1	75	75.0	2.1	Mixed native and exotic trees and shrubs
Stream bank structure	3	2.5	0.2	75	61.8	5.3	Banks firm but held mainly by grass and herbs
Bank undercutting	3	2.7	0.2	75	67.6	4.7	Only on curves and at constrictions
Channel form	3	3.0	0.3	75	75.0	7.1	Medium; width:depth ratio 8:1 to 15:1
Riffle/pool sequence	2	1.5	0.2	50	38.2	5.3	Natural channel without riffle/pool sequence
Retention devices	1	1.5	0.2	25	36.8	5.3	Stream or channel with few or no rocks/logs
Channel sediments	2	2.1	0.2	50	51.5	4.0	Bars of sand and silt common
Stream bottom	1	1.2	0.2	25	29.4	5.8	Bottom mainly loose and mobile sandy sediment
Stream detritus	2	1.6	0.3	50	41.2	6.8	Mainly fine detritus mixed with sediment
Aquatic vegetation	3	3.1	0.2	75	76.5	5.9	Substantial algal growth; few macrophytes

Notes:

* M = Median, X = Mean, SE = Standard error of mean.

**RCE Category Descriptors

Land-use pattern	Land-use pattern beyond immediate riparian zone
Width riparian strip	Width of riparian strip-of woody vegetation
Completeness of riparian	Completeness of riparian strip of woody vegetation
Riperian Vegetation	Vegetation of riparian zone within 10 m of channel
Retention devices	Retention devices in stream
Channel sediments	Channel sediment accumulations

Table 18: Summary RCE Assessments Individual Site Scores

Creek	Site	Score	RCE %
Upper Wilpinjong (above Murragamba Ck)			
	WCX0	41	79
	WCX1	24	46
	WC1	35	67
Murragamba Creek			
	MGX1	19	37
	MGX2	30	58
	MG1	31	60
	MG2	23	44
Middle Wilpinjong (Murragamba Ck to 'Eastern Creek')			
	WC2	32	62
Eastern Creek			
	ECSpring	27	52
	ECX0	26	50
	ECX1	25	48
	ECX1.5	36	69
	ECC1	33	63
	ECX1.75	34	65
	ECX2	32	62
Lower Wilpinjong ('Eastern Creek' to Spring Flat)			
	WC3	31	60
	WC4	26	50
Grouped Sites Mean RCE Scores			
Wilpinjong Ck above Murragamba Ck		27	51
Murragamba Ck (MGX1 to MG2)		28	53
Lower Wilpinjong (WC2 to WC4)		28	54
Eastern Creek (EC Spring to ECX2)		31	60

Analysis of the combined site categories (Table 17 above) indicates that most of the aquatic sampling sites were located in mixed pastoral and woodland habitats with broken or scattered riparian woodland and banks generally held together by herbs and grasses. The sites selected had medium width to depth ratios (between 8 and 15 to 1) with few riffle/pool sequences and few natural retention devices (rocks or logs). Silt and sand bars were common and these were mobile, generally indicating active creek bed and bank erosion. There was generally substantial algae growth and often little or no aquatic plant growth indicating general eutrophication of contained waters.

Comparisons with site RCE scores for the MCP Stage 1 assessment in Moolarben Creek/Upper Goulburn River sub-catchment indicate that overall RCE scores in Stage 2 Upper Wilpinjong Creek sub-catchment (i.e. the present study area) are much lower. Individual site RCE scores in the present study were generally low (Table 18) ranging (in percent terms) from 37 % at Murragamba Creek site MGX1 (an in-line dam in upper Murragamba Creek) to 79 % at the upper Wilpinjong Creek (site WCX0). However, this latter site was visited 4 times and never had water for sampling. Five sites had RCE score between 41 and 50, four sites had RCE scores in the range 51 to 60 % and 6 sites had scores in the range 61 to 70%. RCE scores for sites in Wilpinjong Creek generally decreased downstream whilst the better sites in Murragamba Creek were located in the middle section and the better Eastern Creek sites were located in the lower sections.

Table 19 (below) provides a summary of the water quality results. The water quality results indicate that most sites had very little water holding capacity (range 0.05 to 0.6 m depth, mean depth around 0.16 m) and that is characteristic for the sub-catchment. In contrast the Moolarben/Upper Goulburn sub-catchment sampled for the MCP Stage 1 environmental assessment had a number of sites with greater than 1 m depth and mean depth for the whole study of 0.4 m). Full results of the water quality sampling undertaken during the aquatic field sampling program are shown in **Appendix 4** Table 5.2.

Table 19: Summary of Aquatic Sampling Site Water Quality Monitoring

Creek and Location	Temp	Cond	DO	DO	Acidity	ORP	Turb
Paameter	°C	µs/cm	%Sat	mg/L	pH units	mv	NTU
Wilpinjong Creek							
Minimum	6.29	515.00	11.90	1.10	5.74	134.00	3.20
Mean	20.04	913.58	70.26	6.24	7.41	233.92	44.15
Maximum	26.97	1470.00	120.10	9.60	9.24	325.00	164.50
SE of Mean	1.79	93.46	10.78	0.83	0.34	19.35	13.13
Murragamba Creek							
Minimum	6.10	53.00	3.00	0.30	6.59	82.00	23.10
Mean	17.90	373.93	45.98	4.45	7.24	333.15	259.33
Maximum	27.83	724.00	114.20	9.00	8.91	588.00	543.20
SE of Mean	1.82	50.99	7.35	0.64	0.15	32.60	50.86
Murragamba Creek Spring Fed Dams							
Minimum	22.90	95.00	81.10	7.00	7.73	295.00	11.90
Mean	23.93	148.80	100.82	8.48	8.24	295.00	37.42
Maximum	26.11	230.00	122.00	10.20	8.76	295.00	66.40
SE of Mean	0.59	25.41	6.73	0.52	0.17	0.00	11.31
Eastern Creek							
Minimum	6.04	298.00	9.00	0.80	3.20	261.00	2.30
Mean	19.35	999.60	57.00	5.18	6.13	322.90	149.45
Maximum	26.11	2300.00	123.00	9.90	7.32	676.00	600.00
SE of Mean	1.06	150.31	6.97	0.60	0.30	21.23	39.07
Eastern Creek Spring Fed Dams							
Minimum	16.33	110.00	9.60	0.90	6.25	295.00	2.00
Mean	20.78	537.00	49.34	4.43	6.84	295.00	156.36
Maximum	26.01	1663.00	93.60	8.40	7.87	295.00	554.30
SE of Mean	1.36	206.91	9.81	0.88	0.19	0.00	71.30
Total Survey							
Minimum	6.04	53	3.0	0.3	3.20	82.00	2.0
Mean	19.71	702	59.9	5.4	6.93	300.63	145.4
Maximum	27.83	2300	123.0	10.2	9.24	676.00	600.0
SE of Mean	0.71	73	4.3	0.4	0.16	12.06	22.4
Median	20.13	521	55.6	5.1	6.95	295.00	67.2

Water temperature, dissolved oxygen concentrations and turbidity readings were highly variable and generally reflected seasonal variation (for temperature) and contrasting wet or dry sampling conditions (for turbidity and dissolved oxygen).

Whilst water conductivity showed an overall large variation (range 53 to 2300 µS/cm) with an average of 700 µS/cm for the whole study, the conductivities in this catchment were less than those in the Moolarben Creek sub-catchment (sampled for the MCP Stage 1 assessment), where creek conductivities were routinely 3000 to 6500 µS/cm):

- In contrast to the Moolarben/Upper Goulburn catchment where there was a gradual decrease in conductivity down Moolarben Creek and then down the upper Goulburn River, Wilpinjong Creek sites showed a gradual increase in conductivity downstream with conductivity around 500 µS/cm upstream (at site WCX1 - Splitters Hollow Dam) and around 1100 µS/cm downstream (at site WC4 Spring Flat just below Planters creek confluence).
- Murragamba Creek sites (both in-creek and spring fed dams) had relatively low conductivities (means 371 µS/cm and 149 µS/cm respectively) and the in-stream site conductivity was more variable than spring-fed dam waters. The spring fed dams sampled for this study were all in the middle section of the creek.

- Eastern Creek ponds and in-line dams showed a similar pattern to Wilpinjong Creek, with lower conductivities in the upper catchment and generally elevated conductivities in the lower catchment. Eastern Creek spring fed dams had overall lower conductivities than the creek line dams and they also showed a pattern of lower conductivity in upper slope dams compared to elevated conductivity in downstream dams towards the Wilpinjong Creek confluence.

Water acidity (as pH units) was relatively variable with an overall study range between 3.2 pH units and 9.2 pH units:

- Wilpinjong Creek pH was generally between 6 and 7.2 pH units with one set of alkaline readings from Splitters Hollow Dam (around 9.2 pH units) on one occasion;
- Murragamba Creek pH was generally around neutral with all values except one in the range 6.5 to 7.6 pH units. In contrast the spring fed dams had more alkaline water (range 7.7 to 8.8 pH units); and
- Eastern Creek pH values in the upper and middle creek plus Eastern Creek spring fed dam waters were around neutral (range 6.6 to 7.9 pH units) whilst values in the lower portion of the creek (which had spring seepages along the western bank) were generally highly acid (3.2 to 5.7 pH units).

The combined RCE field assessment plus topo/aerial photo inspections and field water quality sampling results lead to the following conclusions with respect to potential aquatic and fish habitat condition and with respect to potential mining related impact:

- Wilpinjong Creek has relatively good, stable riparian habitat and overall creek structure (compared to the other creeks in the study area) throughout its length in the study area (headwaters to Planters Creek Confluence). It does not provide a large dry weather supply of ponded surface water but would appear to have much sub-surface flow sufficient to support emergent sedge and grass growth (including large swaths of Cumbungi). Given the overall shallow depth of ponded water (when available), the water quality is sufficient to support aquatic life - although the species that would survive would need to be tolerant to a high range of water quality variables. Wilpinjong Creek has sufficient connectivity during moderate to high flows to support some native riverine fish species but probably does not provide large deep ponds to support many native fish;
- Murragamba Creek has had little surface flow over the extended period of this study (2004 to 2007) although there are sufficient signs of short violent flood events. For the most part the creek has little or no suitable aquatic habitat except for in-line dams and even these, unless spring fed are often empty. Agricultural practices have obliterated any semblance of creek structure in the upper catchment and for many of the slope drainages from the flanks of the western ridge. What water there is, in the creek or in the off-line dams, would appear to derived from spring waters;
- Whilst the section of stepped rock constrained pools in the middle section of Murragamba Creek has good riparian vegetation and cover plus good stable pool structures there has not been any significant ponded water to sample. The conditions for the support of aquatic life are good but the water is not there;
- The lower section of Murragamba Creek from the road crossing to the confluence with Wilpinjong Creek comprises a deeply incised channel with steep highly unstable channel sides. Any ponds which form during major storm events are probably short lived as unstable storm-derived sediments are deposited into the depressions. Except for times of flood flow this section of the creek provides little or no aquatic habitat in the form of drought-proof ponds;
- It is concluded that Murragamba Creek provides variable aquatic habitat in some of the in-line dams plus in the off-line dams which are spring fed. Whilst much of the water supply to Murragamba Creek would appear to be derived from springs it would appear that much of this water flows sub-surface and is only occasionally expressed as ponded surface water. Accordingly Murragamba Creek does not provide much fish habitat;
- The upper and middle portion of the Eastern Creek valley has numerous springs on the slopes leading to the creek and there are consequently a number of large in-line dams which capture any occasional surface runoff plus the steady spring fed waters. Consequently the actual creek line between the

dams and downstream of the dams is almost non existent. As for Murragamba Creek there is probably a spring fed sub-surface flow through the valley but this is seldom expressed as ponded water;

- There is a section of incised clay-stone terraced and log-jammed pools with mixed wooded riparian cover located towards the lower end of the creek. Whilst this section includes some permanent pool structures and whilst there is evidence of short sharp storm flows, as for Murragamba Creek, these structures seldom retrain sufficient water to support any significant aquatic life. The final section of Eastern Creek above the Wilpinjong Creek confluence has saline and acidic seepages along the western bank. This creek section here is a broad, deeply incised channel with a flat sandy bed. There is little pool structure and when there is available water it is very shallow and thus short lived; and
- It is concluded that Eastern Creek provides variable aquatic habitat in some of the in-line dams plus in off-line dams which are spring fed. Whilst much of the water supply to Eastern Creek would appear to be derived from springs it would appear that much of this water flows sub-surface and only occasionally expressed as ponded surface water, thus providing little fish habitat.

Table 20 below provides a summary of site diversity and SIGNAL statistics and Table 21 provides a summary of seasonal Diversity and SIGNAL statistics. The full results of the aquatic macroinvertebrate biota survey are contained in **Appendix 4** Tables 5.4 to 5.6.

Table 20: Site Macroinvertebrate Diversity & SIGNAL Indices

Season	Date	Site	Diversity	SIGNAL
Su 06	16/01/06	WCX1	10	4.10
Sp 05	27/09/05	WC1	19	3.69
Sp04	15/12/04	WC2	17	4.21
Sp 05	28/09/05	WC4	15	3.38
Su 06	17/01/06	WC4	16	4.29
Sp 07	31/10/07	WC4	21	4.32
Sp 07	29/10/07	MGX1	21	4.00
Sp 07	29/10/07	MGX2	19	4.00
Sp 05	28/09/05	MG1	22	3.63
Su 06	17/01/06	MG1	25	3.88
Sp04	15/12/04	MG2	16	4.46
Au 05	18/05/05	MG2	15	3.64
Sp 05	22/09/05	MG2	20	3.76
Au 06	08/06/06	MG2	4	3.00
Sp 07	29/10/07	MG2	18	4.27
Sp 07	30/10/07	ECSpring	17	3.67
Sp 07	30/10/07	ECX0	16	4.08
Sp 07	30/10/07	ECX1.5	7	4.86
Sp 07	31/10/07	ECX1.75	17	4.57
Sp 07	30/10/07	ECX1-dam	15	4.14
Sp 05	27/09/05	ECX2	18	4.00
Su 06	17/01/06	ECX2	10	4.20
Au 06	08/06/06	ECX2	5	4.80
Sp 07	30/10/07	ECC1	16	4.14
Min			4	3.00
Max			25	4.86
Mean			15.8	4.05
SE of Mean			1.07	0.09

Table 21: Summary of Seasonal Diversity & SIGNAL Indices

Season		Sp04	Au 05	Sp 05	Su 06	Au 06	Sp 07	Total
	No. samples	2	1	5	4	2	10	23
Seasonal Diversity		24	15	41	33	7	41	53
	Mean Diversity	16.5	15.0	18.8	15.3	4.5	16.7	15.8
SIGNAL Stats								
	Min SIG	4.21	3.00	3.38	3.88	3.00	3.67	3.00
	Max SIG	4.46	3.64	4.00	4.29	4.80	4.86	4.86
Un-weigthed Mean		4.34		3.69	4.12	3.90	4.20	4.04
	SE SIG	0.12		0.10	0.09	0.9	0.10	0.04

As indicated in Table 20 the individual site by season diversities ranged from 14 taxa (MG2 in autumn 2006) to 25 (MG1 in summer 2006) with a mean occurrence of 16 taxa per site. The low diversity occurrence at MG2 also provided the lowest SIGNAL score of 3.00. Site SIGNAL scores were relatively similar across the study and ranged from 3.00 to 4.86 with 8 sites (33 %) providing a 'very poor' rating (i.e. < 4) and 16 sites (67 %) providing a poor rating (i.e. 4 to 5). These proportions were generally similar to the proportions obtained in the Upper Goulburn River sub-catchment for the MCP Stage 1 assessment which yielded 27 % 'very poor' site results and 63 % 'poor' site results. There were 3 sites with 'fair' ratings, all in the Goulburn River downstream of the Ulan Creek.

With regard to seasonal analysis there was very little variation between seasons for the total study Table 21 With the exception of autumn 2006 for which the 2 sites sampled yielded 4 and 5 taxa respectively, the remaining seasonal mean site diversity scores were quite similar ranging from 15 (for the one sample in autumn 2005) to 19 in spring 2005 (5 samples). Seasonal SIGNAL scores were generally similar ranging from 3.7 in spring 2005 (also the highest diversity season) to 4.16 in spring 2007. There were 3 "very poor" seasons (autumn 2005 and 2006 plus spring 2005) and three "poor" rated seasons (spring 2004, 2006, 2007).

SIGNAL (Stream Invertebrate Grade Number Average Level) is an index of pollution tolerance for stream invertebrate animals ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant). The scores are derived from correlation analysis of aquatic macro-invertebrate survey information with RCE and water chemical analysis for a range of different streams. In the Hunter River the appropriate SIGNAL index is SIGNAL HU97 (Chessman et al 1997). Pollution tolerances, as related to water quality are as follows; 7 to 10 relate to excellent water quality, 6-7 to good water quality, 5-6 indicates fair conditions, 4-5 is poor condition and less than 4 generally indicated very poor water quality.

There were 53 aquatic macroinvertebrate taxa recorded from the study from the 24 samples. This compares with 68 taxa from the Upper Goulburn River sub-catchment sampled over much the same period for the MCP Stage 1 assessment. Of the 53 taxa found in the present study 48 were common to both studies. There were a total of 37 insect taxa (of which 34 also occurred in the Upper Goulburn sub-catchment), 6 crustaceans (5 common to both studies) and 4 molluscs (also common to the other study). Four of the remaining 6 taxa were also found in the other sub-catchment. It is concluded that there is a relative similarity in aquatic macroinvertebrate assemblages between the water bodies in the two upper sub-catchments of the Goulburn River.

Individual site diversity over the ten sampling days varied from 4 taxa at site MG2 in autumn 2006 to 25 taxa from site MG1 in summer 06. Seasonal diversity varied from 7 taxa in autumn 2006 (from 2 sites sampled) to 41 taxa in spring 2005 and spring 07 (from 5 and 10 sites sampled respectively). Overall mean site diversity was 16 taxa/ site from the 24 samples. The pollution tolerance of the taxa found throughout the study ranged from very pollutant tolerant (SIGNAL score of 1) to very intolerant (SIGNAL Score of 8) with a mean value for all taxa of 4.04, indicating that there was a relatively even spread of taxa over the total study:

- There were 5 pollution intolerant taxa (SIGNAL scores in the band 7 to 10) with an Elmidae Riffle Beetle (SIGNAL 8) occurring once at site ECC1 in spring 2007;

- Leptoceridae Caddis Flies (SIGNAL 7) occurred 15 times in 5 of the 6 surveys and in all main creeks. Aeshnidae Dragon Flies (SIGNAL 7) occurred 14 times in 5 of the 6 surveys and was also relatively wide spread. The Ancylidae Freshwater limpet (SIGNAL 7) only occurred once at site ECX2 in spring 2005. Baetidae mayfly and Leptoceridae caddis fly were also relatively common in the Goulburn River sub-catchment studies for the MCP Stage 1 Environmental Assessment, occurring at 27 and 23 of the 39 sites sampled respectively;
- There were 24 middle band pollution tolerant taxa (SIGNAL 4 to 6). Of the 8 SIGNAL 6 taxa, Backswimmers, Freshwater mites and Small water striders were relatively common occurring in more than 50 % of samples. Mosquitoes occurred in 46 % of samples and Marsh beetles plus Freshwater shrimp occurred in 25 % of samples. A Gomphidae Dragonfly occurred once at site MG2 in spring 2005; and
- Of the remaining 14 SIGNAL 4 to 5 Taxa, Scavenger water beetles, and Hemicordulidae dragonflies were relatively common occurring in more than 50 % of samples. Minute Rove beetles and Lymnaedae freshwater snails occurred in around a quarter of the samples and the remaining taxa occurred in less than 17 % of samples.

There were 20 very pollution tolerant low band taxa (SIGNAL 1 to 3); 10 SIGNAL 3 taxa, 7 SIGNAL 2 taxa and 3 SIGNAL 1 taxa. Chronominae bloodworms and Diving beetles occurred in 92 % of samples and Lesser water boatmen occurred in 75 % of samples. Five taxa occurred in 50 to 60 % of samples and the remaining 12 taxa occurred in less than 15 % of samples.

7. DATA ANALYSIS

7.1. Statistical Analysis of Flora Quadrat Data

Raw data was collected from the study area and EL6288 from systematic survey plots (e.g. flora quadrats) and was then collated into a database suitable for data analysis. This data was checked prior to the completion of a preliminary data analysis, with the results of the preliminary data analysis reviewed to determine the most appropriate analytical method for the dataset. **Section 4.8** outlines of the technical details of the statistical tests applied to the flora data and should be read in conjunction with this section.

7.1.1. Preliminary Data Analysis

A preliminary data analysis using a standard agglomerative hierarchical clustering analytical method was applied to the raw systematic floristic dataset collected for EL6288 (**Appendix 5**), which resulted in an unacceptably high "statistical stress" level (i.e. >0.15 see **Section 4.8**). Notwithstanding, the preliminary data analysis identified potential outlier data and variables for consideration in further analysis. This allowed for the refinement of the dataset by:

(i) The revision/ exclusion of 'noisy' quadrats; or

(ii) Exclusion of species with relatively low importance to the classification.

On this basis the final dataset was amended to 199 quadrats and 326 species. See **Appendix 5** for further discussion of outlier data. The analysis also provided insight on the general environmental gradients (e.g. fertility and soil moisture) acting within the study area.

7.1.2. Final Data Analysis

The following sections provide a summary of the non-hierarchical clustering analysis undertaken for the 'noise' reduced dataset. This analysis examined the data patterns that support the classification of vegetation formations and other related vegetation matters within the study area (i.e. EEC/ CEEC classifications). The statistical stress level for this analysis was <0.15, indicating a meaningful interpretable result (as explained in Section 4.8).

The Analysis

It was determined from the baseline studies, literature and preliminary analysis that 15 groups would adequately describe the vegetation patterns across EL6288. This analysis produced a dendrogram and ordination with an acceptable stress level of 0.139 (i.e. ordination not random). The analysis objectively selected 101 species of the available 326 (i.e. removal of redundant species) for the 199 quadrats included in the analysis. This analysis provided a meaningful classification of the data (i.e. acceptable stress level), hence enabling a capacity to define the composition of vegetation classes and formations and nature of important environmental gradients.

Figure 16 and **Figure 17** exhibit the dendrogram (diagram linking groups on the basis of similarity) and ordination (a three dimensional graph showing the inter-relation between groups) from this analysis.

The dendrogram shown in **Figure 16** identifies the similarities/ dissimilarities between groups 1-15 (i.e. each group representing a vegetation formation), which are aggregated into 4 broad group clusters (i.e. each cluster representing a vegetation class).

The ordination shown in **Figure 17** graphically shows the similarities between groups and group clusters relative to species correlates (i.e. vectors), with the data spread relative to these vectors providing insight into the environmental gradients acting within the study area. In the case of this analysis environmental gradients interpreted from the data may be useful in understanding the factors underlying the spatial distributions of plant species.

Figure 16: Row Fusion Dendrogram for 15 groups and 4 Group Clusters (Pink, Red, Blue, and Green) derived from a non-hierarchical clustering analysis

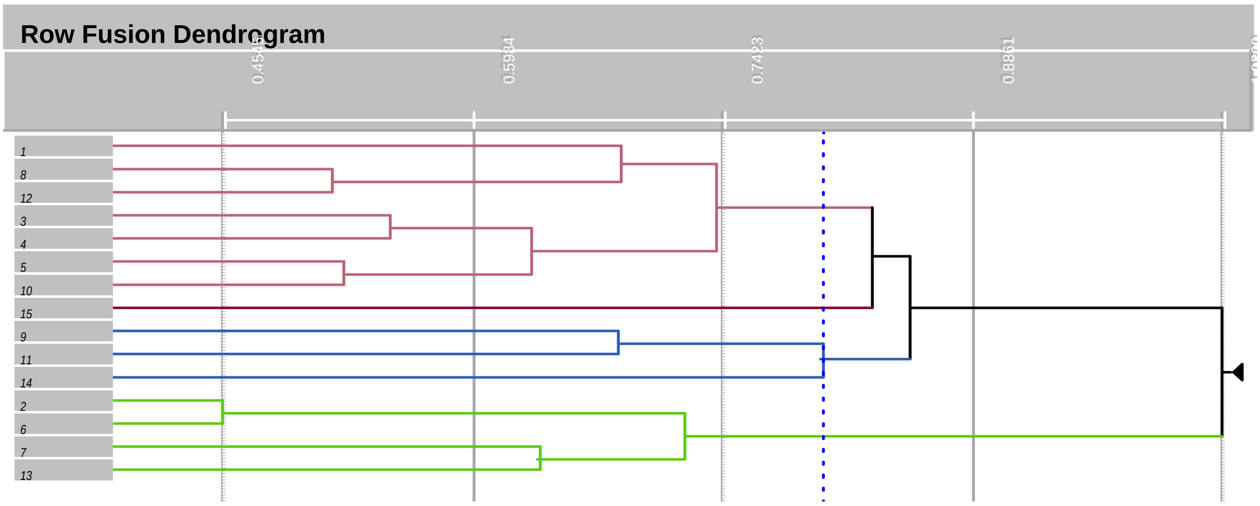
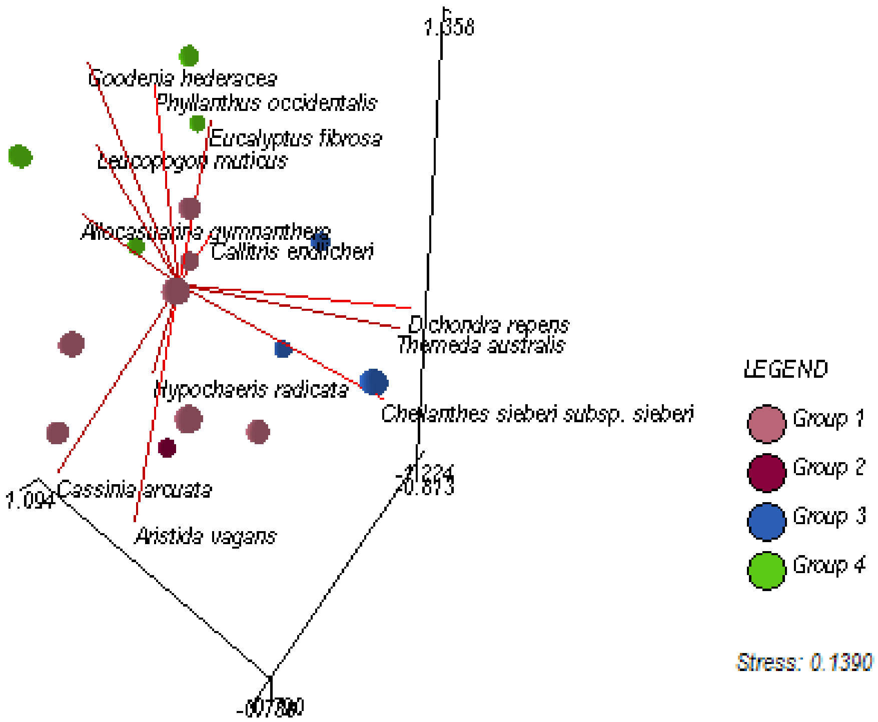


Figure 17: Ordination Plot of 15 Groups and 4 Group Clusters (Pink, Red, Blue, Green) derived from a non-hierarchical clustering analysis



Interpreted from above ordination is a non-random data arrangement, as implied by the low stress level, thus providing insight into main natural environmental gradients influencing the ecology of the study area (i.e. basis of underlying ecological function). From the ordination it appears that soil fertility and soil moisture are important factors (i.e. grass and herbaceous species indicated by *Cassinia arcuata, Dichondra repens* and *Themeda australis* generally do not associate with sclerophyllous shrubby species such as *Phyllanthus occidentalis, Eucalyptus fibrosa, Leucopogon muticus, Callitrus endlicheri, Allocasuarina gymnanthera*).

Anthoropogenic induced environmental gradients are also evident (i.e. factors related to agricultural activities) as evidenced by the divergence between species tolerant of these impacts (i.e. *Aristida ramosa, C. arcuata*) and those that are generally found within intact native vegetation such as *Dichondra repens* and *Themeda australis,* with the exotic *Hypocharis radicata* further supporting this conclusion. The low stress level was achieved without mechanical subjective interference thus providing confidence in conclusions derived from these interpretations.

7.1.3. Analysis by Groups – Vegetation Formations

The non-hierarchical clustering analysis classified 199 quadrats into four group clusters for comparison with regional vegetation studies (i.e. vegetation classes: e.g. Keith (2004)). This was further grouped into fifteen groups for comparison with regional and local vegetation formations such as those defined by BioMetric (2008). Descriptions are as follows.

The primary split in the dendrogram (**Figure 16**) separated flora quadrats contained within groups 2, 6, 7 and 13 (i.e. Group Cluster 4) from the remainder (i.e. Group Clusters 1-3) representing the primary distinction between dry sclerophyll forests on Triassic sandstones and shrubby/ grassy woodlands on Tertiary basalts and Permian lithology. This is interpreted as a generalised surrogate for the soil fertility environmental gradient and can also be considered the main separation for regional vegetation classification (i.e. grassy woodlands and shrubby woodlands).

The second major group division delineates between the White Box (*E. albens*) influenced plant formations and those of the Permian geological formations. Further inspection of the dendrogram identifies the sequential separation of dry sclerophyll forests from grassy/ herbaceous woodlands into various vegetation sub-formations including transitions (i.e. BioMetric, 2007). Commentary on each of the groups, in the context of their group and group cluster, is provided as follows.

Group Cluster 1

Group pair 8 and 12 represent similar vegetation formations characterised by the canopy dominants Yellow Box (*E. melliodora*) - Blakely's Redgum (*E. blakelyi*) – Rough-barked Apple (*A. floribunda*) (i.e. group 8) and Rough-barked Apple (*A. floribunda*) – Banksia (*Banksia marginata*) (i.e. group 12). These groups represent the majority of vegetation cover throughout the lower Murragamba valley, with Yellow Box (*E. melliodora*) - Blakely's Redgum (*E. blakelyi*) vegetation generally restricted to basalt enriched clays along drainage lines and Rough-barked Apple (*A. floribunda*) – Banksia (*Banksia marginata*) vegetation restricted to the adjoining dry deep tertiary sand deposit.

Notwithstanding the similarities there are fundamental dissimilarities that exist between these two groups that are important in the context of this assessment. Notable differences include the presence of canopy dominants such as Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*) with a grassy understorey for group 8 with group 12 being shrubbier without the presence of these two tree canopy species.

The distantly similar group 1 is dominated by Rough-barked Apple (*A. floribunda*) and Blakely's Redgum (*E. blakelyi*), which principally occurs on sandy drainage lines and low rises immediately downlsope of Triassic geological formations (i.e. no basalt). This vegetation is shrubbier that group 8 and contains Blakely's Redgum (*E. blakelyi*), this being absent from group 12.

Groups 3, 4, 5 and 10 are distantly similar to groups 1, 8 and 12 with the vegetation generally formed on midslope sandy clay to clay soils with no direct/ indirect interaction with basalt occurrences. Various Ironbarks and Grey Box (*E. moluccana*) typify these vegetation formations, with restricted isolated occurrences of Blakely's Redgum (*E. blakelyi*), Yellow Box (*E. melliodora*) and White Box (*E. albens*) associated with ecotones between groups 3, 4, 5, 10 and groups 1 and 8.

Group 1 (quadrats (n) = 13)

This group of quadrats represents vegetation dominated by Blakely's Redgum (*E. blakelyi*) and Rough-barked Apple (*A. floribunda*) on sandy soils. The understorey is shrubby with scattered grassy/ herbaceous species. Characteristic shrubs include *Babingtonia cunninghamii* and *Melaleuca thymifolia* together with scattered occurrences of Sifton Bush (*Cassina arcuata*) and *Grevillea sericea*. Reed Grass (*Arundinella nepalensis*) is the characteristic grass species of this vegetation group where it forms dense colonies. Wire Grass (*Aristida ramosa*), *Lomandra multiflora subsp. multiflora* and Poison Rock Fern

(*Cheilanthes seiberi* subsp. *seiberi*) also occur in background densities. This vegetation is generally located on sandy soils with no basalt influence.

Proposed Name: Blakely's Redgum – Rough-barked Apple Forests on course sands

Group 3 (quadrats (n) = 17)

Situated predominantly on lowland claystones and valley infill (i.e. sand content) generally below conglomerate outcrops and minor coal outcrops is vegetation characterised by Narrow-leaved Ironbark (*E. crebra*) of woodland to forest structure with Black Cypress Pine (*C. endlicherii*) forming a tall shrub/ canopy associate. Whilst uncharacteristic Mugga Ironbark (*E. sideroxylon*) and Red Stringybark (*E. macrohyncha*) are locally common together with isolated Dawson's Box (*E. dawsonii*). Sclerophyllous shrub species commonly found on sandy clay soils predominates including Honeypots (*Acrotriche rigida*), *Astroloma humifusum, Lissanthe strigosa, Pultanaea microphylla* and *Cassinia arcuata*. Characteristic groundcovers are generally herbaceous including *Lomandra filiformis subsp. filiformis, Cheilanthes seiberi subsp. seiberi* and *Goodenia hederacea* together with a light cover of Wire Grass (*Aristida ramosa*). This vegetation occupies similar landscapes to group 5 vegetation, with differences being higher Ironbark densities and lower groundcover diversity.

Proposed Name: Lowland Ironbark Forest

Group 4 (quadrats (n) = 24)

The vegetation defined by group 4 is generally described as shrubby herbaceous woodlands on midslopes of the Permian geological formation. The tree canopy is generally described as a Box – Redgum formation with Grey Box (*E. moluccana*) typically being the characteristic canopy species and Blakely's Redgum (*E. blakelyi*) forms a minor associate. The occasional remnant is contains White Box (*E. albens*) and to an even lesser extent Yellow Box (*E. melliodora*) with the occurrence of both these species tied to localised elevated soil fertility and soil moisture. This vegetation type is characteristic of a transition between fertile/ infertile clays soils.

The understorey is generally shrubby with a predominantly herbaceous groundcover including *Styphelia triflora, Lissanthe strigosa* and Sifton Bush (*Cassinia arcuata*). Characteristic groundcovers include species such as *Goodenia hederacea, Calotis cuneifolia, Laxmannia gracilis, Dianella revoluta, Glycine clandestina, Hypericum gramineum* and *Stackhousia viminea* with many of these being indicative of transitional landscapes. Species widespread throughout landscapes characterised by sandy clays such as *Lomandra multiflora* subsp. *multiflora, Aristida ramosa* and *Cheilanthes seiberi* subsp. *seiberi* also occur.

Proposed Name: Lowland Box – Redgum Woodland

Group 5 (quadrats (n) = 14)

Identified by group 5 is footslope vegetation on sandy colluviums overlying claystones, a transitional area characterised by ranging soil conditions from clay soils to deep colluvium. This vegetation is characterised by a range of tree canopy species notably Narrow-leaved Ironbark (*E. crebra*), Black Cypress Pine (*C. endlicherii*), Broad-leaved Ironbark (*E. fibrosa*), Mugga Ironbark (*E. sideroxylon*), Grey Gum (*E. punctata*) and Slaty Box (*Eucalyptus dawsonii*) with none of these species dominating the canopy. This vegetation generally occurs upslope of "Lowland Ironbark Forest" (i.e. group 3) and downslope of group 6 vegetation (i.e. Broad-leaved Ironbark – Grey Gum vegetation). One potential reason for the differences between this vegetation formation and the similar group 3 vegetation could be linked to the ongoing selective logging activities evident within areas classified as group 5.

The understorey is shrubby with a predominantly herbaceous groundcover including Narrow-leaved Wattle (*Acacia linearifolia*), Hop Bush (*Dodonaea viscosa*), Honeypots (*Acrotriche rigida*), *Leucopogon muticus, Lissanthe strigosa, Astroloma humifusum, Persoonia linearis* and Sifton Bush (*Cassinia arcuata*). Grey Mistletoe (*Amyema quandang* var. *quandang*) is commonly found on Narrow-leaved Wattle (*Acacia linearifolia*) and is a substantial nectar resource for honeyeaters. Groundcovers are generally sparse and woody herbaceous. Species characteristic of the sandier environs include *Phyllanthus occidentalis* (*hirtellus*?), *Pomax umbellata* and *Goodenia hedearcea* occur with species characteristic of more fertile landscapes including *Calotis cuneifolia, Gahnia aspera* and *Oxalis perennans* indicating the potential for a transitional landscape. Species widespread throughout landscapes characterised by sandy clays such as *Microlaena stipoides, Aristida ramosa* and *Cheilanthes seiberi* subsp. *seiberi* also occur.

Proposed Name: Footslope Box – Gum – Ironbark Forest

Group 8 (quadrats (n) = 14)

This group of quadrats represents vegetation dominated primarily by Blakely's Redgum (*E. blakelyi*) with Yellow Box (*E. melliodora*) and Rough-barked Apple (*A. floribunda*) also occurring on sandy clays along drainage lines and heavily weathered remnant basalt. The understorey is generally grassy/ herbaceous with scattered shrubs. Grasses characteristic of this vegetation include *Aristida ramosa, Microlaena stipoides, Themeda australis* and *Echinopogon caespitosus* with herbs including Mat Rush (*Lomandra filiformis subsp. filiformis*), *Lomandra multiflora subsp. multiflora, Calotis cuneifolia, Gahnia aspera, Hydrocotyle laxiflora, Oxalis perennans, Asperula conferta, Gahnia aspera, Dichondra repens, Glycine tabacina, Geranium solanderi, Wahalenbergia communis* and Poison Rock Fern (*Cheilanthes seiberi* subsp. *seiberi*). Shrubs include Sifton Bush (*Cassinia arcuata*) and *Exocarpus strictus*.

Proposed Name: Blakely's Redgum – Yellow Box – Rough-barked Apple Woodland

Group 10 (quadrats (n) = 17)

Characterising the vegetation of this group is Grey Box (*E. moluccana*) and Narrow-leaved Ironbark (*E. crebra*), with Mistletoe (*Amyema miquelii*) commonly encountered in the tree canopy. Sifton Bush (*Cassinia arcuata*) and Wire Grass (*Aristida ramosa*) are common understorey constituents together with other species preferring sandy clay conditions such as *Calotis cuneifolia, Gahnia aspera, Astroloma humifusum, Cheilanthes seiberii* subsp. *seiberi, Microlaena stipoides* and *Wahlembergia communis*. This vegetation is restricted to the midslopes of the valley floor where grazing and land clearing pressures occur, with the increased presence of *Austrostipa scabra* evidence of these disturbance regimes.

Proposed Name: Grey Box – Narrow-leaved Ironbark Forest

Group 12 (quadrats (n) = 12)

Located on deep dry sandy deposits near the central northern extremity of the study are shrubby woodlands dominated principally by Rough-barked Apple (*A. floribunda*), though it shares the canopy cover with other less informative eucalypts such as Scribbly Gum (*E. rossii*) and Narrow-leaved Ironbark (*E. crebra*). The locally restricted *Banksia marginata* is a common tall shrub, particularly throughout the lower margins of the tertiary paleochannel. Other shrub species include Sifton Bush (*C. arcuata*), *Brachyloma daphnoides* and *Astroloma humifusum*. Blady Grass (*Imperata cylindrica*) is common throughout together with other characteristics such as *Hibbertia obtusifolia, Lomandra multiflora* subsp. *multiflora, Aristida ramosa, Cheilanthes seiberi* subsp. *seiberi* and *Microlaena stipoides.* Common but less characteristic species include *Dianella revoluta*, *Hydrocotyle laxiflora* and *Lomandra filiformis* subsp. *filiformis*. This vegetation formation is considered a variant of group 1 vegetation formed on adjoining dry course sandy infertile soils, with notable differentiation exhibited by the absence of Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*) and increased shrubbiness.

Proposed Name: Rough-barked Apple – Banksia Woodland

Group Cluster 2

Group 15 is a stand alone group cluster that is distantly related to groups 9, 11 and 14 and groups 3, 4, 5, 8, 10 and 12, with commonalities being clay soils and/or elevated soil fertility. The vegetation of this group is largely associated with cleared lands, these generally not including cleared areas on the tertiary paleochannel. Cleared lands on the valley floor are characterised by cosmopolitan, pioneer and/or grazing tolerant species, with many of these species being characteristic of other clay affiliated vegetation types. Compared with the other groups, species composition appears biased towards exotics, this being expected due to the chronic disturbances prevailing throughout this landscape.

Group 15 (quadrats (n) = 9)

Cleared lands covered by grasslands or Sifton Bush (*Cassinia arcuata*) characterise the vegetation of this group. Sifton Bush (*Cassinia arcuata*) exhibits various densities, which is primarily determined by time since clearing/ slashing. Other characteristic cosmopolitan native species common to the valley floor such *Calotis cuneifolia, Aristida ramosa, Cheilanthes seiberii* subsp. *seiberii* and *Wahlenbergia gracilis* also occur in this vegetation. Water holding capacity increases with increased soil clay content and decreased slope, thus resulting in the occurrence of seasonal natives and exotics such as *Aira elegantissima*, Briza minor*, Euchiton gynocephalus, Arctotheca calendula*, Haloragis heterophylla, Hypercharis radiacata**, *Vulpia myuros*, Parentcellia latifolia*, Petrorhagia nanteullii*, Triptilodiscus pygmaeus, Trifolium arvense** and *Dittrichia graveolens**.

Proposed Name: Secondary Grassland and Shrublands

<u>Group Cluster 3</u>

Whilst groups 9, 11 and 14 are aggregated within group cluster 3, they are largely dissimilar from each other. The broad similarities that exist include the presence of canopy species such as White Box (*E. albens*). Group 14 is largely defined as vegetation on basalt derived soils (i.e. basalt caps), where White Box (*E. albens*) exhibits low densities (i.e. cleared). When compared with group 14, both groups 9 and 11 exhibit greater similarity with associated vegetation generally formed on steeper midslope claystone derived soils with no basalt influence. Physical steep gradients are the likely reason for the differences between 9 and 11, with the vegetation of group 9 on flatter slopes. Soil depth/ moisture could account for the elevated grass/ herb species mix contained within group 11.

Group 9 (quadrats (n) = 3)

Various eucalypts (i.e. uncharacteristic) combine with White Box (*E. albens*) to form the tree canopy species of this group. This group is generally of forest cover on protected shallow claystone derived soils (i.e. south-west to east facing slopes). Increased soil moisture supports a shrubby understorey with a richer grass/ herb cover when compared with group 11. Shrubs characteristic of this vegetation group include *Acacia linearifolia*, *Solanum brownii, Cassina quinquefaria, Acrotriche rigida, Astroloma humifusum,* Black Cypress Pine (*C. endlicherii*) and *Persoonia linearis,* with the latter generally characteristic of the adjoining Triassic geological formation (i.e. dispersal). Grasses and herbs include *Gallium migrans, Opuntia stricta*, Aristida ramosa, Cheilanthes seiberii* subsp. *seiberii, Hydrocotyle laxiflora, Dichondra repens, Glycine tabacina*, *Austrostipa scabra*, *Wahlembergia communis* and *Rumex brownii*. This vegetation group appears intermediate between dry shallow claystone White Box (*E. albens*) formations and White Box (*E. albens*) derived grasslands on basalt, with increased soil moisture and decreased solar radiation being the likely main environmental gradients contributing to the formation of this vegetation.

Proposed Name: Shrubby White Box Forest

Group 11 (quadrats (n) = 5)

White Box (*E. albens*) is the characteristic tree canopy species of this group where it generally forms a forest cover on shallow claystone derived soils of gentler gradients when compared to the steeper slopes that support the group 9 White Box (*E. albens*) formation. Grass/ herb cover appears to increase with reduced slope and grazing intensity. Shrubs characteristic of this vegetation group include Western Wattle (*Acacia decora*), *Acacia implexa, Cassina quinquefaria* and Black Cypress Pine (*C. endlicherii*). Grasses and herbs are generally sparse with characteristic species including *Plantago varia, Gahnia aspera, Aristida ramosa, Cheilanthes seiberii* subsp. *seiberii, Hydrocotyle laxiflora* and *Austrostipa scabra*, with the latter species more common in grazed conditions. Grazing intensity, aspect and slope appear to be the main differences between groups 9 and 11.

Proposed Name: Shrubby White Box Forest

Group 14 (quadrats (n) = 7)

The analysis delineated the vegetation of group 14 on groundcover floristics due to the absence of a tree canopy (i.e. overcleared basalt caps with sparse White Box and Rough-barked Apple occurrences). The vegetation of this group is characterised by grassy herbaceous species and few shrubs (i.e. Sifton Bush *Cassinia arcuata*). Unlike all other vegetation groupings defined by the analysis, this group is characterised by a rich grassy herbaceous assemblage: *Acaena ovina, Austrostipa scabra, Dichelacne micrantha, Pimelea curviflora subsp. sericea, Austrodanthonia racemosa, Desmodium variens, Geranium solanderi, Poa seiberiana, Veronica plebia, Swainsona galegifolia, Themeda australis, Dichondra repens, Wahlenbergia communis, Glycine tabacina* and *Rumex brownii*. Other species contained within this group include *Aristida ramosa, Cheilanthes seiberi subsp. seiberi, Hydrocotyle laxiflora, Lomandra multiflora* subsp. *multiflora* and *Microlaena stipoides*. Honeypots (*Acrotriche rigida*) is a rare but characteristic species. Hare's Foot Clover (*Trifolium repens*), St John's Wort (*Hypericum perfoliatum**), *Petrorhagia nanteulii** and *Cathamus lanatus** are characteristic exotics of this vegetation group.

Proposed Name: Grassy White Box Woodland

<u>Group Cluster 4</u>

The dendrogram shows groups 2 and 6 to be the most similar groups in the analysis. Groups 7 and 13 are related but are substantially dissimilar despite the all these groups being associated with the predominantly sandy Triassic geological formation. The main canopy species of group 6 is Broad-leaved Ironbark (*E. fibrosa*), Grey Gum (*E. punctata*) and Stringybark (*E. sparsifolia*), with the latter two progressively displaced by Black Cypress Pine (*Cypress endlicherii*) (i.e. group 2) then by Scribbly Gum (*E. rossii*) and Narrow-leaved Ironbark (*E. crebra*) (i.e. groups 7 and 13). Understorey differences also exist, which is best described as a transition from low (i.e. group 13) to high (i.e. group 8) species richness. Of particular note is the preference shown by Sheoak (*Allocasuarina gymnanthera*) for groups 2, 7 and 13 (absent from group 6). The grouping of the data suggests that there may be a broad link between vegetation formations and geological stratigraphy. However, local variation is more likely to be accounted for by soil depth/ canopy cover (e.g. soil moisture) and fertility (e.g. clay content).

Group 2 (quadrats (n) = 17)

This group represents vegetation on shallow to skeletal soils throughout the ridgelines of the Triassic geological formation. The canopy cover is principally of woodland structure and dominated by Broad-leaved Ironbark (*E. fibrosa*) and Black Cypress Pine (*Cypress endlicherii*) with an understorey characterised by Sheoak (*Allocasuarina gymnanthera*), *Leucopogon muticus* and *Persoonia linearis*. Honeypots (*Acrotriche rigida*) is also common in places, with subshrubs and herbs comprising the remainder of the groundcover stratum such as *Phyllanthus occidentalis, Goodenia hederacea, Lomandra filiformis* subsp. *filiformis,* Sword Sedge (*Lepidosperma laterale*)*, Pomax umbellata* and Poison Rock Fern (*Cheilanthes seiberi* subsp. *seiberi*).

Proposed Name: Ridgetop Broad-leaved Ironbark – Black Cypress Pine on shallow sands

Group 6 (quadrats (n) = 12)

Quadrats clustered into this group occur on the dry Triassic ridgetops of the southern half of the study area. The tree canopy is characterised by Broad-leaved Ironbark (*E. fibrosa*), Grey Gum (*E. punctata*) and Stringybark (*E. sparsifolia*) with Black Cypress Pine (*Callitrus endlicherii*) forming an associate. The shrubby understorey consists of *Dodonaea viscosa*, *Leucopogon muticus*, *Acrotriche rigida, Phebalium squamulosum* and Geebung (*Persoonia linearis*). Soils of elevated shale content harbour *Podolobium ilicifolium*. Groundcovers are largely scattered and herbaceous and include *Lepidosperma laterale, Goodenia hederacea, Macrozamia secunda, Porantha corymbosa* and *Phyllanthus occidentalis*. Wetter areas contain elevated densities of *Lomandra confertifolia*. Grasses and exotics rarely occur within this vegetation group.

Proposed Name: Broad-leaved Ironbark Grey Gum Forest

Group 7 (quadrats (n) = 23)

Scribbly Gum (*Eucalyptus rossii*) is the characteristic canopy dominant together with Narrow-leaved Ironbark (*E. crebra*) on sandy soils. Broad-leaved Ironbark (*E. fibrosa*), Grey Gum (*E. punctata*) and Black Cypress Pine (*C. endlicherii*), which are found on sandy soils with relatively higher clay content are absent. The shrubby understorey is particularly diverse with characteristic species such as *Acacia leucolobia*, *Grevillea sericea, Macrozamia secunda, Leucopogon muticus, Persoonia curviflora, Macrozamia secunda, Persoonia linearis, Platysace ericoides, Allocasuarina gymnanthera, Brachyloma daphnoides and Styphelia triflora*. Wire grass (*Aristida ramosa*), Matt Grass (*Lomandra glauca*) and *Patersonia sericea* characterise the sparse groundcover together with species in common with group 2 such as *Goodenia hederacea, Pomax umbellata* and *Phyllanthus occidentalis* (*hirtellus*?).

Proposed Name: Scribbly Gum – Narrow-leaved Ironbark Woodland

Group 13 (quadrats (n) = 10)

The vegetation of group 13 is comparatively similar to that described for group 7, with notable differences including decreased grass and herb cover, presumably a function of lower soil fertility and/or soil moisture. Narrow-leaved Ironbark (*E. crebra*) is the characteristic tree cover species with Black Cypress Pine (*C. endlicherii*) and Rough-barked Apple (*A. floribunda*) forming a minor associate. Shrubs such as *Astroloma humifusum, Allocasuarina gymnanthera, Acacia leucolobia, Leucopogon muticus, Brachyloma daphnoides, Calytrix tetragona* and *Cassinia arcuata* are common together with the decreased occurrence of grass and herb species characterised by Wire Grass (*Aristida ramosa*) and *Cheilanthes seiberi subsp. seiberi* in low densities. Honeypots (*Acrotriche rigida*) is also present in lower densities.

Proposed Name: Hardcap Scribbly Gum – Ironbark Forest

7.1.4. Discussion

Regional vegetation types described by Keith (2004) could have been assigned to some of the broad group clusters, with the most obvious geographically relevant vegetation classes being Western Slopes Grassy Woodlands and Western Slopes Dry Sclerophyll Forest. Western Slopes Grassy Woodlands could be assigned to group clusters 1, 2 and 3 as depicted in the above ordination plot, with group cluster 4 representing Western Slopes Dry Sclerophyll Forest. However such broad application of this classification ignores the variability within and between these group clusters.

An important context for assigning broad vegetation classifications is that the classifications should not only consider geographic location but should also consider indirect environmental gradients such as elevation, rainfall and temperature, which vary at a regional level. Whilst these factors have not been quantitatively analysed in this analysis (i.e. only quadrat flora and fauna data from the locality included), indirect evaluation by comparisons with comparable published vegetation classifications from neighbouring regions is possible. In this context it is considered that Coastal Valley Grassy Woodlands, New England Grassy Woodlands and Southern Tableland Grassy Woodlands represent important context in the discussion of study area vegetation.

<u>Grassy Woodlands</u>

The habitat of New England Grassy Woodlands and Southern Tableland Grassy Woodlands is described as occurring on relatively fertile soils derived from low-quartz sedimentary or granitic substrates above 600 m elevation on rolling tablelands receiving 550-900 mm annual precipitation (both rainfall and occasional snowfall). New England Grassy Woodlands is restricted to the northern tablelands north from Brendameer - Walcha whilst Southern Tableland Grassy Woodlands occur on the southern and central tablelands south from Sofala. Ulan is situated almost equidistant from these limits.

These broad vegetation classes share floristic similarities especially in the groundcover, with composition varying with substrate and topography. A greater abundance of stringybark eucalypts and shrubs are found on hills and sandy loams than on slopes and clay loams. Both these vegetation classes grade locally into Tableland Clays Grassy Woodlands on more fertile clay soils or Western Slopes Grassy Woodlands with decreasing elevation and rainfall to the west. The latter is considered more relevant to the study as Tableland Clays Grassy Woodlands do not occur within or nearby the study area.

In reviewing the dendrogram and ordination plot, it is clear that group clusters 1, 2 and 3 are distinctly dissimilar from each other despite most being formed on clay soils with midslope to valley floor position. The species of group cluster 1 favour a grassy herbaceous mix, with increased shrubbiness and Ironbark occurrence contained within group cluster 2. Canopy species such as Yellow Box (*E. melliodora*) and Blakely's Redgum (*E. blakelyi*) exhibit their highest cover abundance throughout the vegetation of cluster 1, with drainage lines and basalt influence prominently featuring. With regards to cluster 1 it is considered that the vegetation defined by these groups are transitional between those of group clusters 2, 3 and 4 with the latter considered part of the Western Slopes Dry Sclerophyll vegetation class.

On considering altitude and rainfall, the vegetation of study area is situated at the margin of prescribed habitats for New England Grassy Woodlands and Southern Tablelands Grassy Woodlands, with both these vegetation classes noted as grading into Western Slopes Grassy Woodlands with decreased rainfall and elevation. Moreover, the site is located near the spine of the Great Dividing Range but on the eastern side not the western slopes (i.e. coastal side). Therefore, the consideration of Coastal Valley Grassy Woodlands may also be relevant to the classification of study area vegetation.

Coastal Valley Grassy Woodlands are found on clays and clay loams on undulating hills, and plains on shales and granitites up to 350 m elevation and receiving less than 1000 mm annual rainfall in coastal rainshadow valleys with flat to undulating terrain. Soils are deep, moderately fertile, loamy soils derived from shales and granitic substrates. Grey Box (*E. moluccana*) is a characteristic canopy species of drier Coastal Valley Grassy Woodlands such as those occurring in the central Hunter Valley and lower Goulburn River, where intergradations with western vegetation types on Permian geological formations also occurs (HCR CMA, 2006). Such comparisons may also be made with western Sydney vegetation, such as Cumberland Plain Woodlands, where Benson (1992) considers these vegetation types as being similar to those found on the western slopes.

Understorey species characteristic of both Coastal Valley Grassy Woodlands and group cluster 2 include *Desmodium varians* (slender tick-trefoil), *Dichondra repens* (kidney weed), *Geranium solanderi* (native geranium), *Hydrocotyle laxiflora* (stinking pennywort), *Asperula conferta* (common woodruff), *Wahlenbergia gracilis* (Australian bluebell), *Cheilanthes sieberi* subsp. *sieberi* (poison rock fern), *Aristida ramosa* (purple wiregrass) and *Themeda australis* (kangaroo grass) *Carex inversa* (knob sedge), *Dichelachne micrantha* (plumegrass) and *Microlaena stipoides* var. *stipoides* (weeping grass). Such similarities are not surprising given the underlying geological similarities (e.g. Permian geological formation).

In conclusion it is considered that the vegetation of EL6288 is reflective of north-south and east-west transitions. Indirect environmental gradients such as latitude, temperature, rainfall and elevation imply a stronger influence of Western Slopes Grassy Woodlands. However the influence of other vegetation classifications cannot be ignored. Table 22 below summarises these findings and proposes names for each group and group cluster, with nomenclature following regional vegetation classes and formations where possible.

Table 22: Vegetation of EL6288

Group Cluster	Group	Proposed Name of Vegetation Formation/ Landcover Type	Geology	Characteristic Species	Related Keith (2004) Vegetation Class	Comparable BioMetric Sub-Formation
1	1	Blakely's Redgum - Rough-barked Apple Woodland on course sands	Permian (Illawarra Coal Measures)	12	Western Slopes Grassy Woodland	Blakely's Red Gum - Rough-Barked Apple flats woodland of the NSW western slopes (Benson 281)
1	3	Lowland Ironbark Forest	Permian (Illawarra Coal Measures)	18	Western Slopes Dry Sclerophyll Forest	Blue-leaved Ironbark heathy woodland of the southern part of the Brigalow Belt South Bioregion
1	4	Lowland Box – Redgum Woodland	Permian (Illawarra Coal Measures)	11	Western Slopes Grassy Woodland	Blakely's Red Gum - Yellow Box - Rough-barked Apple grassy woodland of the Capertee Valley, Sydney Basin*
1	5	Footslope Ironbark – Gum –Box	Permian (Illawarra Coal Measures)	12	Western Slopes Dry Sclerophyll Forest	Slaty Box - Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin
1	8	Blakely's Redgum - Yellow Box – Rough-barked Apple Woodland	Permian (Illawarra Coal Measures)	19	Western Slopes Grassy Woodland	Blakely's Red Gum - Yellow Box - Rough-barked Apple grassy woodland of the Capertee Valley, Sydney Basin*
1	10	Grey Box – Narrow-leaved Ironbark Forest	Permian (Illawarra Coal Measures)	12	Western Slopes Grassy Woodland*	Grey Box - Narrow-leaved Ironbark shrubby woodland on hills of the Hunter Valley, North Coast and Sydney Basin
1	12	Rough-barked Apple - Banksia Woodland	Tertiary Paleochannel	25	n/a	n/a
2	15	Secondary Grasslands and Shrublands	Permian (Illawarra Coal Measures)	11	n/a	n/a
3	9/11	Shrubby White box Forest	Permian (Illawarra Coal Measures)	21	Western Slopes Dry Sclerophyll Forest	White Box shrubby open forest on fine grained sediments on steep slopes in the Mudgee region (Benson 273)
3	14	Grassy White Box Woodland	Tertiary Basalt	15	Western Slopes Grassy Woodland	White Box - Yellow Box grassy woodland on basalt slopes in the upper Hunter Valley, Brigalow Belt South*
4	2	Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	Narrabeen Group	19	Western Slopes Dry Sclerophyll Forest	Grey Gum - Narrow-leaved Stringybark - Ironbark woodland on ridges of the upper Hunter Valley, Sydney Basin
4	6	Broad-leaved Ironbark Grey Gum Forest	Narrabeen Group/ Illawarra	16	Western Slopes Dry Sclerophyll	Grey Gum - Narrow-leaved Stringybark -

Group Cluster	Group	Proposed Name of Vegetation Formation/ Landcover Type	Geology	Characteristic Species	Related Keith (2004) Vegetation Class	Comparable BioMetric Sub-Formation
			Coal Measures		Forest	Ironbark woodland on ridges of the upper Hunter Valley, Sydney Basin
4	7	Scribbly Gum Narrow-leaved Ironbark Woodland	Narrabeen Group	16	Western Slopes Dry Sclerophyll Forest	Scribbly Gum - Brown Bloodwood woodland of the southern Brigalow Belt South
4	13	Hardcap Scribbly Gum - Ironbark Woodland	Tertiary Paleochannel	18	n/a	Scribbly Gum - Brown Bloodwood woodland of the southern Brigalow Belt South
n/a	n/a	Crop/ Plantation	Permian (Illawarra Coal Measures)	n/a	n/a	n/a

* Note: Vegetation dominated by Grey Box (*E. moluccana*) typically belongs to vegetation formations in coastal districts east of the Great Dividing Range. Whilst the study area's geographical characteristics do not fit the model for 'Coastal Grassy Woodlands', as defined by Keith (2004), the consideration of this vegetation classification for the study area is potentially relevant.

Vegetation classifications of the site were compared with BioMetric vegetation classifications to support and verify the classifications defined within the study area. In some cases these comparisions proved difficult particularly for vegetation located near the Permian – Triassic outcrop and vegetation located downslope of basalt caps/ along drainage lines. The main factor affecting the assignment of BioMetric vegetation sub-formations to the vegetation classifications used to define study area vegetation is the influence of inter-regional intergradations in the Ulan area. Geological and climatic transition exhibit strong influences within the area as does the mid elevation of the district (i.e. substantially lower than the tablelands to the north and south, but higher than the adjoining coastal valley and western slopes). Related BioMetric classifications marked with an astrix are indicative of these inter-regional intergradations, with the selected vegetation formation considered the 'best fit'. No Keith (2004) vegetation class is proposed for vegetation groups 12 and 13 as this vegetation appears locally restricted and is thus treated as a separate vegetation class provisionally named "Murragamba Sands Woodlands".

7.1.5. Vegetation Statistics

A summary description of the naturally formed native vegetation contained within the study area, which is inclusive of all structural variants (i.e. grassland, shrubland, woodland and forest), is provided in **Table 23**. A flora species list supporting these vegetation formations and subformations is provided in **Appendix 5**.

Table 23: Native Vegetation of the MCP Stage 2 Study Area

Native Vegetation Class	Sub-formation	Area	Species Richness
Western Slopes Dry Sclerophyll Forest	Footslope Ironbark - Gum - Box	373.47	149
	Broad-leaved Ironbark Grey Gum Forest	666.11	114
	Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	396.61	158
	Scribbly Gum Narrow-leaved Ironbark Black Cypress Pine	27.54	183
	Lowland Ironbark Forest	94.70	144
	Shrubby White Box Forest	27.81	117
Western Slopes Grassy Woodland	Blakely's Redgum – Yellow Box – Apple Forest	55.7	212
	Lowland Box - Redgum	85.17	206
	Grassy White Box Woodland	92.54	121
	Grey Box – Narrow-leaved Ironbark Forest	101.00	105
	Blakely's Redgum - Rough-barked Apple Woodland	61.4	197
"Murragamba Sands Woodland"*	Rough-barked Apple - Banksia Woodland	282.71	124
	Hardcap Scribbly Gum - Ironbark Woodland	88.62	91
	Cyperoid Herbland	0.92	24

* Note: Non-Keith (2004) vegetation class. A locally described vegetation formation.

Areas of vegetation cover that have been adversely affected by clearing for agriculture, linear infrastructure, farm infrastructure or extractive industries is provided as follows in

Table 24: Disturbed Vegetation Statistics of the MCP Stage 2 Study Area

Sub-formation	Species Richness	Area
Secondary Grasslands and Shrublands	176	923.54
Crop/ Plantation	n/a	51.00
Disturbed/ No Natural Vegetation	n/a	53.24

7.1.6. Trends - Environmental Gradients

The ordination implies the main environmental gradient as soil fertility. **Figure 17** indicates a gradient from 'fertile' landscapes typified by a grassy/ herbaceous understorey (e.g. *Themeda australis*) to less fertile landscapes dominated by woody herbs, shrubs and Ironbark (e.g. Broad-leaved Ironbark and Sheoak). There is also evidence of at least a second environmental gradient, as exhibited by the data spread for 'fertile' landscapes. Given the semi arid character of the district it is hypothesised that the availability of water (e.g. soil moisture) is the likely secondary environmental gradient.

Of particular interest are the horizontal and vertical trends in the ordination. Species characterising the vertical trend such as *Goodenia hederacea* and *Phyllanthus occidentalis* at the top is likely to represent vegetation formed on sandy infertile soils while Sifton Bush (*Cassina arcuata*) and Wire Grass (*Aristida ramosa*) at the bottom are more fertile ‘clayey’ soils (and also potentially vegetation subject to increased disturbance regimes). It is hypothesised that this axis depicts a soil fertility related environmental gradient, which coincidently is also evident in the preliminary analysis (**Appendix 5**).

The rationale for the direction and length of the Sifton Bush (*Cassina arcuata*) vector relative to *Dichondra repens* and *Themeda australis* is potentially indicative of disturbance, degree of soil fertility (e.g. claystone clays compared to basalt) and/or soil moisture (e.g. proximity to springs), with the expression of these environmental gradients on a separate axis to the vertical.

Observations of Sifton Bush (*Cassina arcuata*) within the study area support this hypothesis as this species is particularly common and dense on claystone derived soils in actively grazed areas, with lower densities observed on less disturbed vegetation such as basalt derived clays. Kangaroo Grass (*Themeda australis*) is another indicator of lower grazing pressure and increased soil fertility with Wire Grass (*Aristida ramosa*), a grazing tolerant species, almost co-linear with Sifton Bush (*Cassina arcuata*). It is also possible that the inferred soil moisture environmental gradient is having an interaction with disturbance/ soil fertility, thus resulting in the divergence of ‘clay’ affiliated species.

Also implied by the ordination is the potential influence of plant dispersal on plant associations. For instance a localised influence of a strong environmental gradient such as soil fertility and/or moisture is likely to have influence over adjacent areas, with increasing distance from the source proportionally decreasing its influence. This is in essence the definition of a transition whereby there is a ‘one way’ transferral of plant species across the landscape from a biodiversity source to a biodiversity sink (e.g. species drift from fertile to infertile habitats). That is the presence of species within the landscape is primarily controlled by the action of environmental gradients rather than the more classical view being ‘they just exist there’. Examples of this in the study area are particularly evident around natural springs and basalt outcrops where these locally important landscape features exert strong environmental gradients. These are regarded as important to the formation of grassy vegetation types and in this context represent ‘biodiversity hotspots’.

The influence of anthropogenic environmental gradients on species cover abundances is also relevant when characterising the natural environment (e.g. increased weed species richness and diversity resulting in displaced native plants; altered hydrology; grazing; pasture improvement; time since disturbance). For instance, it is too simplistic to imply that observations of grassy habitats are fertile, a misleading conclusion that could be developed when ignoring these additional influences on vegetation.

For example Austin *et. al.* (1981) identified the combined effects of grazing and seasonal rainfall patterns lead to divergent successional trends between grazed and ungrazed areas of previously similar character. Wallaby Grass (*A. caespitosa*) was successful in persisting within grazed areas due to its retained reproductive capacity under these conditions while Windmill Grass (*Enteropogon acicularis*) was found to be sensitive to this interaction. As previously discussed, interactions of this nature exist within the study area where the lengthy history of grazing, cropping and land clearing has resulted in the development of successional trends that operate in parallel and/or compete with natural evolutionary pathways.

Prober and Theile (2004) offer support to this observation by finding grassy woodlands of the western slopes and tablelands vary naturally across an east-west gradient (i.e. climatic variables). For eastern stands of grassy woodlands, Prober and Theile (2004) found agriculture to exert similar influences on plant-cover abundances as found in western woodlands. The NSW Scientific Committee (2001) imply a similar concept by stating Wire Grass (*Aristida ramosa*) dominance is often attributed to agricultural activities.

It is important to note that similarities implied by the ordination between naturally occurring grassy vegetation types and proximal agricultural landscapes not directly influenced by the main environmental gradient(s) are potentially misleading with interpretation requiring contextual consideration. For instance the influence of agriculture (e.g. introduction of fertilisers, movement of sheep across the landscape etc) is likely to have profoundly influenced the post cleared landscape (e.g. altered the regime of species distributions that typically occupy productive and less productive landscapes).

From these disturbance regimes it is possible to suggest that convergent evolutionary pathways may have developed (i.e. naturally grassy areas appear similar to agriculturally induced grassy areas through fertiliser applications), this being a reasonable assertion on the basis of agriculture representing an intentional manipulation of the environment for specific purposes (i.e. livestock grazing). Ignoring the influence of agriculture within this landscape is likely to result in misleading conclusions regarding the classification of natural vegetation formations (Austin et. al. 1981), particularly if the removal of agricultural practices results in a substantial change in vegetation structure (i.e. regrowth preferentially being shrubby species).

From the analysis it is assumed that natural features supporting increased biodiversity (e.g. basalt/ soil moisture) interact with adjoining landscapes that have reduced exposure to these important environmental gradients (e.g. ecological drift). Moreover, it is also assumed that agriculture has substantially affected the cover and abundance of groundcover plants particularly for cleared grazed and/or cropped landscapes.

In this respect it should be recognised that the residual native species diversity of these areas is likely to differ to that of the pre-cleared landscape and potentially no longer characteristic of these landscapes. Thus, understanding the complex inter-relationships between natural and anthropogenic environmental gradients forms a fundamental basis for interpreting the dynamics between natural biodiversity source and sink areas – thus supporting the primary focus of this assessment (i.e. classification and characterisation of vegetation formations indicative of natural conditions for impact assessment).

7.1.7. Outlier quadrats

Below is a description of outlier quadrats removed from the non-hierarchical agglomerative analysis.

Quadrats 67, 96 and 119

This group of quadrats is restricted to three samples located in or alongside the lower Murragamba/ Eastern Creeks and Wilpinjong Creek (i.e. downslope of basalt caps). Semi-permanent water and/or high soil moisture combined with chronic disturbance regimes are the main representative themes across these samples, as reflected by the largely absent tree and shrub cover, high groundcover and presence of exotics. Native species found in moist to wet environs are common, with many not found anywhere else within the study area. Characteristic species include *Arundinella nepalensis, Hypericum gramineum*, *Haloragis heterophylla, Carex appressa, Isotoma fluviatilis, Juncus articulatus, Scheonus apogon, Xyris compacta, Cyperus fulvus, Eriocaulon scariosum, Eleocharis gracilis, Drosera burmannii, Goodenia macbarronii, Philydrium lanuginosum Urticularia dichotoma, Myriophyllum gracile var. lineare and Scheonus moorei*. This species assemblage generally represents the vegetation cover of localised groundwater surface expressions (i.e. may potentially represent isolated groundwater dependant ecosystems).

Quadrats 12, 138 and 176

The highly disturbed vegetation cover of the study area, as represented by treeless landscapes exposed to routine agriculture, is characterised by this assemblage of plant species. Exotics are common and represent the main vegetation cover together with various cosmopolitan natives. Species characterising the less disturbed parts of this landscape include *Cynodon dactylon, Hypercharis radicata*, Acetocella vulgaris*, Alternathera pungens*, Choris truncata, Cerastrium glomeratum*, Calotis lappulacea, Hypericum perforatum** and *Solanum cinereum*. Heavily disturbed areas such as those of elevated soil moisture and fertility are characterised by *Bromus horaceus*, Hordium leporinum*, Erodium crinitum, Lolium rigidum*, Medicago spp., Catharmus lanatus*, Cirsium vulgare*, Elymus scaber, Lepidium africanum*, Sporobolus creber* and *Rumex brownii*.

Quadrat 148

This quadrat is located in the mid lower section of the Murragamba valley below a Tertiary basalt flow. The vegetation is formed on Permian claystones as evidenced by surface rock material (i.e. slaty) and nearby claystone mines. Grazing activity is evident.

The vegetation is represented by a small remnant on Yellow Box (*E. melliodora*) with a simplified grassy understorey. Simplified structure and floristics is in part attributed to the agricultural history of the site, but other impacts such as infrastructure or past buildings may also be relevant.

Also of interest and potentially of importance to the overall analysis of vegetation formations throughout the valley floor is the proximity of the quadrat to the predicted outcrop of the 'Moolarben Coal Seam', this being a shallow coal seam within the upper Permian formation. Matters of interest implied by this outcropping coal seam include:

- The potential presence of groundwater flows through the seam;
- Localised soil fertility derived from 'volcanic' tuff that overlays the Moolarben Coal Seam; and
- Presence of oxidised coal that locally increases soil organic carbon content.

Further investigation of any potential relationship between the Moolarben Coal Seam and vegetation cover was examined using tree species as a potential indicator. It was noted from the spatial analysis that the majority of White Box (*E. albens*) and Yellow Box (*E. melliodora*) located on the Permian geological formation within the Murragamba Valley (i.e. 10 White Box (*E. albens*) and 11 Yellow Box (*E. melliodora*) records) are generally located within 180 m of the predicted Moolarben Coal Seam outcrop, with most located within 100 m (i.e. coal outcrop interpreted from Triassic outcrop, stratigraphy profile and topographical contours). The remainder of White Box (*E. albens*) and Yellow Box (*E. melliodora*) are located on or immediately downslope of basalt caps. These observations are considered important in determining the extent of vegetation formations dominated by these canopy species. **Figure 18** illustrates these observations relative to basalt and predicted Moolarben coal seam outcrop.

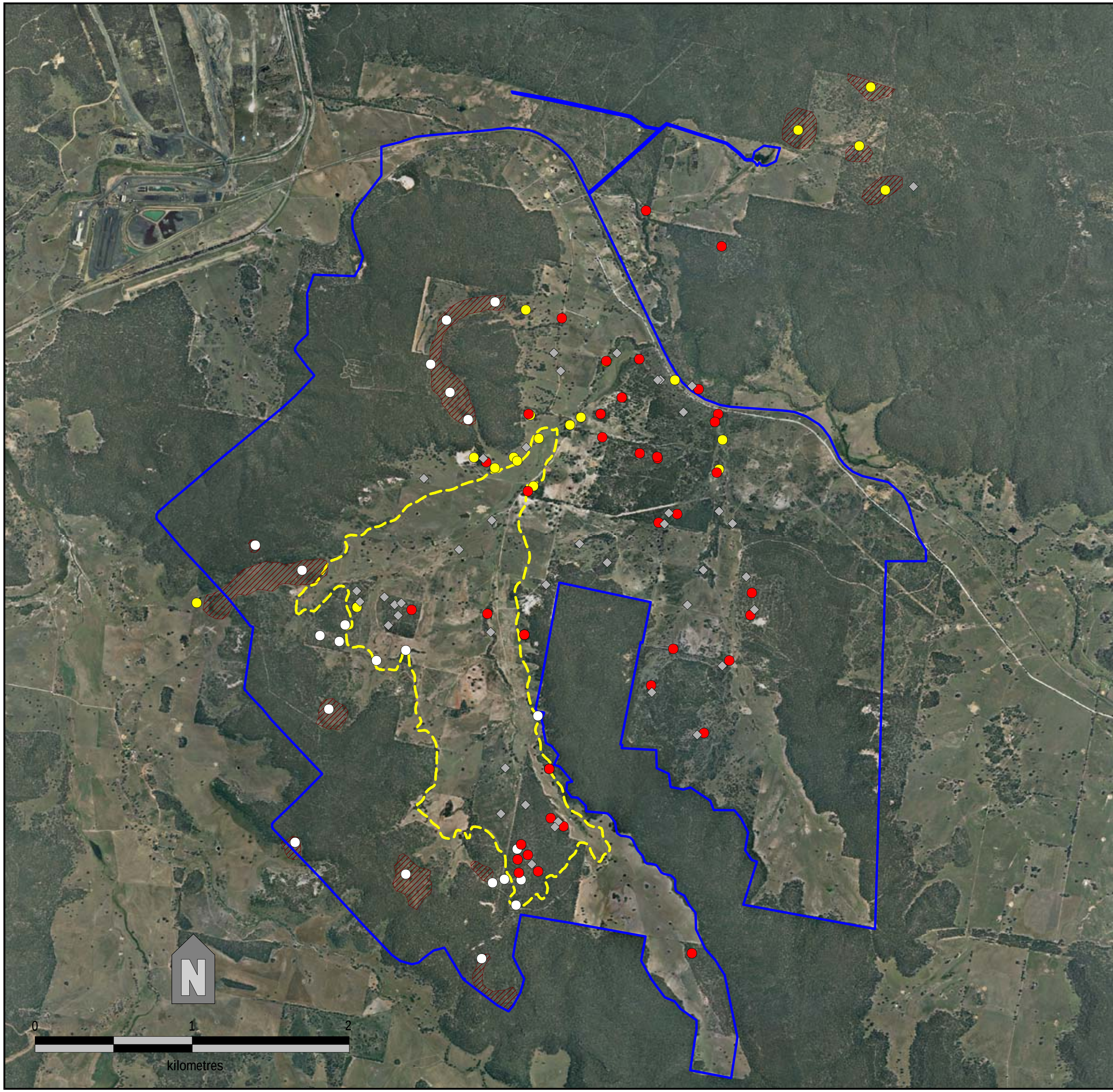
Three outlier Yellow Box (*E. melliodora*) records are located 680 – 780 m from the Moolarben Coal seam outcrop, however their outlier status is explained by their position within the Murragamba Creek downslope from the outcrop (i.e. down dip). Located below the coal seam outcrop and presumably outside the localised influence of this coal seam is an increased abundance of Grey Box (*E. moluccana*) and Slaty Box (*E. dawsonii*), with both White Box (*E. albens*) and Yellow Box (*E. melliodora*) predominantly absent from these parts of the landscapes.

As expected it is noted that Blakely's Redgum (*E. blakelyi*) has occurrences within the area outlined by the Moolarben Coal seam outcrop, where the greatest crown densities are primarily located along drainage lines (i.e. elevated soil moisture levels). However, it is also noted that Blakely's Redgum (*E. blakelyi*) occasionally exhibits minor isolated occurrences that coincide with vegetation dominated by Grey Box (*E. moluccana*) and Slaty Box (*E. dawsonii*) throughout 'drier' landscapes with such occurrences likely to be linked to localised impeded drainage on heavier clays of poor structure (i.e. claystone soils without beneficial influences from the Moolarben Coal Seam and/ or basalt).

7.2. Fauna Diversity

The Shannon Weiner Index was used to compare between vegetation formations in analysing fauna diversity, with a higher score indicating higher diversity. A corresponding Eveness Score approaching 1 indicates the data to be evenly distributed (i.e. even representation of species occurrences rather than dominance by a few).

This broad analysis of the formal bird survey data potentially implies a relationship between bird fauna diversity and vegetation containing higher tree hollow densities (i.e. presence of Blakely's Redgum, Scribbly Gum or Grey Gum). The presence of Box species and/or proximity to the interface between the Permian – Triassic geological formations also appears to positively influence fauna diversity. Interestingly the outcropping Triassic geological formation also has elevated flora based foraging resources and general habitat. An analysis of the study area's bird fauna diversity is provided as follows in Table 25.



Drafter: MA Date: 19 Nov 08 File: F1119_EA2_Fig22.WOR

Legend

- *Eucalyptus albens*
- *Eucalyptus melliodora*
- *Eucalyptus moluccana*
- *Eucalyptus blakelyi*
- Predicted Moolarben Coal Seam Outcrop
- Basalt
- Study Area

FIGURE 18

Predicted outcrop of Moolarben Coal Seam, Basalt Caps and known occurrences of Box and Redgum Species

Sources
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Ecovision Consulting (2008)

ECOVISION CONSULTING

Table 25: Fauna diversity within vegetation formations

Vegetation Formation	Species Richness	Observation Count	Shannon Weiner	Eveness
Scribbly Gum Narrow-leaved Ironbark Woodland	54	208	3.68	0.69
*Blakely's Redgum - Yellow Box – Apple Forest	44	251	3.43	0.62
*Lowland Box – Redgum Forest	48	186	3.40	0.65
Shrubby White Box Forest	41	218	3.31	0.62
Broad-leaved Ironbark Grey Gum Forest	28	56	3.13	0.78
*Grassy White Box Woodland	23	44	2.94	0.78
Footslope Ironbark - Gum – Box Forest	34	170	2.80	0.55
Lowland Ironbark Forest	17	51	2.53	0.64
*Blakely's Redgum - Rough-barked Apple Woodland	16	46	2.45	0.64
Grey Box - Narrow-leaved Ironbark Forest	17	81	2.40	0.55
Ridgetop Broadleaved Ironbark Black Cypress Pine Woodland	76	134	2.12	0.80
Roughbarked Apple – Banksia Woodland	52	94	2.00	0.87
Hardcap Scribbly Gum - Ironbark Woodland	4	8	1.26	0.60
Secondary Grasslands and Shrublands	11	53	1.60	0.40

In this context a description of the study areas faunal diversity is provided as follows (i.e. based on vegetation/ landscape classifications).

7.2.1. Secondary Grasslands and Shrublands

The low Shannon Weiner diversity index combined with the second lowest Eveness score indicates the fauna diversity of the Secondary Grasslands and Shrublands to be relatively simplistic with dominance exerted by only a few species. This is an expected result given the depauperate habitat values of this landscape including a substantially reduced level of 'ecological roughness' (i.e. tree and shrub cover) and likely effects of high evapotranspiration rates on vegetation cover.

7.2.2. Valley Floor and lower midslopes

Western Slopes Dry Sclerophyll Forests on the valley floor such as Lowland Ironbark Forest and Hardcap Scribbly Gum Ironbark Woodland are characterised by relatively high reptile and amphibian species richness, when compared to the adjoining grassier woodlands, with the converse occurring for bird species richness (i.e. comparatively low). Reptiles include the Mountain Dragon and Two-clawed Worm Skink, with amphibians including Peron's Tree, Broad-palmed Frog, Eastern Dwarf Toadlet, Eastern Banjo Frog, Smooth Toadlet, Ornate Burrowing Frog and Northern Burrowing Frog.

Also common in this landscape is the Common Brush-tailed Possum together with other 'tree hollow' arboreal species such as White Striped Mastiff Bat, Sulphur-crested Cockatoo, White-throated Treecreeper, Eastern Rosella, Southern Boobook and Galah. Implied by these species is the presence of trees with hollows, with most suitable tree hollows contained within this landscape being limited to mature Blakely's Redgum of the Blakely's Redgum – Rough-barked Apple Woodland formation and Scribbly Gum within the nearby hardcap Scribbly Gum – Ironbark formations. Tree hollows resources are more common elsewhere (i.e. Triassic outcrop), where breeding activity by these species is more likely.

More fertile landscapes supporting grassier vegetation formations such as Yellow Box – Redgum Forest and Lowland Box Redgum Woodland differ by having greater bird representation. Whilst it is likely that the high degree of bird occupation within these environments is attributable to soil fertility, the simplification of these habitats through isolation and prolonged agricultural activities may also be a contributing factor (e.g. less reptiles and frogs).

Species characteristic of vegetation in the valley floor and lower midslopes include the Fuscous Honeyeater, White-plumed Honeyeater, Hooded Robin, Brown Treecreeper and Diamond Firetail. Species in common with nearby Western Slopes DSFs on the valley floor include White-throated Treecreeper, Noisy Minor, Eastern Rosella, Galah, Pied Butcherbird and Australian Magpie. These species are widespread throughout the study area with most being resilient to existing disturbance regimes.

Bird species specific to the grassier vegetation formations on the valley floor include Black-faced Cuckoo Shrike, Superb-fairy Wren, Crested Shrike-tit, Magpie-lark, Willie Wag-tail, Jackie Winter, White-plumed Honeyeater, Hooded Robin, Brown Treecreeper, Southern Whiteface and Diamond Firetail. While the Eastern Grey Kangaroo is frequently found within this habitat, the Red-necked Wallaby is notably absent perhaps due to the fragmented and simplified vegetation structure.

Species of nearby Lowland Box Redgum Forests include burrowing frogs and forest/ woodland bird species, as previously mentioned for the valley floor Western Slopes DSFs vegetation formations,. The presence of Grey Butcherbird, Laughing Kookaburra, Weebill and Common Bronzewing, White-browed Babbler, Western Gerygone, Rainbow Bee-eater, Red-rumped Parrot, Eastern Rosella all represent species capable of occupying vegetation of heterogenous structure and floristics (e.g. transitional zones and/or disturbed landscapes).

Vegetation remnants within this landscape generally represent the most productive areas of the study area, particularly where the landscape is linked to nearby basalt caps upslope. This vegetation, in combination with water availability (i.e. seeps and ponds), represent areas of source habitat which are likely to be important for many fauna species during breeding periods and as a refuge area during drought.

7.2.3. Midslopes near the Triassic Outcrop

Adjoining ridgetop and midslope vegetation at the outcrop of the Triassic geological formation is Footslope Box – Gum – Ironbark Forest, a vegetation formation similar to other valley floor dry sclerophyll forest formation in having a mix of fauna species typical of grassy and shrubby habitats. Bird species characteristic of this formation include the Grey Shrike Thrush, Striated Pardalote, Brown Thornbill, Grey Butcher Bird, White-browed Babbler, Noisy Friar Bird, Spotted Pardalote and Pied Currawong.

The increased presence of *Acacia linearifloia*, particularly in near the interface with Broad-leaved Ironbark – Grey Gum Forest in footslope sheltered gullies, supports substantial populations of Grey Mistletoe (*Amyema quandang*). Birds exploiting this resource include the Yellow-faced honeyeater, Stripped Honeyeater and Spiny-cheek Honeyeater with the Eastern Spinebill also foraging on this nectar source in addition to localised dense patches of Five Corner (*Styphelia triflora*). At cleared edges particularly in close proximity to remnant Box dominated vegetation are Speckled Warbler populations.

The data indicates the European Fox and Rabbit are restricted to these formations; however what is likely is that the midslope vegetation formations represent core habitat from which these species will radiate from and into adjoining areas for foraging purposes.

7.2.4. Upper slopes and Ridgetops

Grassy White Box Open Woodlands on basalt caps was found to be largely devoid of fauna species due largely to the absence of an established tree cover canopy. However, the faunal composition on the margins of these basalt caps is expected to mimic the conditions found at the Triassic outcrop (i.e. transient between productive grassy woodlands of the valley floor and shrubby infertile ridgetop vegetation). Observations included the Eastern Yellow Robin, Grey Shrike Thrush, Striated Pardalote, Grey Fantail, White-throated Treecreeper and Yellow-rumped Thornbill, which generally represent the extent of any landscape similarity. In contrast, species such as the Galah, Yellow-faced Honeyeater, Crested Pigeon, Australian Magpie and Hooded Robin are species in common with other valley floor grassy formations. These patterns in faunal occurrence suggest Grassy White Box Open Woodlands to be a foraging area, a conclusion consistent with the simplified habitat characteristics of this area (i.e. low to no fallen timber, no tree hollows, blocky rock formations)

Conversely intact ridgetop vegetation formations dominated by Broad-leaved Ironbark and Scribbly Gum represent vegetation on infertile soils dominated by bird species such as Grey Shrike Thrush, White-eared Honeyeater, Rock Warbler, Southern Boobook, Sacred kingfisher, Eastern Yellow Robin, Musk Lorikeet and Glossy Black Cockatoo. Rocky outcrops support a diverse reptile assemblage including geckos, skinks and snakes. Mammals include the Red-necked Wallaby, Common Ringtail Possum and Short-beaked Echidna. Diversity is high in both these vegetation formations, with diversity in Ridgetop Broadleaved Ironbark – Black Cypress Pine Woodland is substantially lower presumably due to the open character of this vegetation formation and absence of Grey Gum (i.e. tree hollows).

7.3. Aquatic Communities

From the combined literature review, site walkover analysis plus aquatic ecology sampling program results presented in Sections 5.7 and 6.4 above, the following conclusions can be drawn regarding the aquatic ecology of the study area:

- In the main, rainfall onto the vegetated basalt cap ridge tops would appear to be dispersed over multiple drainage paths due to the extreme fracturing of the surface rock, which would also appear to slow down the drainage and probably aid local infiltration to the sandy soils. As a consequence, the drainages down-slope from the vegetated basalt cap hill tops to Murragamba Creek and to Eastern Creek are not well defined (in terms of the provision of aquatic habitat). Some drainage swales have in-line dams and, for the most part, the land between dams has been cleared and tilled and supports mainly pasture grasses. Some drainage lines sections can be discerned by remnant lines of trees or by patches of sedges (or soaks - see below);
- Most of the Wilpinjong, Murragamba and Eastern Creek aquatic ecology sampling sites (i.e. sites with ponded water suitable for sampling) were located in mixed pastoral and woodland habitats with broken or scattered riparian woodland and banks generally held together by herbs and grasses. The sites had medium width to depth ratios (between 8 and 15 to 1) with few (if any) riffle/pool sequences and few natural retention devices (rocks or logs). Silt and sand bars were common and these were mobile, generally indicating active creek bed and bank erosion. There was generally substantial algae growth and often little or no aquatic plant growth indicating general eutrophication of contained waters. The water quality results indicate that most sites had very little water holding capacity (range 0.05 to 0.6 m depth, mean depth around 0.16 m) and this is characteristic for the sub-catchment;
- Water temperature, dissolved oxygen concentrations and turbidity readings, whilst highly variable, generally reflected seasonal variation (for temperature) and contrasting wet or dry sampling conditions (for turbidity and dissolved oxygen);
- Whilst water conductivity showed an overall large variation (range 53 to 2300 µS/cm) the average for the whole study was 700 µS/cm. Elevated conductivity only occurred in spring seepage pools in lower Eastern Creek waters (range 1100 to 2300 µS/cm);
- Water acidity (as pH units) was variable with an overall study range between 3.2 pH units and 9.2 pH units. However, the extremes related to only a few sites; the one high alkaline reading from Splitters Hollow Dam and a series of low acid readings from seepage spring water along the lower Eastern Creek bank;
- There were springs and ground seepages observed in both the Murragamba and Eastern Creek sub-catchments. In the main these were degraded or modified by intensive agricultural activities or were dug out to provide in-line stock watering dams (see Aquaterra (2008) for more detail/descriptions of springs in the study area). Other than the spring fed in-line dams, most other groundwater seeps provided little or no significant aquatic habitat, either via surface water flow or via hyporheic zones;
- There were proportionally more springs along the longer slope drainages flowing east into Murragamba Creek than from the shorter slope drainages from the western ridge. There was also proportionally more spring activity in the lower Murragamba Creek sub-catchment (last 3 km length above the confluence) than in the upper sub-catchment, with springs generally close to the creek line (i.e. within 500 m each side of the creek line);
- There was proportionally more spring activity in the upper two-thirds of the Eastern Creek sub-catchment, with scattered areas of boggy ground which supported mixed sedges and pasture grasses. Spring activity was generally evenly spaced around the creek line and generally located close to the creek line. Most of the areas of seepage were located in cleared, and in some cases tilled lands, and many of the observed springs had associated spring-fed stock watering dams established downstream;

- There was one permanent spring at the top of the catchment in Eastern Creek which was directed into a small ornamental pond with an extensive seepage area downstream (Spring 60 in Aquaterra 2008). The pond (Aquatic Ecology Site ECSpring) supported a complete aquatic ecological assemblage of aquatic plants plus macroinvertebrates but no fish. This pond would meet the classification of an aquatic GDE except that the pond would appear to have been constructed. The aquatic plants and macroinvertebrates were common to the study area; and
- There were spring seepages observed along portions of the banks of both Murragamba and Eastern Creeks, but almost all were impacted by tilling or creek bank erosion. The exception was a series of seepages along the lower Eastern Creek western bank along the creek section within 1 km upstream of the Wollar Road culvert. In one section this seepage supported both fully developed GDE herb and sedge plant communities and there was direct seepage to the creek. Other spring seepages in this location were intercepted by in-line dams. These seepages were distinguished from all other springs and seepages (as described above) by their having elevated conductivity and low pH.

With respect to potential aquatic and fish habitat condition and with respect to potential mining related impact:

- Wilpinjong Creek has fair to good (stable) riparian habitat and overall creek structure (compared to the other creeks in the study area) throughout its length in the study area (headwaters to Planters Creek Confluence). It does not provide a large dry weather supply of ponded surface water but would appear to have much sub-surface flow sufficient to support emergent sedge and grass growth (including large swaths of Cumbungi). Given the overall shallow depth of ponded water (when available), the water quality is sufficient to support aquatic life - although the species found are generally those tolerant to a high range of water quality variables. Wilpinjong Creek has sufficient connectivity during moderate to high flows to support some native riverine fish species but does not appear to provide large deep ponds to actually support many native fish;
- Murragamba Creek has had little surface flow over the extended period of this study (2004 to 2007) although there are sufficient signs of short violent flood events. For the most part the creek has little or no suitable aquatic habitat except for in-line dams and even these, unless spring fed are often empty. Agricultural practices have obliterated any semblance of creek structure in the upper catchment and for many of the slope drainages from the flanks of the western ridge. What water there is, in the creek or in the off-line dams, would appear to be derived from spring waters;
- Whilst the section of stepped rock constrained pools in the middle section of Murragamba Creek has good riparian vegetation and cover plus good stable pool structures there has not been any significant ponded water to sample. The conditions for the support of aquatic life are good but the water is not there;
- The lower section of Murragamba Creek from the road crossing to the confluence with Wilpinjong Creek comprises a deeply incised channel with steep highly unstable channel sides. Any ponds which form during major storm events are probably short lived as unstable storm-derived sediments are deposited into the depressions. Except for times of flood flow, this section of the creek provides little or no aquatic habitat in the form of drought-proof ponds;
- It is concluded that Murragamba Creek provides variable aquatic habitat in some of the in-line dams plus in the off-line dams which are spring fed. Whilst much of the water supply to Murragamba Creek would appear to be derived from springs, it would also appear that much of this water flows sub-surface and is only occasionally expressed as ponded surface water. Accordingly Murragamba Creek does not provide any significant fish habitat;
- The upper and upper-middle portion of the Eastern Creek valley has numerous springs on the slopes leading to the creek and there are consequently a number of large in-line dams which capture any occasional surface runoff plus the steady spring derived waters. Consequently the actual creek line between the dams and downstream of the dams is almost non existent. As for Murragamba Creek there is probably a spring fed sub-surface flow through the valley but this is seldom expressed as

surface ponded water and there are only occasional in-line sedges or lines of riparian trees which may be dependent on this sub-surface flow;

- There is a section of incised clay-stone with stepped pools and log jams with moderate wooded riparian cover towards the bottom of the creek which displays some permanent pool structures but, as for Murragamba Creek these structures seldom have sufficient water to hold (in spite of the evidence of short sharp storm flows).
- The final, lower section of Eastern Creek above the Wilpinjong Creek confluence has saline and acidic seepages along the western bank. The creek section here is a broad, deeply incised channel with a more or less flat silty-sand bed. There is little pool structure and when there is available water pools are very shallow and thus short lived; and
- It is concluded that Eastern Creek provides variable aquatic habitat in some of the in-line dams plus in off-line dams which are spring fed. Whilst much of the water supply to Eastern Creek would appear to be derived from springs it would appear that much of this water flows sub-surface and is only occasionally expressed as ponded surface water. Accordingly Eastern Creek does not provide much fish habitat.

The literature reviews plus the aquatic ecology studies undertaken between 2004 and 2007 indicate that, with regard to the threatened species provisions of the Commonwealth EPBC Act and the NSW Fisheries Management Act 1994, there were no threatened aquatic plants, fish or macroinvertebrate species or populations found within the aquatic habitats of the upper Goulburn River sub-catchment study area, nor are any expected. In regard to fish captures only two fish were caught or sighted, Plague Minnow and Long-finned Eel. Fish were only seen or caught in the lower sections of the three main creeks (Wilpinjong Creek sections along the Ulan-Wollar Road plus sites upstream from the confluence with Wilpinjong Creek in Murragamba and Eastern Creeks).

7.4. Interdependence between Terrestrial and Aquatic Ecosystems

The lack of suitable fish habitat (i.e. connected ponded water supplies) throughout the study area also limits the potential for other animals which are specifically dependent on ponded water resources:

- Long necked turtles were observed during the study but were only noted from a few pools in Wilpinjong Creek or from a few larger dams;
- There was no suitable platypus habitat observed (or expected) and most likely no suitable native water rat habitat available in the study area;
- No Myotis fishing bats were found or observed during either the terrestrial or aquatic field surveys; and
- Red bellied black snakes were observed around a few larger dams, Splitters Hollow Dam, a large in-line dam in Eastern Creek and nearby vegetation connected with these locations.

However, there are a number of other more subtle dependencies linking surface water availability and terrestrial fauna. Most animals (reptiles, birds and mammals) need drinking water. Whilst many would use the small ephemeral ponded water supplies available in the main creeks, many would be dependent on the water contained in the constructed dams. Of these, the constructed dams collecting spring water are likely to be highly important during drier periods when in-line dams dependent on surface runoff are dry.

Another important water source for animals is that available from the many bogs and seeps in the study area. Surface soaks with small ponded water are particularly prevalent downslope of Carr’s Gap, the headwaters of Eastern creek and within the creek banks of lower Easter Creek Judging by the tracks around these areas plus from direct observations, these are exploited by a variety of animals ranging from kangaroos and wild pigs to small woodland birds and insects. An additional (and highly variable) source of ponded surface water in the study area is provided by the disused quarries scattered throughout the study area. Some of these are steep walled and probably comprise as much a hazard for macro-fauna as a resource for flying biota. Other more accessible sites could supply good, relatively deep sources of water which could be important during prolonged drought periods.

The combined surface water resources also provide a valuable food source for a host of animals in the form of insects which breed in the water and disperse as adults via a flying stage. This is a particularly important food source for micro-bats (see for example Laegdsgaard, et. al. 2004) and for many woodland birds. From study area records the Hooded Robin appears to have a strong relationship with the distribution of soaks, particularly those presenting permanent fresh water resources with high water quality. In this respect the size of a home range is likely to be an important factor in determining the sensitivity of dependant fauna species. In the case of Hooded Robins it is considered that this species is far more dependant on permanent water resources (i.e. average 18 ha home range) when compared to wide ranging dispersive species such as Diamond Firetails and microchiropteran bats.

7.5. Identification of EECs

One endangered ecological community listed on the NSW TSC Act and Commonwealth EPBC Act known as White Box Yellow Box Blakely's Red Gum Woodland and Derived Grasslands (EEC/ CEEC respectively) is of relevance to the study area. The results of the vegetation analysis were examined to determine the presence of this EEC/ CEEC within the study area using the following resources:

- White box Yellow box Blakely's red gum woodland - endangered ecological community listing (NSW Scientific Committee, 2002);
- White box Yellow box Blakely's red gum woodland - identification guidelines (NPWS, 2002);
- Threatened Species Scientific Committee (2006a). Commonwealth Listing Advice on White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland;
- Threatened Species Scientific Committee (2006b). Commonwealth Conservation Advice on White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland;
- Department of the Environment and Heritage (DEH, 2006). Box-Gum grassy woodlands and derived native grasslands - Information Guide; and
- Species list for the EPBC Policy Statement 3.5 - White Box - Yellow Box - Blakely's Red Gum Grassy Woodlands and Derived Native Grasslands - last updated 22 May 2006 (Excel - 454 KB).

Common to both the NSW and Commonwealth listings are guidelines with a flow chart to assist the determination of an EEC/CEECs presence/ absence. These guidelines differ between each other, with the Commonwealth flow chart being more explicit in applying the listing advice.

Notwithstanding the differences, both flow charts begin with a fundamental question concerning the presence/ absence of the communities canopy dominants these being White Box, Yellow Box and/or Blakely's Redgum. Thus, this question represents the first determinant for this vegetation community within the study area.

7.5.1. Canopy Dominants

The primary question posed by the NSW and Commonwealth guidelines for WBYBBRW EEC/ CEEC occurrences in the Sydney Basin Bioregion are:

> *"Is, or was previously, at least one of the most common overstorey species White Box, Yellow Box or Blakely's Redgum" (DEH, 2006) or*

> *"White Box, Yellow Box or Blakely's Red Gum, or a combination of these species, are or were present" (DEC, 2002)*

Applying these to the study area can be completed in two ways, either by reviewing vegetation groups as defined in **Section 7.1.3** against the listings and/or analysing the current distribution of the canopy dominants throughout the study area. Both approaches are employed in this analysis, with the latter approach forming an important component of the analysis (i.e. identify distribution parameters that control the presence of the canopy dominants hence permitting an estimation of pre-clearing extent). Such an analysis is essentially an inclusive approach that considers simplistic considerations (i.e. community composition) and more complex arrangements that include the consideration of cover-abundance.

The discussion provided in **Section 7.1.7** for quadrat 148 reveals one of the more cryptic determinants underpinning the distribution of White Box, Yellow Box or Blakely's Red Gum throughout the study area. A combined interpretation of spatial distributions for these canopy dominants and the statistical analysis implicate the potential for an association with the Moolarben coal seam, a relatively minor coal layer in the upper Permian formation. On excluding any occurrences on basalt caps, it appears that White Box is generally found in drier upslope positions broadly along the interpreted outcrop of this coal seam, with Yellow Box generally frequenting the intersection of this coal seam with 'wetter' areas near Murragamba Creek. In this respect Yellow Box may also exhibit a preference for drainage lines that coincide with eroded basalt material. However, Blakely's Redgum does not necessarily exhibit such a defined relationship and is more frequently found along drainage lines and areas of impeded drainage on clays, with cover abundance being greatest near major creeks.

It is postulated that the elevated organic carbon content of soils influenced by outcropping coal seams such as the Moolarben coal seam, provide localised conditions favourable for at least White Box with Yellow Box seemingly requiring greater soil moisture levels (i.e. perched groundwater and/or creek lines).

Evidence supporting the above predicted distribution of canopy dominants is found in a continuous expanse of native vegetation cover that exists between Murragamba Creek and the Triassic outcrop near the upper reaches of this creek. In this transect of continuous vegetation cover it was observed that discontinuity of these canopy dominants naturally occurs across the valley floor landscape. Further confirmation of this observation is presented in the statistical analysis where quadrats located within the above inferred 'zone of absence' are classified as a "Grey Box – Ironbark" characterised vegetation formation.

Further support of these conclusions is provided in the final determination for "Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions - endangered ecological community listing" (http://www.environment.nsw.gov.au/determinations/EucalyptusMicrocarpaEndCom.htm). As indicated below this listing identifies Coastal Grey Box (*E. moluccana*) woodlands in the Sydney Basin as being distinct from this listing as well as White Box Yellow Box Blakely's Redgum Woodland:

> *" 9. Two woodland communities that are listed as Endangered Ecological Communities under the Threatened Species Conservation Act adjoin and intergrade with Inland Grey Box Woodland:*
>
> - *Fuzzy Box on alluvials of the NSW South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions*
> - *White Box Yellow Box Blakely's Red Gum Woodland*
>
> *Woodlands of Eucalyptus pilligaensis and E. populnea, and those of E. moluccana (Coastal Grey Box) in the Sydney Basin Bioregion are also related. Inland Grey Box Woodland can grade into inland riverine forests of Eucalyptus camaldulensis (River Red Gum) and E. largiflorens (Black Box) along inland rivers and floodplains. These later communities are not covered by this Determination."*

There is no characteristic presence of White Box and/or Yellow Box within the "Grey Box – Ironbark" vegetation formation, with Blakely's Red Gum occurring only as a localised minor associate in selected areas of impeded drainage (i.e. drainage swales, minor poorly defined creeks/ open depressions and groundwater seeps). This conclusion is consistent with the advice given to the Minister of DEH (2006), where it states:

> *"Sites dominated by Western Grey Box (E. microcarpa) or Coastal Grey Box (E.moluccana) without Yellow Box, White Box or Blakely's Red Gum as co-dominants are not considered to be part of the ecological community, except in the Nandewar Bioregion."*

When considering the State listing for WBYBBRW EEC the following references made by the NSW Scientific Committee (2001) support the exclusion of Coastal Grey Box (*E. moluccana*) dominated vegetation formations from WBYBBR EEC/ CEEC:

> *"7. Related communities are the Eucalyptus microcarpa, Eucalyptus pilligaensis Grey Box/ Eucalyptus populnea Poplar Box communities of the western slopes and plains and the Eucalyptus*

moluccana, Grey Box, communities of the Clarence, lower Hunter Valley and Western Sydney. These are not covered by this Determination"

And

"4. Woodlands with Eucalyptus albens are most common on the undulating country of the slopes region while Eucalyptus blakelyi and Eucalyptus melliodora predominate in grassy woodlands on the tablelands. Drier woodland areas dominated by Eucalyptus albens often form mosaics with areas dominated by Eucalyptus blakelyi and Eucalyptus melliodora occurring in more moist situations, while areas subject to waterlogging may be treeless. E microcarpa is often found in association with E. melliodora and E. albens on the south western slopes. Woodlands including Eucalyptus crebra, Eucalyptus dawsonii and Eucalyptus moluccana (and intergrades with Eucalyptus albens), for example in the Merriwa plateau, Goulburn River National Park and western Wollemi National Park, are also included. Intergrades between Eucalyptus blakelyi and Eucalyptus tereticornis may also occur here"

With regards to the latter explanatory note made by the NSW Scientific Committee (2002), it is important to understand the context pertaining to 'woodlands including'. Implied by this statement is a prerequisite where '*woodlands including'* in the WBYBBRW EEC definition implies that at least one of the canopy characteristics must be present. The former statement supports this interpretation, as 'similar' Grey Box (*E. moluccana*) dominated vegetation communities are known to occur within the Sydney Basin Bioregion and are not regarded as part of the EEC/ CEEC (e.g. refer to 'Coastal Grassy Woodlands' in Keith (2004); 'Cumberland Plain Woodland' in Benson (1992); and various Coastal Grey Box characterised communities for the Upper Hunter (HCR CMA, 2006)).

Summary

Implied by this analysis is an ecological community controlled explicitly by the availability of water and/or elevated soil fertility, with the combination of these factors having restricted occurrence in the study area (i.e. creeklines, Moolarben coal seam outcrop, basalt caps). Focal areas indicative of these characteristics have been predominantly cleared, presumably in congruence with its suitability for agriculture. As a consequence only remnants and/or natural unassisted regrowth (e.g. grasslands and shrublands) now persist, with some of these grasslands and shrublands potentially occurring as derived formations that belong to the WBYBBRW EEC/ CEEC classification.

7.5.2. Groundcovers (Grassiness)

Another important factor used to determine the presence of White Box Yellow Box Blakely's Redgum Woodland EEC/ CEEC is the extent of groundcover compared to the shrubbiness of the vegetation patch. Generally, shrubbier vegetation is less grassy with the overall ecological characteristic of such vegetation formations considered to fall outside the definition of this EEC/ CEEC. DEC (2002) give general guidance in the following statement:

"shrubby woodlands, which generally occur in upper or midslope situations on shallower soils, are not part of the EEC"

This is confirmed by the advice to the Minister of DEH (2006) for the Commonwealth listing where it states:

"Shrubs can occur naturally in grassy woodlands, and can form an important part of the Box – Gum Grassy Woodland and Derived Grassland ecological community, however, on poorer soils throughout its range, this ecological community grades into shrubby woodlands" and

"remnant with a continuous shrub layer, in which the shrub cover is greater than 30%, is considered to be a shrubby woodland and so is not part of the listed ecological community."

However exceptions exist where elevated shrubbiness may arise from disturbance. This is generally indicated by the presence of species such as *Cassinia* spp. and *Acacia* spp., thus potentially introducing complexity into the analysis requiring subjective considerations.

This element of community definition was examined statistically using vegetation structure data collected during the survey (i.e. quadrat data). The ordination (**Figure 19**) shows considerable variability within and between vegetation classes, with this result expected as the variability of vegetation structure across the site is a strong indicator of many natural and anthropogenic influences on vegetation such as:

- The spatially, temporally and mechanically diverse disturbance history of the study area through varied agricultural practices such as grazing (heavy and light), cropping, slashing, burning, fertilising and logging;
- The effects of climatic extremes such as drought; and
- The natural complexity in spatial representations of vegetation formations as described within this report.

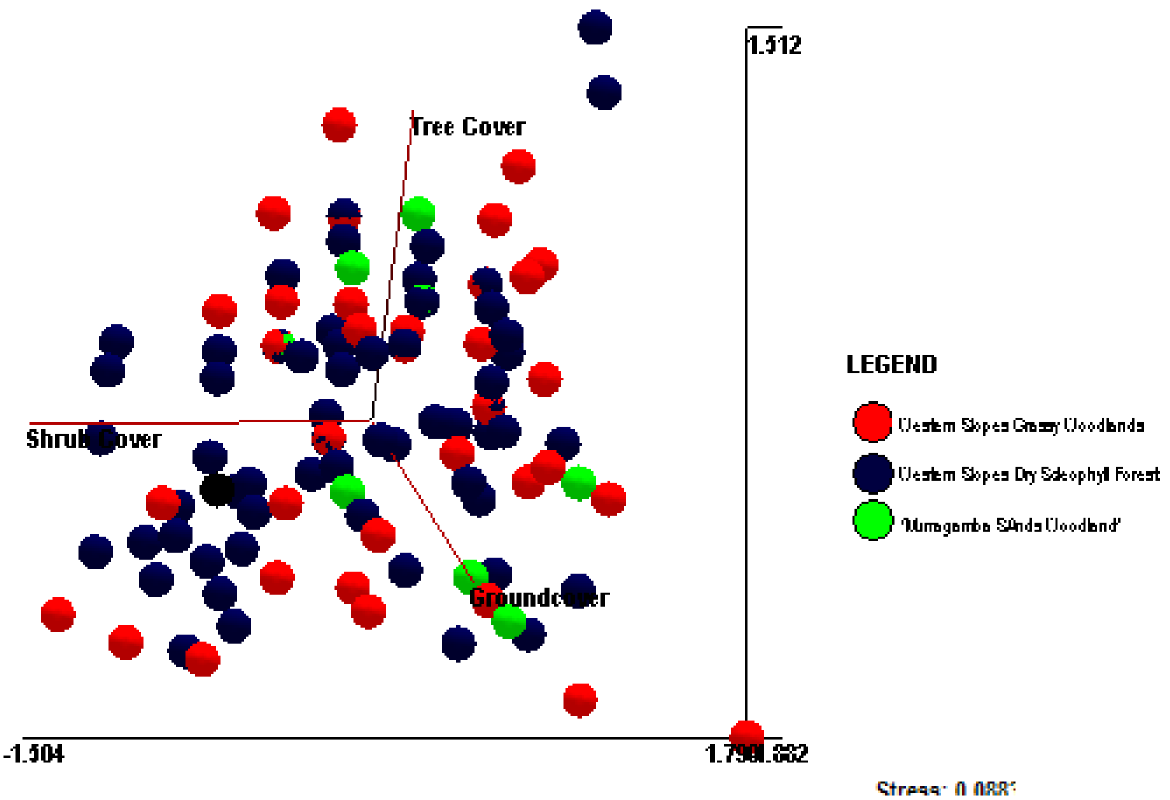


Figure 19: Ordination Plot of Quadrats according to tree, shrub and groundcover strata

In this respect it is considered that community composition is a more reliable technique in determining the extent of WBYBBRW EEC/ CEEC throughout the study area. An analysis of structure in this manner can only be reliably used where disturbance histories are known and can be measured relative to expected natural conditions.

For the study area the extent, intensity and timeframe of agricultural activities are considerable and varied with substantially overlap of these land use practices coinciding with lands that historically contained this EEC/ CEEC. In this context the examination of a communities 'grassiness' (i.e. grass and soft herb cover relative to woody herbs) through vegetation structure is likely to be obscured by the affects of sheep grazing, for example, where such agricultural activities are known to positively favour certain grass species (i.e. *Austrostipa scabra* and *Austrodanthonia* spp.). Such landuses are known to lead to the dominance of grazing tolerant grass species, which may or may not be indicative of past natural vegetation cover. The displacement of palatable 'sensitive' species characteristic of the WBYBBRW EEC/ CEEC, which may or may not have occurred in areas dominated by the above mentioned grazing tolerant species, cannot be appropriately considered in a vegetation structure analysis such as this.

7.5.3. Community Composition and Cover Abundance

A reductionist approach to classifying intact native vegetation into communities using legal definition via community composition comparisons (i.e. quantitative analysis) is simplistic and can ignore the importance of other determinants. The information provided for in the Final Determinations of the TSC Act broadly characterises this community and is largely qualitative. As alluded to in the Final Determination, it is not a definitive list and does not describe in detail the local or regional characteristics of this community.

As was found in (Motorplex (Australia) Pty Limited v Port Stephens Council [2007] NSWLEC 74), a detailed analysis of community composition and its correlation to the landscape is more appropriate in determining the presence or absence of an ecological community. A more simplistic comparison of species lists was considered to be inadequate, as it is in this study.

As such, a more detailed analysis of community composition and its correlation to the landscape in the study area was undertaken to determine how this related to the presence or absence of an endangered ecological community. In this analysis both techniques were utilised, with community composition used to inform a non-hierarchical agglomerative clustering analysis of raw quadrat data (see Section 7.1.3 for vegetation groups defined by the statistical analysis). **Appendix 6** provides various quantitative data for each quadrat relative to the legal definitions for White Box Yellow Box Blakely's Redgum Woodland and derived grasslands EEC/ CEEC (i.e. number of grass species, non-shrub species, shrub species, exotics, important species and total species).

It is clear from this analysis that the reductionist approach alone could easily miss-direct the classification of vegetation within the study area. Numerous quadrats **not** having one or more of the characteristic canopy species as co-dominants do however contain sufficient understorey biodiversity to be considered part of the EEC/ CEEC classification. However distinctions between sites known to have the canopy dominants and those that never contained the canopy dominants (i.e. classifying vegetation cover with no tree canopy as a derived grasslands and shrublands) cannot be conclusively determined from this approach.

Field observations of patterns in community composition and species distribution correlated with the patterns observed in the final statistical analysis between species and environmental gradients, particularly the availability of water resources and soil fertility. The varied influence of the environmental gradients across the landscape, and corresponding community composition, led to a degree of similarity between some communities. Proximal lands not having the required mix of environmental gradients may demonstrate similarities with the legal definition of White Box Yellow Box Blakely's Redgum Woodland and derived grasslands EEC/ CEEC but have fundamental differences such as the absence of the characteristic canopy species (see State and Commonwealth guidelines for identifying box-gum woodlands).

7.5.4. Conclusions

The analysis of plant community composition and consideration of relevant legislation and guidelines has lead to the classification of the following vegetation formations as belonging to the White Box Yellow Box Blakely's Redgum Woodland and derived grasslands EEC/ CEEC definition:

- Blakely's Redgum - Yellow Box - Apple Woodland;
- Blakely's Redgum - Rough-barked Apple Woodland;
- Grassy White Box Woodland; and
- Lowland Box - Redgum Woodland.

The identification of derived grasslands and shrublands that belong to the White Box Yellow Box Blakely's Redgum Woodland and derived grasslands EEC/ CEEC definition where quadrat data was not obtained was evaluated through the understanding provided in the preceding sections and the consequential application of relevant GIS data (e.g. geology, contours, Moolarben Coal Seam outcrop, creeks) and remote sensing of aerial photography (GeoSpectrum, 2008). Mapping using remote sensing techniques was undertaken by phototyping (i.e. comparing the land cover characteristics of known derived grasslands with other parts of the study area) using 0.5 m pixel resolution digital imagery.

7.5.5. Mapping and Statistics

A conservative inclusive approach has been adopted in classifying the parts of the study area that belong to the White Box Yellow Box Blakely's Redgum Woodland and derived grasslands EEC/ CEEC to meet the objectives of both the State and Commonwealth listings for this ecological community. Classification and mapping for this ecological community was based primarily on resolving the natural distribution of characteristic tree canopy species throughout the study area followed by an analysis of the understorey characteristics including community composition, vegetation structure and disturbance histories. The overall extent of EEC/ CEEC mapping is the culmination of both listings, as this approach will satisfy the intent of both these listings including the identification of treeless derived grasslands/ shrublands.

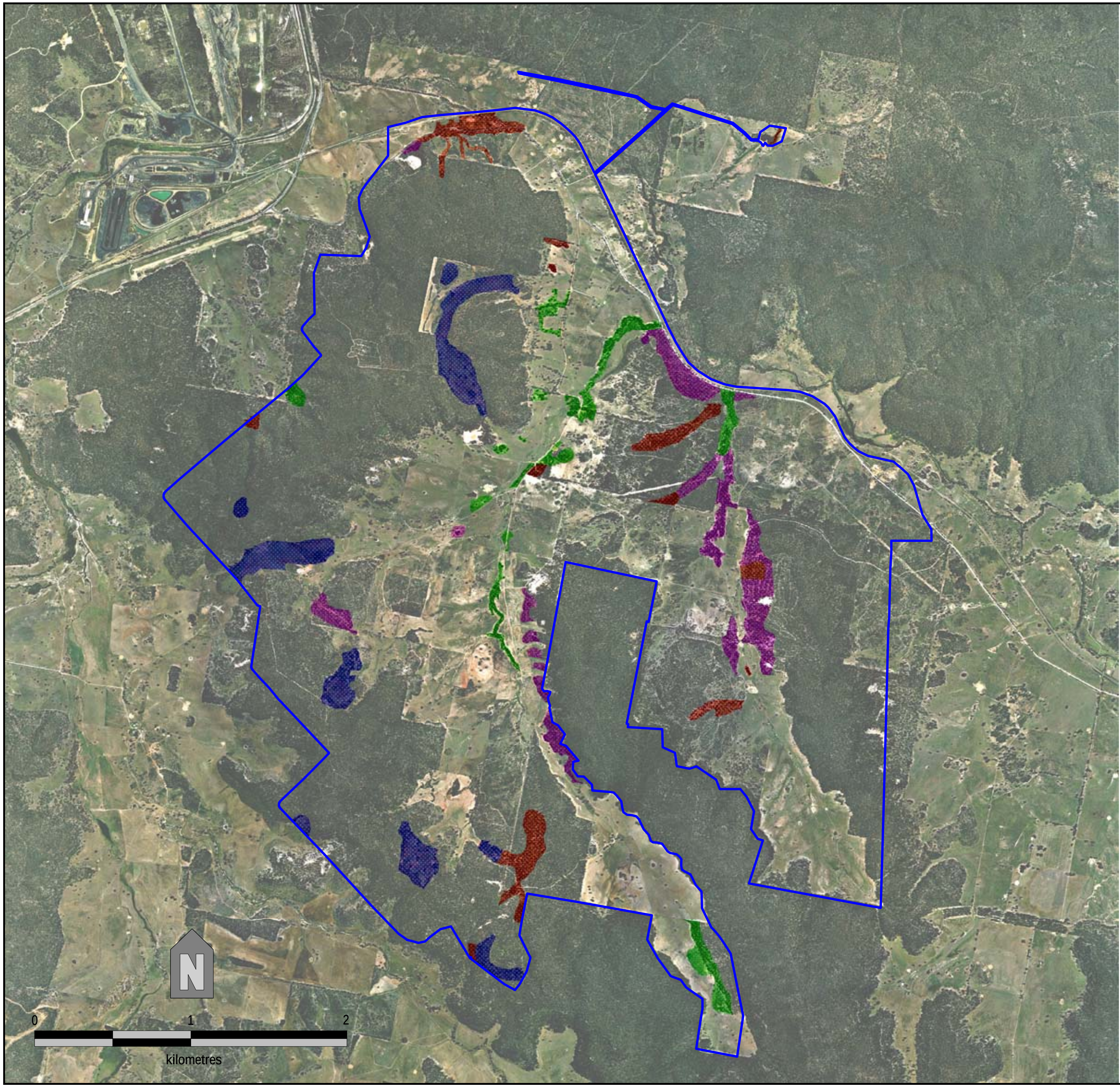
From the results of this study, it is considered that White Box Yellow Box Blakely's Redgum Woodland and derived grasslands EEC/ CEEC is primarily restricted to remnant basalt caps. Secondary manifestations of this ecological community occurs downslope of these basalt outcrops in connection with the weathered Moolarben coal seam outcrop and/or reliable water resources such as perched groundwater, aquatardes and open depressions (i.e. Murragamba Creek). Isolated areas of derived grasslands are also recognised and have been identified. **Figure 20** represents the spatial culmination of this analysis, with Table 26 providing various statistics that support this map.

Table 26: EECs/CEEC Statistics for the Study Area

Vegetation Formation	Structure	Area (ha)
Blakely's Redgum - Rough-barked Apple Woodland	Open Forest	26.84
	Woodland	23.92
	Open Woodland	7.14
	Shrubland	1.06
	Grassland	2.44
Blakely's Redgum - Yellow Box - Apple Woodland	Open Forest	19.59
	Woodland	13.83
	Open Woodland	14.83
	Shrubland	5.74
	Grassland	1.71
Grassy White Box Woodland	Open Forest	0.43
Grassy White Box Woodland	Woodland	13.96
	Open Woodland	31.25
	Shrubland	15.73
	Grassland	31.17
Lowland Box - Redgum Woodland	Open Forest	11.94
	Woodland	59.4
	Open Woodland	8
	Shrubland	5.83
Total	-	*294.81*

7.6. GDEs of the Study Area

As described and documented in Aquaterra (2008) "there is abundant evidence in the large number of springs and seeps that the groundwater discharges to the surface throughout the area. However, with few exceptions, the volumes of individual spring and seep discharges are very small. Many seeps were only visible as patches of dampness or lush grass. The flow rate of the largest spring flow observed in the study area is estimated at less than 0.1 L/s. Nevertheless, the accumulation of groundwater discharges is sufficient to maintain semi-perennial flow in the major tributaries (either visible flow or flow within the sandy stream beds). Landowners report that a number of spring-fed dams are able to maintain permanent water through extended dry periods due to groundwater seepage".



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Legend

- Blakely's Redgum - Rough-barked Apple Woodland
- Blakely's Redgum - Yellow Box - Apple Woodland
- Grassy White Box Woodland
- Lowland Box - Redgum Woodland
- Study Area

FIGURE 20

Distribution of EECs/ CEECs within the Study Area

Sources
Copyright GeoSpectrum Australia (2008)
Copyright Ecovision Consulting (2008)

ECOVISION CONSULTING

Potential GDEs of the MCP study area were identified using the eight-step rapid assessment (DLWC, 2002), with those conforming to this assessment method described below in accordance with its associated broad GDE classification.

7.6.1. Terrestrial GDEs

No terrestrial GDEs mappable at the vegetation formation level are known to occur throughout parts of the study area to be impacted by underground mining. However, small mappable vegetation assemblages occur throughout the valley floor where groundwater seepage provides moist to wet soils harbouring specific native plant formations. Other potential GDEs are also discussed in the following sections.

Underground 1 and 2

No terrestrial woodlands and/or forests occurring throughout the landscape affected by underground mining can be classed as a GDE. Unlike the approved Underground 4 there are no occurrences of the Parramatta Redgum (*Eucalyptus parramattensis*) vegetation that would otherwise indicate locally increased soil moisture levels. Similarly there are no isolated occurrences of ferns and other moisture affiliated groundcover species,

Aquaterra (2008) reason that the presence of GDEs on the Triassic Narrabeen Sandstones in this area do not appear to be conducive to retaining water to the extent that would support a unique vegetation formation, due to the massive structure and lack of barriers. This conclusion is consistent with the results of the surveys within the study area as reported above.

Open Cut 4

Scattered throughout O/C 4 are numerous isolated and localised groundwater seeps and soaks that exhibit plant assemblages that are highly localised and distinct from surrounding vegetation. Most of these soaks and seeps are located on east facing midslopes adjacent to Murragamba and Eastern Creeks. Plant species observed includes various sedges, Narrow-leaved Goodenia (*Goodenia macbarronii*), *Haloragis heterophylla*, *Myriophyllum* spp., Sundews (*Drosera* spp.) and Bladderwort (*Utricularia dichotoma*). For these types of plant assemblages the groundwater resources would have to be permanent or at best semi-permanent otherwise many would not persist. The size of these GDEs range from 2000 m^2 to as small as 100 m^2.

Parts of the WBYBBRW and Derived Grasslands EEC/ CEEC also appear to be reliant on groundwater resources within the Murragamba. That is, the distribution of WBYBBRW and Derived Grasslands EEC/ CEEC that is dominated by Yellow Box appear influenced by water availability. Yellow Box does not form a canopy dominant or associate throughout the mid to upperslope landscapes (i.e. along the Moolarben Coal Seam outcrop), other than for locations such as the footslope of basalt flows (e.g. Carrs Gap).

Bands of White Box (*E. albens*) that appear to be interacting with the Moolarben Coal Seam do not appear linked with the occurrence of groundwater, as there is limited to no accessible groundwater resources in these upper landscapes (Aquaterra, 2008). From this it is considered that White Box (*E. albens*) is predominantly reliant on drier landscapes where it can draw nutrient from the coal seam and/or overlying tuff strata (i.e. volcanic material), a scenario consistent with the preferred landscape position of White Box (*E. albens*).

It is considered that nutrient availability linked to the outcropping Moolarben Coal Seam results in a localised elevated surface soil fertility and soil structure along this outcrop, with these soil conditions conducive to increased soil moisture levels through improved infiltration rates that result from increased organic matter content and the fine particle fraction. The response of the understorey within areas influenced by the outcropping Moolarben Coal Seam is generally grassy herbaceous with reduced shrub cover, although the incidence of this relationship is not necessarily evenly distributed across the extent of the outcropping Moolarben Coal Seam, rather generally restricted to lands where basalt also interacts.

Parts of the Murragamba Sands Woodland could also represent an area of terrestrial GDE, particularly on the periphery of its spatial extent. Blady Grass (*Imperata cylindrica*) and *Banksia marginata* are both common understorey components of a Rough-barked Apple dominated woodland band found along the edge of this vegetation formation, with these species potentially indicative of elevated soil moisture levels.

7.6.2. Base flow GDEs

Aquaterra (2008) found that groundwater contributes to base flow in parts of the Murragamba and Wilpinjong Creeks. Accordingly, riparian plus aquatic and fluctuating hyporheic zones may be groundwater dependent. Assessment of riparian vegetation (as presented in this chapter above) did not indicate any specific riparian plant formations that could be considered groundwater dependent. Assessment of aquatic habitats including hyporheic zones is considered separately.

7.6.3. Aquifer and Cave GDEs

No GDEs of this character occur within the study area. However, there are numerous small patches of sedges in spring fed drainage lines in Murragamba and Eastern Creeks which are fed from shallow perched groundwater, with the occurrence of most of these seeps likely to be a consequence of tree cover removal.

Two spring fed GDEs of significance were identified within the study, with their locations described as:

- Near the confluence of Eastern Creek and Wilpinjong Creek; and
- Upper Eastern Creek on property referred to as the Powers Property.

Both of these spring fed GDEs appear to be natural as demonstrated by the range of aquatic plants found within them, in particular the GDE located near the confluence of Eastern Creek and Wilpinjong Creek. Both these GDEs number of native grass, sedge and herb species characteristic of water-logged soils including *Juncus planifolius*, *Myriophyllum gracile* var *lineare*, *Utricularua dichotoma*, Narrow-leaved Goodenia *Goodenia macbarronii*, Rough Raspwort *Haloragis heterophylla* and *Schoenus moorei*. This vegetation is located elsewhere in the study area, but has highly restricted occurrence.

7.6.4. Wetland GDEs

A semi-permanent coverage of water occurs near the confluence of Murragamba Creek and the unnamed tributary stemming from Carrs Gap. It is considered that the shallow wetland area is created as a result of in-stream flow constrictions and consequently is dependent on, and responds to surface water level fluctuations with minor dependence on local seepages or spring water possible. Whilst surface water level is in turn dependent on groundwater base-flow, the fluctuations in water level are mainly governed by water draw down from local evaporation.

7.6.5. Terrestrial Fauna Dependence on GDEs

The distribution of threatened fauna species of the study area is not strictly governed by GDEs rather a mix of landscape features. However, there appears to be a relationship between water availability and the distribution of some woodland birds, namely the Hooded Robin and Diamond Firetail. Both these woodland bird species have demonstrated spatial distributions that incorporate open permanent water bodies such as springs, creeks, dams and creek pools.

The open ponded water described for **Section 7.6.4** is likely to represent a critical focal resource for woodland birds and microchiropteran bats. Surface intercepted groundwater resources at this location provide permanent or reliable water supporting the lifecycles of foraging resources such as aquatic insects. The rarity and/or concentration of these resources in the Murragamba have acted to restrict the location of the Hooded Robin's home range. In a spatial sense, the Diamond Firetail is comparatively less sensitive to these issues as its home range is generally larger than that of the Hooded Robin and is a species capable of moving through undesirable parts of the landscape to access necessary resources.

7.7. Ecological Communities

The vegetation, fauna and aquatic biota described in Section 5, 6 and 7 of this report have been categories into four ecological communities of which two are aligned with vegetation classes described by Keith (2004) these being Western Slopes Dry Sclerophyll Forest and Western Slopes Grassy Woodlands.

The study area's 'cleared' lands, these being areas with no tree canopy cover, are mostly described as secondary grasslands and shrublands. Intact native vegetation containing characteristic grasses, herbs and shrubs are classifiable as 'derived grasslands and shrublands' and are described under their comparable native vegetation formation. A transitional grass/ shrub woodland termed ‘Murragamba Sands Woodland’ occurring on a tertiary paleochannel, which is not described by Keith (2004), is also described.

The description of ecological communities includes the characteristic floristics, structure, fauna assemblages, stream conditions, overall condition and threatened biodiversity values.

7.7.1. Secondary Grasslands and Shrublands

Description:	Cleared forest and woodland communities, predominantly of box – redgum – ironbark origin. Includes areas of early regrowth and regenerating shrublands with simplistic flora characteristics. This unit also includes disturbed roadside vegetation and chronically disturbed land due to previous claystone mining. Variable floristic composition, which is largely linked to disturbance history.
Structure:	Variable due to disturbance, seasonal and climatic conditions. Groundcovers up to 80% cover. Some areas contain regrowth shrubs to 4-10m in height, with cover varying from 0-60%. Occasional remnant and regrowth trees occur with heights from 8-18m, and cover varying from 0-10%.
Floristics:	On soils of low fertility the vegetation is characterised as grassland dominated by native grasses such as Wire Grass *Aristida ramosa*, Redleg Grass *Bothriochloa macra,* Speargrass *Austrostipa scabra*, Rats Tail *Sporobolus creber* and exotic naturalised grasses such as Catsear *Hypochaeris radicata,* Hairfoot Clover *Trifolium arvense*, Sheep Sorrel *Acetosella vulgare* and thistles. Native herbs and orchids can frequently appear. Shrubs include Sifton Bush *Cassinia arcuata*, Mudgee Wattle *Acacia spectabilis* and *Calytrix tetragona* may dominate under certain conditions with the latter two species generally restricted to upper midslopes where cleared lands are proximal to the Triassic geological formation. Occasional trees include Narrow-leaved Ironbark *Eucalyptus crebra*, Grey Box *Eucalyptus moluccana* and White Box *Eucalyptus albens*.
	On soils of higher fertility, the land is maintained as pasture and native grasses have been replaced by seeded pasture species such as Ryegrass *Lolium* spp, Clover *Trifolium* spp, Medic *Medicago* spp and Fescue *Vulpia* spp, and weedy exotics such as Sheep Sorrel *Acetosella vulgare* and Prairie Grass *Briza minor*. Occasional shrubs include Sifton Bush *Cassinia arcuata*. Occasional trees include White Box *Eucalyptus albens*, Blakely's Red Gum *Eucalyptus blakelyi*, Rough-barked Apple *Angophora floribunda* and Grey Box *Eucalyptus moluccana*.
	Some areas exhibit early natural regeneration, with various shrub dominances. In ungrazed areas near naturally vegetated land on cleared mid-slopes of the valley floor, Sifton Bush *Cassinia arcuata* dominates. In a broad valley containing deep alluvial sands near the eastern boundary of the study area, *Banksia marginata* occurs. On well-drained sandy soils scattered through the study area, Mudgee Wattle Acacia *spectabilis* dominates. In moderately protected areas particularly at the foot slopes of steep gullies, Narrow-leaved Wattle *Acacia linearifolia* dominates.
	Roadside vegetation is generally open woodland with wattles (*A spectabilis* and *A linearifolia*) and Sifton Bush *Cassinia arcuata* dominating the understorey, and relatively disturbance-tolerant grasses such as Three-awned Speargrass *Aristida ramosa* and *Calotis cuneifolia* dominating the groundcover. Less disturbed areas support Kangaroo Grass *Themeda australis* and a variety of native herbs. Common trees include Grey Box *Eucalyptus moluccana*, Blakely's Red Gum *Eucalyptus blakelyi* and Narrow-leaved Ironbark *Eucalyptus crebra*.
	Areas previously subjected to claystone mining are chronically disturbed, with most surfaces characterised by bare ground. A large variety of eucalypts and pioneer species are sparsely scattered through these areas, with limited groundcover species.

Fauna Values:	Mostly open pasture areas with scattered shelter shrubs and trees on the valley floors of the southern part of the study area. Generally abundant pasture grass seeds for granivores. Mistletoes occur in isolated trees. There is little roosting or shelter habitat of value for most species, but good foraging value for more disturbance-tolerant granivores. Water available in farm dams and creeklines is potentially important. A large range of threatened birds have been observed within this landscape, however their reliance on the habitats contained there within is limited.
Condition:	Whilst variable, the vegetation of this class is generally regarded as disturbed due to previous clearing, earthworks, mining, cropping and pasture management with most areas not generally representative of intact native vegetation cover. However, selected areas may contain elevated native species richness, particularly in close proximity to basalt caps, riparian corridors and native vegetation cover, thereby forming highly localised native derived grasslands/ shrublands of varying condition. These latter ‘derived grasslands and shrublands’ have been separately mapped as a grassland or shrubland under a comparable vegetation type.
Significance:	One threatened plants species (i.e. *Diuris tricolor*) has been recorded within EL6288, generally within ungrazed grasslands on soils of low fertility. This species is not known to occur within the study area despite the presence of isolated habitat values.
	At least 10 threatened fauna species have been reliably recorded within this vegetation including the Glossy Black Cockatoo, Large-eared Pied Bat, Little Pied Bat, Speckled Warbler, Brown Treecreeper, Painted Honeyeater, Hooded Robin, Yellow-bellied Sheath-tail Bat, Large Bent-wing Bat, Grey-crowned Babbler and Diamond Firetail. For the majority of these species this vegetation only supports foraging activity, perhaps with the exception of the Diamond Firetail where it could potentially complete its full lifecycle under certain circumstances (i.e. sufficient native grasses and elevated nesting positions such as isolated trees near permanent water sources).
	With regard to threatened fauna species, it is interesting to note that a large number of Hooded Robin records (22 of 26) are from this vegetation formation. Similarly, a high proportion of Diamond Firetail and Brown Treecreeper records are also associated with this vegetation. These records are mainly from unimproved pasture, both grazed and ungrazed, within close proximity to Yellow Box – Redgum and Grassy White Box vegetation. It is interpreted that occupation within this vegetation formation by these species is transient.
	Critical fauna habitat features or resources found within this vegetation include Mistletoes (*Amyema* spp.), which is important for the Painted Honeyeater. No listed critical habitat under the TSC Act or EPBC Act occurs within this vegetation formation.

7.7.2. Western Slopes Dry Sclerophyll Forests

Description:	Open forest and woodland consisting of numerous Box – Gum – Ironbark sub-formations primarily on sedimentary (sandy to clay) derived soils.
Structure:	Trees within this ecological community vary from 10-22m in height, with cover varying from 5-40% and up to 60% where dominated by Black Cypress Pine (*Callitrus endlicherii*). Shrubs occur from 0.5-4m in height and 5-45% cover, and up to 14m where dominated by Black Cypress Pine. Groundcover to 1m in height, with cover varying from 0-30%.
Floristics:	Dominant tree species on shallow ridgetop soils include Broad-leaved Ironbark *Eucalyptus fibrosa*, Grey Gum *Eucalyptus punctata* and Narrow-leaved Stringybark (*E. sparsifolia*). Blue-leaved Stringybark *Eucalyptus agglomerata* locally common on deeper sandy soils on the upper slopes with the stringybark *Eucalyptus sparsifolia* being characteristic of exposed rocky outcrops. Skeletal sandy soils are more often dominated by Scribbly Gum *Eucalyptus rossii,* Narrow-leaved Ironbark *Eucalyptus crebra* and Black Cypress Pine *C. endlicherii*. Claystone derived soils are dominated by Mugga Ironbark Eucalyptus sideroxylon with Coastal Grey Box *Eucalyptus moluccana* and Slaty Box *Eucalyptus dawsonii* forming co-dominants and/or associates. White Box *Eucalyptus albens* may form monotypic stands with forest structure on claystone derived soils.
	Disturbed areas are often dominated by Black Cypress Pine *Callitris endlicherii*. Other dominant shrub species include Honey pots *Acrotriche rigida*, Geebung *Persoonia linearis*, Forest Goodenia *Goodenia hederacea*, Sheoak *Allocasuarina gymnanthera*, Blunt-beard Heath *Leucopogon muticus*, Urn-heath *Melichrus urceolatus*, Box-leaved Wattle *Acacia leucolobia, Babingtonia cunninghamia* and Sifton Bush *Cassinia arcuata*.
	Few grasses occur within this vegetation class, with the dominant species being Three-awned Speargrass *Aristida ramose,* Short-haired Plumed Grass *Dichelachne micrantha* and Speargrass *Austrostipa scabra*. Common herbs include *Phyllanthus occidentalis*, *Pomax umbellata, Poranthera corymbosa,* and Rock Fern *Cheilanthes sieberi* ssp *sieberi*. A variety of terrestrial orchids were recorded. Increased grass diversity and spring flowering orchids occur more commonly in vegetation containing Narrow-leaved Ironbark and Red Stringybark, which is located on degraded tuffaceous claystones.
	Black Cypress Pine *Callitris endlicherii* forms a dominant canopy in some parts of this community with a diverse sclerophyllous shrubby understorey consisting of Beard-heath *Leucopogon muticus*, Narrow-leaved Geebung *Persoonia linearis*, Heath *Brachyloma daphnoides*, *Acacia linearifolia*, Five Corners *Styphelia triflora*, Native Fuchsia *Correa reflexa*, Common Fringe-myrtle *Calytrix tetragona*, Box Wattle *Acacia leucolobia* and Sheoak *Allocasuarina gymnanthera*.
	The groundcover is generally sparse, with mostly woody herbs and few grasses. Common herb species include *Platysace ericoides*, *Pomax umbellata*, *Poranthera microphylla*, *Phyllanthus occidentalis*, *Isotoma axillaris*, Forest Goodenia *Goodenia hederacea*, Flax Lily *Dianella revoluta*, *Patersonia sericea* and Mat-rush *Lomandra confertifolia*. Grasses include Wallaby Grass *Austrodanthonia* spp, *Poa* spp, Three-awned Speargrass

	Aristida ramosa and Reedgrass *Arundinella nepalensis*. Several terrestrial orchid species occur.
Fauna Values:	Mostly open forest to woodland with sparse to moderate shrubs and a variable groundcover. Occurs mainly on elevated lands and rugged ridgelines A range of small to large tree-hollows occur, mainly within Scribbly Gum and Grey Gum, providing potential roosting/nesting resources for bats, small to large arboreal mammals, and in some areas, for large forest owls and parrots (e.g. Glossy Black-cockatoo). Grey Mistletoe (*Amyema quandang var. quandang*) occurs in association with *Acacia linearifolia*, particularly throughout the footslopes and sheltered sites. Fallen woody debris and leaf litter are a feature of this community with an abundance of fallen logs noted in inaccessible areas. *Callitris* sp is a feature of the understorey and canopy of many areas. Generally water resources are limited and isolated to scattered closed depressions (e.g. dams and springs). Some areas of this community have small to large surface rocks providing habitat for many reptile species. Sandier locations support large populations of burrowing frog species.
Condition:	This community is predominantly void of weeds due to the upslope position of these woodlands relative to the surrounding agricultural activities, limited extent of land clearing and generally low soil fertility. Logging is evident throughout selected parts, particularly the lower more accessible slopes, presumably for fence posts and mine props supporting the Ulan underground development. The vegetation is predominantly intact despite past disturbances such as track construction works and exploration drilling for coal. Consequently, weeds are generally restricted to track margins and ephemeral creeklines.
Significance:	No threatened plant species were recorded within this ecological community. However, one ROTAP species was recorded this being *Pseudanthus divaricatissimus* - 3Rca.
	Eleven threatened fauna species have been recorded including the Gang Gang Cockatoo, Glossy Black Cockatoo, Large-eared Pied Bat, Speckled Warbler, Brown Treecreeper, Painted Honeyeater, Large Bent-wing Bat, Powerful Owl, Gilbert's Whistler and Diamond Firetail.
	Critical fauna habitat features or resources include mistletoes (*Amyema* spp.) for the Painted Honeyeater, particularly near the interface with grassy woodlands, and stands of Sheoak *Allocasuarina* sp for the Glossy Black Cockatoo. Large tree hollows present within Grey Gum (*E. punctata*) represent important roost habitat for Glossy Black Cockatoo and potentially Powerful Owl. No listed critical habitat under the TSC Act or EPBC Act occurs within this ecological community.

7.7.3. Western Slopes Grassy Woodlands

Description:	Forest and woodland vegetation primarily dominated by Box eucalypt species on dry Permian and Tertiary Basalt derived soils and Redgum – Rough-barked Apple assemblages on drainage line consisting of deep sands overlying clays.
Structure:	Tree heights vary from 8-22m, with a cover varying from 5-45%. Shrubs occur from 0.5-10m in height, with a cover varying from 0-40%. The groundcover occurs up to 1.4m in height, with a cover varying from 5-60%.
Floristics:	Characteristic tree species include Yellow Box *Eucalyptus melliodora*, Narrow-leaved Ironbark *Eucalyptus crebra*, Grey Box *Eucalyptus moluccana*, White Box *Eucalyptus albens* and Blakely's Red Gum *Eucalyptus blakelyi*. Dominance varies according with soil fertility and soil moisture, with fertile basalt influenced drainage lines characterised by Redgum and Yellow Box and less fertile dry shallow claystone derived soils characterised by Grey Box. White Box generally occurs in association with the outcropping Moolarben Coal Seam or Basalt caps.
	Shrub species are generally diverse, yet sparsely distributed. Common shrub species include Honey pots *Acrotriche rigida*, Peach Heath *Lissanthe strigosa*, Sifton Bush *Cassinia arcuata*, *Cassinia quinquefaria* and *Acacia* spp. Drainage lines support *Melaleuca thymifolia* and *Leptospermum polygalifolium*, with the latter more common on sandier substrates.
	Box woodlands typically support a grassy understorey of relatively high plant species diversity. Common grasses include Weeping Grass *Dichelachne micrantha*, Three-awned Speargrass *Aristida ramosa,* Wallaby Grass *Austrodanthonia racemosa* and Kangaroo Grass *Themeda australis*. Common herbs include Rock Fern *Cheilanthes sieberi* ssp *sieberi*, Kidney Weed *Dichondra repens*, *Calotis cuneifolia*, *Glycine tabacina* and Native Cranberry *Austroloma humifusum*. A variety of terrestrial orchids were recorded.
	Drainage lines support an array of species dependant on soil moisture such as *Arundinella nepalensis, Goodenia macbarronii* and varies sedges and herbs beneath a canopy often dominated by Blakely's Red Gum *Eucalyptus blakelyi* (which can occur in near pure stands). Shrubbiness increases within upland drainage lines where soil fertility is lower, with the presence of grasses and herbs proportionally limited by increased shrub cover. There is a high diversity of native herbs and grasses within this formation typified by Reedgrass *Arundinella nepalensis*, Poison Rock Fern *Cheilanthes sieberi* ssp *sieberi*, Narrow-leaved Goodenia *Goodenia macbarronii*, Stinking Pennywort *Hydrocotyle laxiflora* and Catsear *Hypochaeris radicata*.
Fauna Features:	Mostly woodland with sparse shrubs and a groundcover equally split between grassy vegetative cover and leaf litter. Occurs within an overcleared landscape characterised by a fragmented native vegetation cover of small patch size. Tree hollows are rare to absent providing limited resources for roosting/nesting species such as bats, small to large arboreal mammals, and large forest owls these being absent from this landscape. Mistletoes commonly occur throughout this vegetation class. Fallen woody debris and logs have patchy distributions.
	Water resources are limited to farm dams, chain of ponds and isolated springs, with the local availability of this resource generally restricted to this

landscape. Profusely flowering eucalypts are a feature including Grey Box, White Box, Yellow Box, Mugga Ironbark and Blakely's Redgum.

Condition: Anthropogenic influences have adversely impacted the grassy woodlands of the study area due to the association of this landscape with agricultural activity. Logging and/or broad scale clearing have resulted in patchy fragmented vegetation occurrences that include isolated areas of derived grasslands. The majority of grassy woodland remnants are isolated by cleared floristically impoverished lands, resulting in localised disturbed vegetation boundaries conducive to the presence of exotic flora and weedy natives such as Catsear *Hypochaeris* spp., Prairie Grass *Bromus* spp., *Vulpia* spp. and Sifton Bush *C. arcuata*. The latter species appears to function as a pioneer species occupying disturbed environs.

Vegetation of the drainage lines remains largely intact in parts despite the occurrence of past land clearing events for agricultural lands. In upland drainage lines weeds are generally low in abundance and are restricted to species capable of occupying moist soils, with weed species richness and cover increasing downslope particularly where there are basalt influenced soils. Sifton Bush *Cassinia arcuata* occasionally forms a dominant shrub species in areas where the disturbance history is more pronounced (i.e. derived shrublands). The absence of trees with hollow throughout the lower reaches indicates the tree canopy cover to be relatively young, perhaps less than 100 years. When compared with slightly elevated tree hollow density in upland drainage lines, it is speculated that the lower reaches were once completed cleared.

Significance: Some of the vegetation formations described within this vegetation class form part of the endangered ecological community known as 'White Box Yellow Box Blakely's Red Gum Woodland and derived grasslands', which is listed under the TSC Act as endangered and EPBC Act as critically endangered.

One threatened plant species, the Hoary Sunray *Leucochrysum albicans* var *tricolor* (Endangered – EPBC Act), was recorded within Grey Box dominated vegetation to the west but not within the study area.

Fourteen threatened fauna species have been recorded including the Glossy Black Cockatoo, Large-eared Pied Bat, Little Pied Bat, Speckled Warbler, Brown Treecreeper, Painted Honeyeater, Square-tailed Kite, Hooded Robin, Black-chinned Honeyeater, Grey-crowned Babbler, Large Bent-wing Bat, Eastern Long-eared Bat, Yellow-bellied Sheath-tail Bat and Diamond Firetail.

As expected, this community is of notable value particularly for the threatened woodland birds identified in Reid (1999) and Stevens (2001), *i.e.* Brown Treecreeper, Speckled Warbler, Grey-crowned Babbler and Diamond Firetail. It is likely that this vegetation community represents the highest local values for declining woodland birds.

A proportionally higher number of threatened microchiropteran bat species were recorded within the Blakely's Red Gum vegetation formations than in any other vegetation type.

Critical fauna habitat features or resources include an abundance of mistletoes (*Amyema* spp.) for the Painted Honeyeater. No listed critical habitat under the TSC Act or EPBC Act occurs within this vegetation class.

7.7.4. Murragamba Sands Woodlands

Description:	Dry sclerophyll woodland vegetation characterised by a variable mosaic of eucalypts including Scribbly Gum (*E. rossii*), Narrow-leaved Ironbark (*E. crebra*) and Rough-barked Apple (*A. floribunda*) on a tertiary sands deposit. The banksia *Banksia marginata* is a characteristic tall shrub for sections of this ecological community, particularly near its margin with adjoining communities.
Structure:	Trees within this community vary from 12-18m in height, with a cover varying from 15-50%. Shrubs occur from 0.5-10m in height, with a cover varying from 5-70%. The groundcover occurs up to 1m in height, with a cover varying from 15-60%.
Floristics:	Dominant tree species within this community are Rough-barked Apple *Angophora floribunda*, Scribbly Gum *Eucalyptus rossii* and Narrow-leaved Ironbark *Eucalyptus crebra*. Dominance varies according to sand depth and soil moisture.
	The shrub layer is diverse with sclerophyllous species including Native Cranberry *Astroloma humifusum*, *Babingtonia cunninghamii*, *Daviesia acicularis*, Sifton Bush *Cassinia arcuata*, Black Cypress Pine *Callitris endlicherii* and *Pultenaea microphylla*.
	The groundcover is grassy and dominated by Blady Grass *Imperata cylindrica*, Three awn Speargrass *Aristida ramosa*, Hedgehog Grass *Echinopogon caespitosa*, Weeping Meadow Grass *Microlaena stipoides*, *Dichelachne micrantha* and Reedgrass *Arundinella nepalensis*. Common herbs include Rock Fern *Cheilanthes sieberi* ssp *sieberi*, Native Cranberry *Astroloma humifusum*, Mat-rush *Lomandra confertifolia*, Tufted Bluebell *Wahlenbergia communis*. The Slender Onion Orchid *Microtis parviflora* occurs throughout.
	A natural spring-fed vegetation association occurs within this community, in a small area near the confluence of Murragamba and Wilpinjong Creeks. No trees or shrubs occur in this area. A number of native grass and herb species characteristic of water-logged soils occur in this area, including *Juncus planifolius*, *Myriophyllum gracile* var *lineare*, *Utricularua dichotoma*, Narrow-leaved Goodenia *Goodenia macbarronii*, Rough Raspwort *Haloragis heterophylla* and *Schoenus moorei*. This vegetation is located elsewhere in the study area, but has highly restricted occurrence.
Condition:	The majority of this community has been previously cleared for agriculture. However, it is difficult to determine whether existing occurrences of this community are natural communities or the regenerating vegetation that is a consequence of widespread clearing. Weeds are generally low in abundance and are restricted to species capable of occupying sandy soils. Sifton Bush *Cassinia arcuata* occasionally forms a dominant shrub species in areas where the disturbance history is more pronounced. Generally no logging of this vegetation has occurred, as this vegetation is generally unsuitable for firewood or structural purposes.
Fauna Features:	The deep sands provide excellent burrowing habitat for frogs and reptiles, with many species observed as a consequence. Tree hollows are rare but occur in the largest of Scribbly Gum *Eucalyptus rossii*. Banksia *Banksia marginata* provides a unique source of nectar within the study area, as this species is does not occur anywhere else.

Significance:	No threatened plant species as listed on the TSC Act and EPBC Act have been observed within this vegetation community.
	Six threatened fauna species have been recorded within this community, including the Glossy Black Cockatoo, Speckled Warbler, Brown Treecreeper, Large Bent-wing Bat, Squirrel Glider and Diamond Firetail.
	Critical fauna habitat features or resources within this community include deep sands for burrowing and scattered tree hollows. No listed critical habitat under the TSC Act or EPBC Act occurs within this community.

7.8. Biodiversity Hotspots of the Study Area

Areas of important biodiversity values contained within the study area have been spatially classified as 'Biodiversity Hotspots'. These hotspots are shown in **Figure 21** and are defined by factors detailed in Table 27.

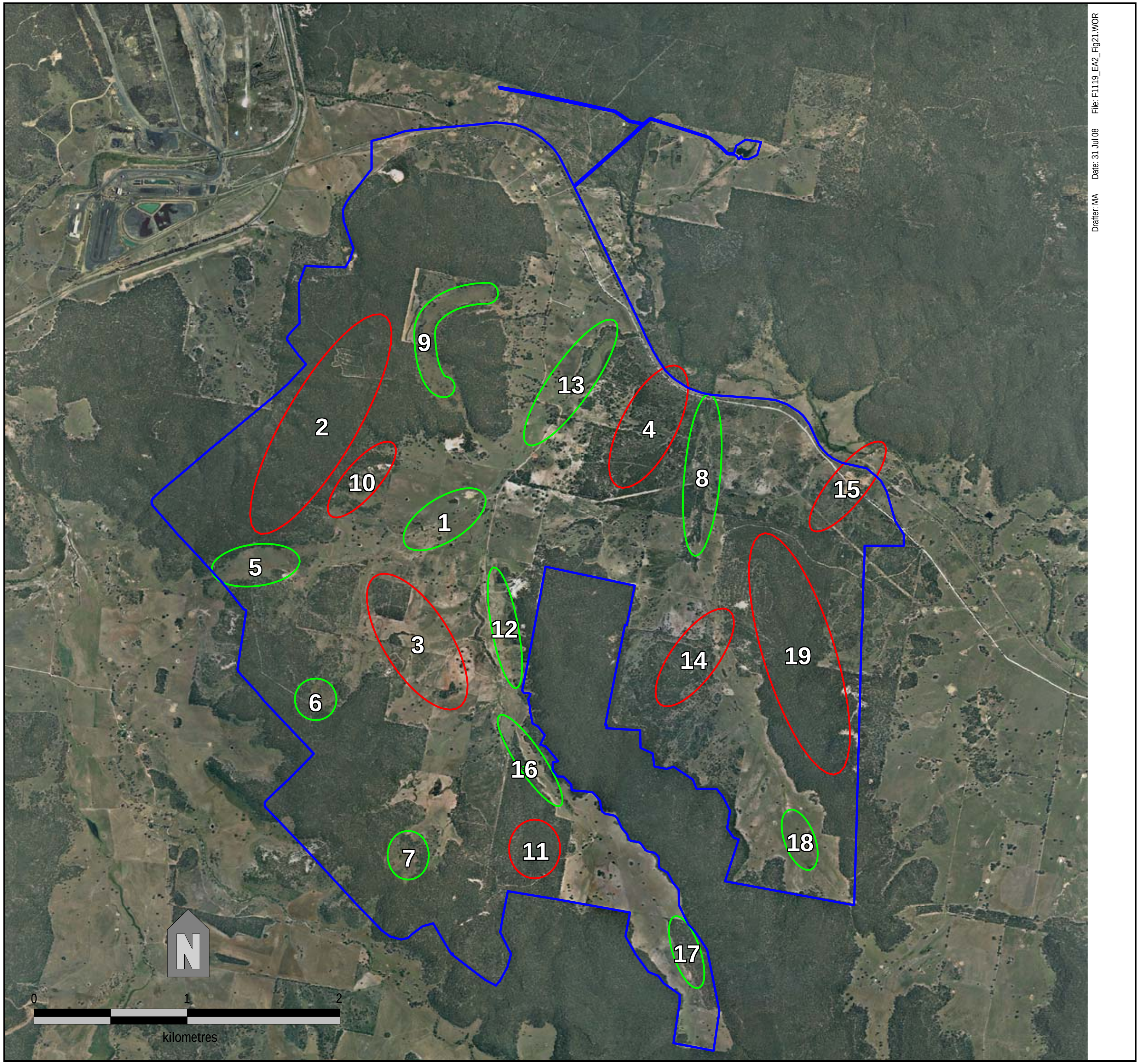
Table 27: Biodiversity Hotspots of the Study Area

Biodiversity Hotspot	Source or Sink	Prevailing Environmental Gradients	Known and Probable Ecological Values of Importance
1	source	springs; fertility	Hooded Robin; Diamond Firetail; WBYBBRW EEC; GDEs; water
2	sink	infertility	Glossy Black-cockatoo; Gang Gang Cockatoo; Large-eared Pied Bat; connectivity
3	sink	infertility	Diamond Firetail; Speckled Warbler; Grey-crowned babbler; microchiropteran bats
4	sink	infertility	Diamond Firetail; Speckled Warbler; microchiropteran bats; GDEs; connectivity
5	source	fertility	Hooded Robin; Diamond Firetail; Speckled Warbler; WBYBBRW EEC/ CEEC
6	source	fertility	Speckled Warbler; WBYBBRW EEC/ CEEC
7	source	springs; fertility	Speckled Warbler; WBYBBRW EEC/ CEEC
8	source	springs; fertility	Hooded Robin; Diamond Firetail; WBYBBRW EEC/ CEEC; GDEs; water
9	source	fertility	Diamond Firetail; Speckled Warbler; Black-chinned Honeyeater; WBYBBRW EEC/ CEEC
10	sink	infertility	*Pomaderris queenslandica*; Speckled Warbler; woodland bird habitat
11	sink	infertility	Speckled Warbler; Painted Honeyeater; Large-eared Pied Bat; Brown Treecreeper; woodland bird habitat; connectivity
12	source	fertility	Hooded Robin; Diamond Firetail; Speckled Warbler; microchiropteran bats; WBYBBRW EEC/ CEEC
13	source	riparian; fertility	Hooded Robin; Diamond Firetail; Speckled Warbler; Brown Treecreeper; microchiropteran bats; WBYBBRW EEC/ CEEC; GDEs; water
14	sink	infertility	Speckled Warbler; microchiropteran bats; connectivity
15	sink	infertility	Speckled Warbler; woodland bird habitat; connectivity
16	source	riparian; fertility	Diamond Firetail; Speckled Warbler; microchiropteran bats; WBYBBRW EEC/ CEEC; GDEs; water
17	source	riparian; fertility	Diamond Firetail; Speckled Warbler; microchiropteran bats; WBYBBRW EEC/ CEEC
18	source	springs	Diamond Firetail; GDEs; Water
19	sink	infertility	Glossy Black-cockatoo; Large-eared Pied Bat; connectivity

'Source' areas represent productive landscapes (e.g. grassy woodlands) where resources are comparatively more available. Conversely, 'sink' areas represent less productive areas where biomass is relatively inaccessible, limited and/or imported, with biomass often stored (i.e. woody shrubby plants in forests) and/or consumed.

The Speckled Warbler and Brown Treecreeper appear capable of occupying both source and sink areas, with the former often seeking increased shrub cover for protection against predation and the latter seeking landscapes that continue to contain trees with hollows (i.e. source landscapes are generally cleared and/or have been cleared and no longer have these resources).

Diamond Firetails, primarily being gramnivores, rely on source localities with its high mobility permitting local movement between source localities. The Hooded Robin on the other hand is a home range restricted species with viable occurrence seemingly dependant on the concentration of critical lifecycle resources such as those contained in productive Western Slopes Grassy Woodlands. This not a feature of the shrubbier dry understorey of the Western Slopes Dry Sclerophyll Forests where the resource base is comparatively more widespread thus less concentrated.



Legend

- Sink Hotspot (net resource consumption)
- Source Hotspot (net resource production)
- Study Area

FIGURE 21

Biodiversity Hotspots of the Study Area

Source

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8. IMPACT EVALUATION

Stage 2 of the MCP is described briefly in **Section 3** of this report, with a full description of activities, timing and duration provided in the main Environmental Assessment report. Impacts are as follows:

- Construction and operation of the infrastructure area south of Ulan-Wollar Road east of the Council waste transfer station and gravel pit;
- O/C 4, east of the proposed main infrastructure area and south of the Ulan-Wollar Road; and
- Undergrounds No. 1 and 2, in the western study area south of the Ulan-Wollar Road and infrastructure area, between the O/C 4 to the east and O/Cs 1, 2 and 3 (i.e. approved Stage 1 of the MCP).

8.1. Development Impacts

The proposed development will permanently modify much of the study area and in so doing result in the loss/ modification of native vegetation cover, aquatic ecosystems and associated fauna. Key issues arising from the development of lands covered by native vegetation include:

- Impacts on threatened biodiversity;
- Impacts on basal ecological function that supports threatened biodiversity lifecycles;
- Reduction of wildlife connectivity;
- Impacts on watercourses plus combined surface and groundwater supply to those watercourses; and
- Interactions with groundwater dependant ecosystems.

Impacts on threatened terrestrial biodiversity are most likely to occur during the construction phase of the development (i.e. direct impact from clearing activities) with mining operations resulting in lasting direct and indirect impacts. More specifically, issues of concern include the loss of:

- Threatened plant/ fauna populations and their habitats;
- Breeding/ core fauna habitat (e.g. trees with hollows);
- White Box Yellow Box Blakely's Redgum Woodland and derived Grasslands EEC/ CEEC;
- Wildlife connectivity; and
- Aquatic habitats/ Riparian Funciton plus associated surface and groundwater water supply.

8.2. Impact Quantification

Impacts have been quantified at the regional and local level. For terrestrial landscapes regional impact quantification has been calculated by comparing the loss of vegetation cover per geological formation and Mitchell Landscapes, thus representing a generalised understanding of cumulative impacts. Vegetation formations, as defined by this study, represent the basis for calculating local impacts.

8.2.1. Water Quantity and Quality

The main consideration with regard to possible cumulative impacts from combined coal mining in the district relates to the total amount and way water is used. Whilst the intent is to operate the MCP as a 'no discharge mine', practicably, there will be times when there are water surpluses. When this occurs, the mine will only discharge water, which meets the ANZECC (2000) criteria for the protection of aquatic ecosystems. Given the overall low volume of water available for aquatic ecosystems in the upper Goulburn River catchment this discharge is considered, on balance, a beneficial impact.

8.2.2. Local Impacts

Mine Construction

General construction orientated impacts are also expected. The initial open-cut mine works include building of access and haul road, clearing of vegetation, stripping and stockpiling of topsoils, dewatering of dams plus creation of diversion channels to collect and divert runoff around the proposed open cut footprint. Initial underground mining construction works will include the construction of access tracks over the proposed mine footprint for the installation of various monitoring equipment.

Works undertaken within drainage lines have the potential for accidental mobilisation of soils during flash floods and works within the three defined creek lines can also impact directly on ponded waters. Dewatering of dams could impact fish and other aquatic biota (such as turtles) which may reside in the dams. Diminished water quality could also affect the palatability of waters for various terrestrial species reliant on this resource, thus potentially deterring the occupation of areas excluded from mining.

Vegetation Impacts

Approximately 1,756 ha of intact native vegetation will be impacted direct or indirectly by stage 2 of the MCP, including 851 ha of direct permanent vegetation loss (i.e. open cut mining and infrastructure) and 905 ha of indirect vegetation impacts (i.e. underground operations). Table 28 identifies the extent of impacts for each impact area by vegetation formation.

Table 28: Impacts on Intact and Other Vegetation Cover by Impact Area

Impact Area	Vegetation Formation	Area (ha) Intact Vegetation	Area (ha) Other Landcover
Infrastructure Area (Direct Impact)	Broad-leaved Ironbark Grey Gum Forest	3.48	
	Footslope Box - Gum - Ironbark Forest	11.24	
	Grey Box - Narrow-leaved Ironbark Forest	1.48	
	Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	0.12	
	Rough-barked Apple - Banksia Woodland	0.02	
	Scribbly Gum Narrow-leaved Ironbark Woodland	15.52	
	*Blakely's Redgum - Yellow Box - Apple Woodland	1.32	
	*Blakely’s Redgum – Rough-barked Apple Woodland	16.45	
	*Lowland Box - Redgum Woodland	0.95	
	Secondary Grasslands and Shrublands		47.81
	Disturbed/ No Natural Vegetation		6.69
Open Cut 4 (Direct Impact)	Broad-leaved Ironbark Grey Gum Forest	11.76	
	Cyperoid Herbland	0.57	
	Footslope Box - Gum - Ironbark Forest	94.84	
	Hardcap Scribbly Gum - Ironbark Woodland	67.44	
	Grey Box - Narrow-leaved Ironbark Forest	82.89	
	Lowland Ironbark Forest	63.69	
	Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	1.62	
	Rough-barked Apple - Banksia Woodland	264.42	
	*Blakely's Redgum - Rough-barked Apple Woodland	33.95	
	*Blakely's Redgum - Yellow Box - Apple Woodland	26.99	
	*Lowland Box - Redgum Woodland	58.83	
	Crop/ Plantation		50.40
	Secondary Grasslands and Shrublands		502.59
	Disturbed/ No Natural Vegetation		13.52
Out of Pit Dumps (Direct Impact)	Footslope Ironbark - Gum - Box Forest	19.16	
	Blakely's Redgum - Rough-barked Apple Woodland	2.81	
	Broad-leaved Ironbark Grey Gum Forest	46.57	
	Lowland Ironbark Forest	9.59	
	Grassy White Box Woodland	2.95	
	Blakely's Redgum - Yellow Box - Apple Woodland	12.51	

Impact Area	Vegetation Formation	Area (ha) Intact Vegetation	Other Landcover
	Secondary Grasslands and Shrublands		34.39
	Chronically Disturbed/ No Natural Vegetation		0.07
Underground No. 1	Broad-leaved Ironbark Grey Gum Forest	270.5	
(Indirect Impact)	Footslope Ironbark - Gum - Box Forest	58.71	
	Lowland Ironbark Forest	11.95	
	Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	208.57	
	Scribbly Gum Narrow-leaved Ironbark Woodland	6.64	
	Shrubby White Box Forest	14.13	
	*Blakely's Redgum - Rough-barked Apple Woodland	2.18	
	*Blakely's Redgum - Yellow Box - Apple Woodland	6.60	
	*Grassy White Box Woodland	53.55	
	Crop/ Plantation		0.6
	Secondary Grasslands and Shrublands		48.41
	Disturbed/ No Natural Vegetation		2.36
Underground No. 2	Broad-leaved Ironbark Grey Gum Forest	183.25	
(Indirect Impact)	Footslope Ironbark - Gum - Box Forest	11.48	
	Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	40.22	
	Shrubby White Box Forest	11.05	
	*Grassy White Box Woodland	25.60	
	Secondary Grasslands and Shrublands		5.57
Total		1,755.60	712.41

Lands within the control of MCMs, which are not impacted by Stage 2 of the MCP and are outside the mine lease declared for Stage 1, include 460 ha of intact native vegetation and 175 ha of available secondary grasslands and shrublands/ croplands as shown in Table 29.

Table 29: Lands controlled by MCMs that are not impacted by Proposed Stage 2 of the MCP

Vegetation Formation	Area (ha) Intact Vegetation	Other Landcover Types
*Blakely's Redgum - Rough-barked Apple Woodland	135.91	
*Blakely's Redgum - Yellow Box - Apple Woodland	3.67	
Broad-leaved Ironbark Grey Gum Forest	42.25	
Cyperoid Herbland	0.35	
Footslope Ironbark - Gum - Box Forest	121.76	
*Grassy White Box Woodland	9.88	
Grey Box - Narrow-leaved Ironbark Forest	10.82	
Hardcap Scribbly Gum - Ironbark Woodland	4.55	
*Lowland Box - Redgum Woodland	12.03	
Lowland Ironbark Forest	6.81	
Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	30.84	
Rough-barked Apple - Banksia Woodland	17.48	
Scribbly Gum Narrow-leaved Ironbark Woodland	63.8	
Secondary Grasslands and Shrublands		317.65
MINUS Stage 1 commitments (see note)		-143.00
Total	460.15	174.65

Note: As part of the consent for Stage 1, there is a condition (i.e. condition 42(D) schedule 3 of the project approval) that requires at least 143 ha of revegetation works in the vicinity of the Redhills property.

Main Infrastructure Area

Impacts on native vegetation would essentially be limited to the clearing of small currently isolated and/or disturbed vegetation classified as mostly belonging to the Western Slopes Dry Sclerophyll Forest vegetation class. The surface infrastructure would result in the displacement of native vegetation, fauna habitats and some (mostly dry) aquatic environs. Losses, in terms of native and disturbed vegetation types, are presented in the following table.

Table 30: Impacts on Intact Vegetation Cover and other Landcover Types – Infrastructure Area

Vegetation Formation	Structure	Area ha	Area ha
*Blakely's Redgum - Rough-barked Apple Woodland	Open Forest	0.4	
	Woodland	12.01	
	Open Woodland	1.06	
	Shrubland	0.54	
	Grassland	2.44	
*Blakely's Redgum - Yellow Box - Apple Woodland	Open Forest	0.37	
	Woodland	0.95	
Broad-leaved Ironbark Grey Gum Forest	Open Forest	2.09	
	Woodland	1.39	
Footslope Ironbark - Gum - Box Forest	Open Forest	6.29	
	Woodland	1.5	
	Open Woodland	1.11	
	Shrubland	2.34	
Grey Box - Narrow-leaved Ironbark Forest	Woodland	1.48	
*Lowland Box - Redgum Woodland	Woodland	0.95	
Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	Open Forest	0.12	
Rough-barked Apple - Banksia Woodland	Grassland	0.02	
Scribbly Gum Narrow-leaved Ironbark Woodland	Open Forest	0.37	
	Woodland	3.15	
	Shrubland	12	
Secondary Grasslands and Shrublands	Grassland		47.81
Chronically Disturbed/ No Natural Vegetation	n/a		6.69
Total		50.58	54.50

* Note: Denotes EEC/ CEEC

None of the local conservation reserves adjoin the infrastructure impact area. There would be no significant loss of ponded aquatic habitat and no significant loss of boggy/seepage GDEs.

Possible impacts on biodiversity partly or wholly reliant on aquatic ecosystems arise from:

(i) Proposed modifications within the Bora Creek sub-catchment Infrastructure area; and

(ii) Proposed modifications to the Splitters Hollow Dam plus the installation of a pipeline between the Bora Creek sub-catchment and the upper Wilpinjong Creek sub-catchment.

Whilst the proposed works would utilise existing roads and fire track where possible there may still be possible direct and indirect impacts arising from these activities including construction impacts associated with access road works and pipe-line creek and drainage crossings and indirect impacts due to possible runoff from disturbed soils. Splitters Hollow dam will remain in its current condition to be used for stock or environmental purposes for example water storage bush fire fighting.

Open Cut 4

Aside from the vegetation and habitat impacts discussed in Table 28 the first direct impact on aquatic ecosystems arising from the proposed O/C 4 mining is the loss of large sections of Murragamba and Eastern Creeks. There will also be the loss of numerous ephemeral drainage lines channelling water from the adjacent ridge tops, the loss of drainage swale and creek in-line dams, plus the loss of spring-fed dams. This will result in the total loss of intact aquatic habitat within the footprint of this open cut operation.

The second direct impact is the interruption and eventual loss of the various shallow perched groundwater systems currently providing water to many of the spring fed dams and bogs plus to remnant sections of woodland in and possibly down-slope of the open cut footprint. There would also be a loss of the hard rock aquifers within the footprint and the consequent loss of groundwater connectivity down dip of the open cut footprint. This will likely impact on the water balance of aquatic habitats plus possible local GDEs down dip and there could also be alterations to water quality (both negative and positive) arising from changes in water availability and changes in remaining groundwater quality. Clean water diversions will direct the drainage of non-mine water the disturbed mine areas.

Impacts on native vegetation would involve clearing of relatively intact native vegetation in the southern and central northern parts of the proposed OC4 area and clearing of a mosaic of disturbed vegetation formations throughout the remainder of the open cut area. This will result in the displacement of native vegetation, fauna habitats and low to high order aquatic environs. Losses, in terms of native and disturbed vegetation types, are quantified in Table 31.

Table 31: Impacts on Intact Vegetation Cover and other Landcover Types - O/C 4

Vegetation Formation	Structure	Area Intact (ha)	Area Other (ha)
*Blakely's Redgum - Rough-barked Apple Woodland	Open Forest	19.44	
	Woodland	10.17	
	Open Woodland	4.34	
*Blakely's Redgum - Yellow Box - Apple Woodland	Open Forest	8.06	
	Woodland	9.04	
	Open Woodland	3.6	
	Shrubland	4.58	
	Grassland	1.71	
Broad-leaved Ironbark Grey Gum Forest	Open Forest	11.76	
Cyperoid Herbland	Grassland	0.57	
Footslope Ironbark - Gum - Box Forest	Open Forest	35.14	
	Woodland	25.33	
	Open Woodland	11.53	
	Shrubland	22.84	
Grey Box - Narrow-leaved Ironbark Forest	Open Forest	35.79	
	Woodland	6.93	
	Open Woodland	37.84	
	Grassland	2.33	
Hardcap Scribbly Gum - Ironbark Woodland	Open Forest	37.4	
	Woodland	5.68	
	Open Woodland	7.48	
	Shrubland	16.88	
*Lowland Box - Redgum Woodland	Open Forest	9.47	
	Woodland	38.2	

Vegetation Formation	Structure	Area Intact (ha)	Area Other (ha)
	Open Woodland	8	
	Shrubland	3.16	
Lowland Ironbark Forest	Open Forest	36.61	
	Woodland	10.66	
	Shrubland	16.42	
Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	Open Forest	1.62	
Rough-barked Apple - Banksia Woodland	Open Forest	1.64	
	Woodland	87.3	
	Open Woodland	64.35	
	Shrubland	4.75	
	Grassland	106.38	
Secondary Grasslands and Shrublands	Open Woodland		11.42
	Shrubland		54.72
	Grassland		436.45
Chronically Disturbed/ No Natural Vegetation	Open Woodland		1.2
	Grassland		12.21
	n/a		0.11
Crop/ Plantation	Grassland		50.4
Total		707	566.51

* Note: Denotes EEC/ CEEC

Overburden Emplacements

During the initiation of open cut mining overburden material would be placed in permanent out of pit emplacement areas. Initial overburden emplacement will take place at an Out of Pit Dump located south-east of U/G 2. The out of pit dump emplacements would also extend a little to the north-west over longwalls 10, 11 and 12A. Placement of this material would cover some 2 km of native vegetation containing ephemeral ridge top drainage lines. These drainage lines are generally contained within Broad-leaved Ironbark – Grey Gum Forest vegetation and have no aquatic structure and consequently no aquatic values other than their contributions of down slope surface flows and infiltration flows to shallow subsoil aquifers and to deeper rock aquifers. Aside from the possible water quality problems associated with initial overburden stabilisation and rehabilitation, the nature of the overburden material is likely to be such that there will be increased surface flow discharges off the overburden area plus decreased infiltration potential from the overburden material to the rock aquifers below. The impacts on intact native vegetation cover and other landcover types are as follows in Table 32.

Table 32: Impacts on Intact Vegetation Cover and other Landcover Types – Out of Pit Overburden Emplacements

Vegetation Formation	Structure	Area Intact (ha)	Area Other (ha)
*Blakely's Redgum - Rough-barked Apple Woodland	Open Forest	2.81	
*Blakely's Redgum - Yellow Box - Apple Woodland	Open Forest	7.31	
	Open Woodland	5.2	
Broad-leaved Ironbark Grey Gum Forest	Open Forest	46.57	
Footslope Ironbark - Gum - Box Forest	Open Forest	18.25	
	Shrubland	0.91	
*Grassy White Box Woodland	Woodland	2.55	
	Open Woodland	0.4	

Vegetation Formation	Structure	Area Intact (ha)	Area Other (ha)
Lowland Ironbark Forest	Open Forest	9.59	
Secondary Grasslands and Shrublands	Shrubland	.	1.1
	Grassland	.	33.29
Chronically Disturbed/ No Natural Vegetation	Grassland		0.07
Total		93.59	34.39

* Note: Denotes EEC/ CEEC

Significant ecological values likely/potentially affected include:

- EEC - White Box Yellow Box Blakely's Red Gum Woodland EEC/ CEEC;
- Threatened plant – *Pomaderris queenslandica*;
- Threatened and declining woodland birds;
- Breeding habitat for the threatened Painted Honeyeater;
- Core habitat for threatened microchiropteran bats;
- Potential foraging habitat for the threatened Regent Honeyeater; and
- Munghorn Gap Nature Reserve adjoins the open cut on the southern boundary.

Development and operation of O/C 4 will necessitate the progressive removal over the life of the mine of around 7.5 km of Murragamba Creek, 4.2 km of Eastern Creek (Worley Parsons 2008) plus the complete removal of associated feeder drainages plus all springs and dams on the western slopes up to the wooded ridge lines in both sub-catchments. Mining to the east of the Eastern Creek sub-catchment would remove several minor ridge drainages flowing directly to Wilpinjong Creek or to Planters Creek.

A 1.3 km section of Murragamba Creek in the middle reaches of the creek will not be mined but open cut mining will take place nearby the western edge of the creek. The lowest 800 m section of Murragamba Creek to the confluence with Wilpinjong Creek would not be mined. Similarly, in Eastern Creek 1 km of the upper (non-ridge) creek would not be mined and the lowest 300 m section (above the confluence with Wilpinjong Creek) would not be mined.

Underground Mining

Two underground mines are proposed (U/G 1 and U/G 2). They are both located south of the Ulan - Wollar Road between O/C 4 (this proposal) and O/Cs 1, 2 and 3 (i.e. approved Stage 1 of the MCP). Impacts associated with both these operations are direct and indirect; being the occurrence of surface cracking and subsidence respectively.

The design of the underground mine incorporates adequate setbacks to ensure no impacts on Goulburn River National Park or Munghorn Gap Nature Reserve. The entrance to both undergrounds will be located on currently cleared land contained within the approved Open Cut No. 1. Almost no native vegetation would be cleared or removed for the operation of both these underground mines. There would be a need to maintain existing tracks and potentially construct additional access pathways for the purposes of subsidence monitoring and implementation of various works such as erosion control.

Subsidence impacts have been assessed for this project (MSEC 2008) and the following subsidence related issues are relevant to flora and fauna assessment. Subsidence impacts are to be expected to affect the cliff-lines, with the resultant change being isolated rock falls from overhangs and increased cracking. No closures in existing cliff face cracks are expected during the operation, rather the cracking is expected to enlarge momentarily during the movement of mining under the cliff areas.

The ephemeral surface drainage of the Underground No 1 and 2 areas predominantly flow from west to east into Murragamba Creek. These minor drainages and creek systems have little or no capacity to intercept and store flood waters for any length of time and consequently, other than constructed dams or disused quarry pits intercepting both surface and spring water flows, there is little or no permanent aquatic habitat, no fish passage requirements and no significant aquatic GDEs. Subsidence impacts could introduce some ponding in undermined sections of these drainages. Given the present low capacity for permanent or semi-permanent aquatic habitat formation in these drainages additional ponding is on balance considered a beneficial impact.

Subsidence could also result in surface cracking leading to interception of surface water runoff to sub-surface geological structures. Depending on the depth of cover above the underground mine there may also be sufficient cracking of any aquacludes above the mine to allow intercepted surface waters plus groundwater to drain to the mine. This may lead to a loss of surface water runoff from the ridges towards the creeks (MSEC, 2008). Alternatively, where the cracking does not lead to drainage to the mine, the intercepted surface water could mix with groundwaters in higher geological strata and resurface elsewhere down slope, possibly with altered water quality. Subsidence impacts arising from proposed U/G 1 is quantified in Table 33.

Table 33: Impacts on Intact Vegetation Cover and other Landcover Types - Underground No. 1

Vegetation Formation	Structure	Area Intact (ha)	Area Other (ha)
*Blakely's Redgum - Rough-barked Apple Woodland	Open Forest	1.65	
	Woodland	0.53	
*Blakely's Redgum - Yellow Box - Apple Woodland	Open Forest	3.79	
	Woodland	2.81	
Broad-leaved Ironbark Grey Gum Forest	Open Forest	256.52	
	Woodland	6.43	
	Open Woodland	1.37	
	Shrubland	6.18	
Footslope Ironbark - Gum - Box Forest	Open Forest	33.31	
	Woodland	0.48	
	Open Woodland	22.87	
	Shrubland	2.05	
*Grassy White Box Woodland	Open Forest	0.41	
	Woodland	2.02	
	Open Woodland	16.29	
	Shrubland	15.73	
	Grassland	19.1	
Lowland Ironbark Forest	Shrubland	11.95	
Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	Open Forest	154.08	
	Woodland	33.65	
	Open Woodland	11.2	
	Shrubland	3.47	
	Grassland	6.17	
Scribbly Gum Narrow-leaved Ironbark Woodland	Open Woodland	6.64	
Shrubby White Box Forest	Open Forest	6.75	
	Woodland	7.38	
Secondary Grasslands and Shrublands	Grassland		48.41
Chronically Disturbed/ No Natural Vegetation	Grassland		2.36
Crop/ Plantation	Grassland		0.6
Total		632.83	51.37

* Note: Denotes EEC/ CEEC

Subsidence impacts arising from proposed U/G 2 is quantified in Table 34.

Table 34: Impacts on Intact Vegetation Cover and other Landcover Types - Underground No. 2

Vegetation Formation	Structure	Area Intact (ha)	Area Other (ha)
Broad-leaved Ironbark Grey Gum Forest	Open Forest	183.25	
Footslope Ironbark - Gum - Box Forest	Open Forest	3.43	
	Open Woodland	4.86	
	Shrubland	3.19	
*Grassy White Box Woodland	Woodland	7.14	
	Open Woodland	8.05	
	Grassland	10.41	
Ridgetop Broad-leaved Ironbark - Black Cypress Pine on shallow sands	Open Forest	40.22	
Shrubby White Box Forest	Open Forest	5.58	
	Open Woodland	5.47	
Secondary Grasslands and Shrublands	Open Woodland	.	0.07
	Shrubland	.	1.24
	Grassland	.	4.26
Total		271.6	5.57

* Note: Denotes EEC/ CEEC

Impacts on Springs and Seeps

As noted above, all springs and seeps located in the open cut areas draining to Murragamba and Eastern Creeks from their respective western slopes would be lost over the life of the mine. Loss of drainage lines plus creek lines to open cut mining will result in the loss of riparian and drainage swale vegetation dependent on shallow retained waters in drainage sediment deposits. Loss of spring fed dams will result in the loss of aquatic ecosystems dependent on the retained springwaters.

8.3. Overburden Placement in Void and Rehabilitation

The open cut void will be progressively filled with overburden with retained topsoil placed over the overburden followed by rehabilitation to stabilise the soil profile. Prior to rehabilitation activities the overburden profile would be contoured to provide suitable drainage swales to interlink the temporary diverted or impounded surface runoff from areas upstream of the void to the new creek diversions. This work may include energy dissipater structures and chain-of-pond in-line dams, designed to minimise possible erosion impacts of surface water runoff from the rehabilitating overburden. However, this rehabilitation activity does not restore shallow perched groundwater and sub-surface water flows.

Open-cut mining would also sever the links between the various hard rock aquifers and the nature of the overburden is such that there is no possibility of the restoration of the individual hard-rock aquifer flows (or connectivity from the up dip aquifers). In effect the final void will start to fill (saturate) from the bottom of the void up as both infiltrating rainwater plus up dip aquifer waters flow into and mix through the overburden. Over time there is likely to be an equilibrium established between the effective level of the saturated overburden materials within the void and the downslope aquifers as the contained void overburden conglomerate aquifer feeds into the various down dip aquifers (Aquaterra 2008). Whether the balance could result in the void aquifer being sufficiently high (i.e. shallow) or with sufficient surface complexity to provide seepage flows back into any of the surface drainages (including the engineered creek diversions discussed above), is not known. The mixing of severed aquifer water plus locally derived infiltration water within the overburden conglomerate could also lead to the leaching of various materials from the conglomerate with resultant changes to aquifer water quality down-dip.

In summary, whilst surface drainage lines, new (diversion) creek lines plus in-line dams, ponds and riffle structures can be constructed to manage surface water runoff from the site in a manner which minimises the potential for erosion, and maximises both agricultural and aquatic ecological benefits, there is likely to be a long-term impact on the availability and quality of groundwater within the study area and possibly down dip from the study area. Terrestrial rehabilitated landscapes within the rehabilitation area may not gain access to shallow sub-surface perched groundwater resources, as currently is the case, and as a consequence the redevelopment of biodiversity hotspots over time is likely to be more ‘sink’ orientated (see Section 7.8 for more detailed explanations of sources and sinks) as the drivers of productive landscapes (i.e. surface/ groundwater resources and basalt) are likely to be largely disconnected in the rehabilitated landscape.

8.4. Impacts on the Conservation Reserve Network

8.4.1. Goulburn River National Park

The Goulburn River National Park borders the northern boundary of the study area where there are no mining activities proposed near this reserve.

O/C 4 is located in the vicinity of Goulburn River National Park, but is separated from the mine by Wilpinjong Creek and its associated riparian vegetation, at an average distance of at least 1km (generally greater than 1.5 km). There is also substantial native vegetation occurring between the two areas.

The Triassic sandstones overlaying U/G’s 1 and 2 are not hydraulically connected with Goulburn River National Park, thus unlikely to have any impacts on this reserve. Consequently the only expected impacts are short term impacts limited to matters such as noise, light and dust when the open-cut mining progresses closest to the northern boundary (approximately 2 years – maximum production).The MCP would not directly contribute to any other existing impacts on the Goulburn River National Park such as inappropriate fire regimes, road kill, and introduction of weeds, pathogens or feral animals. To the contrary, proposed management plans will seek to reduce the extent of local existing impacts on this conservation reserve.

There would be no impediment to existing access pathways to Goulburn River National Park during the mine operation. However, temporary delays in gaining access to the Goulburn River National Park may be experienced from the Ulan to Wollar Road during blasting operations associated with OC4. Notification of these delays will be posted on the roadside.

8.4.2. Munghorn Gap Nature Reserve

Munghorn Gap Nature Reserve borders the southern boundary of the study area. Open cut mining operations will occur downslope and adjacent to the Munghorn Gap Nature Reserve. Setbacks from the Munghorn Nature Reserve will range from 20m to 350m with the average being between 200 to 250 m. Underground mining is located sufficiently distant from the Munghorn Gap Nature Reserve where adequate setbacks are provided to ensure no direct subsidence impacts.

The MCP will not directly contribute to any other existing impacts on the Munghorn Gap Nature Reserve such as inappropriate fire regimes, road kill, and introduction of weeds, pathogens or feral animals. To the contrary, proposed management plans would reduce the extent of local existing impacts on this conservation reserve, particularly the localised control of feral animals such as wild goats.

8.5. Summary

8.5.1. Vegetation Losses

The area loss of intact native vegetation is summarised as follows in terms of BioMetric equivalents (see **Section 7.1.4**) and WBYBBRW EEC/ CEEC (see **Section 7.5**).

Table 35: Summary Impacts on Intact Native Vegetation - BioMetric Formations (where relevant)

Relevant BioMetric Formation	Direct	Indirect
*Blakely's Redgum - Rough-barked Apple flats Woodland of the NSW western slopes	53.21	2.21
*Blakely's Redgum - Yellow Box – Rough-barked Apple Grassy Woodland of the Capertee Valley, Sydney Basin	100.60	6.61
Grey Gum – Narrow-leaved Stringybark – Ironbark woodland on ridges of the Upper Hunter Valley, Sydeny Basin	63.55	704.18
Blue-leaved ironbark heathy woodland of the southern part of the Brigalow Belt South Bioregion	73.28	11.95

Relevant BioMetric Formation	Direct	Indirect
Slaty Box – Grey Gum shrubby woodland on footslopes of the upper Hunter Valley, Sydney Basin	125.24	69.37
*White Box – Yellow Box Grassy Woodland on basalt slopes in the upper Hunter Valley, Brigalow Belt South Bioregion	2.95	79.36
White Box Shrubby Open Forest on fine grained sediments on steep slopes in the Mudgee region (Benson 273)	0	25.8
Grey Box - Narrow-leaved Ironbark Shrubby woodland of the Hunter Valley, North Coast and Sydney Basin Bioregion	84.37	0
Scribbly Gum – Brown Bloodwood woodland of the southern Brigalow Belt South Bioregion	82.96	6.64
Unclassified Native Vegetation (Rough-barked Apple - Banksia Woodland)	265.01	0
Total	851.17	904.43

* Note: Denotes EEC/ CEEC

Table 36: Summary Impacts on Intact Native Vegetation - WBYBBRW EEC/ CEEC

Vegetation Formation	Direct (ha)	Indirect (ha)
*Blakely's Redgum - Rough-barked Apple Woodland	53.21	2.21
*Blakely's Redgum - Yellow Box - Apple Woodland	40.82	6.61
*Grassy White Box Woodland	2.95	79.36
*Lowland Box - Redgum Woodland	59.78	0
Total	156.7	88.18

8.5.2. Biodiversity Hotspots

The impacts of mining can be qualitatively accounted by predicting the temporal change in biodiversity hotspots (as defined in Section 7.8) in response to mining. Mining will exert direct permanent impacts from open cut operations plus partial losses and indirect impacts from subsidence through altered hydrological regimes. It is expected that these impacts applied as a landscape level would have long term implications without intervention with specific impact management strategies.

8.5.3. Indirect Longterm Impacts on Conservation Reserves

Notwithstanding the predicted low impact scenario on adjoining conservations reserves, as discussed in **Section 8.4**, there is however concern over the reliance of biodiversity contained within these conserves and the impacted landscape. In adopting a landscape approach to the impact analysis it is considered that the removal of productive landscapes from areas mined by OC4 is likely to have influence on the dynamics of adjoining infertile ‘sink’ landscapes such as those contained within the reserve network. This effect is likely to be most heightened during drought conditions where productive landscapes could act as an important refuge for many species.

The landscape assessment of the study area has found various ‘source’ and ‘sink’ nodes (i.e. biodiversity hotspots), which are likely to be inter-related with each other in terms of the life cycles of some biota (e.g. microchiropteran bats and species dependant on trees with hollows). The general theme implied is the importance of productive landscapes for foraging or dispersal mechanisms, such as those found in the valley floor, for species that may use less productive landscapes as breeding habitat (e.g. caves and tree hollows). This concept potentially applies to species such as the Brown Treecreeper and cave roosting microchiropteran bats (e.g. Eastern Bentwing Bat and Large-eared Pied Bat).

With this perspective, it is hypothesised that indirect impacts on the adjoining conservation reserve network would be experienced over time as local ‘source’ or productive landscapes have been removed from the locality (e.g. open cut mining and removal of ‘fertile’ soils and surface intercepted groundwater resources). Sink landscapes would need to adjust, with such adjustments potentially influencing species viability particularly during periods of environmental stress such as drought. The Brown Treecreeper, which has been identified by the NSW Scientific Committee (2001) as declining from Munghorn Gap Nature Reserve, is perhaps at risk of being adversely impacted by the loss of ecological function currently contained within the Murragamba Valley. Similar implications also apply to the Large-eared Pied Bat.

Response

In this sense an impact management response is required to minimise these predicted long term impacts. It is expected that conventionally rehabilitated landscapes on overburden would preferentially develop as ‘sink’ hotspots in the short to medium term (i.e. low probability of water availability and soil fertility), with the preferred development of ‘source’ hotspots likely to occur in the long term (i.e. recovery of groundwater resources is predicted to be 30 – 40 years post mining with associated basalt nutrient enrichment likely to take longer). The extent and the spatial arrangement and complexity of these long term ‘source’ habitats is not known and is likely to be random, thus presenting an additional uncertainty.

Intervention is required to deliver more productive landscapes supporting the development of 'source' hotspots post-mining (i.e. mimicking ecological function). Recommended is the introduction of specific rehabilitation methods into the conventional rehabilitation approach to increase the certainty of productive landscapes forming within the rehabilitated landscape in both a timely and spatially desirous manner. This would include, but not necessarily be restricted to, an interconnected stream reconstruction plan involving ‘chain of ponds’ and trial structures that locally retard the movement of groundwaters in an attempt to mimic existing perched groundwater resources (i.e. aquacade). Allied with this would be the revegetation of existing cleared lands, particularly those in strategic locations such as sites where surface intercepted groundwaters occur, to minimise short to medium term disruptions.

9. RELEVANT MATTERS OF ECOLOGICAL SIGNIFICANCE

9.1. Matters of State Significance

The following matters of ecological significance focus on threatened species, populations, communities and their habitats identified by the database searches, literature reviews and surveys of the study area. While all species identified in **Section 5** warrant discussion they may not necessarily be relevant to the assessment (i.e. no potential or known habitat impacted by the development).

For each species, population and ecological community identified in Section 5 the following is provided:

- Description of the habitat;
- Commentary regarding the importance of the study area and likelihood of an impact;
- The conservation status of the species, population or ecological community;
- The focus of recovery efforts; and
- Priority action statements relevant to the study area and surrounding district.

The following sections discuss the importance of the study area in terms of habitat availability and impact likelihood. The remaining information, which is taken from http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/index.aspx, is provided in **Appendix 7** and provides context for the development of targeted impact management strategies.

The purpose of the information described above is to support the identification of the subject species list, these being species, populations or ecological communities that are likely to be impacted by the proposed development. Threatened biodiversity identified as subject species will be further discussed in this report, with those not selected being excluded from further analysis.

9.1.1. Threatened Species – Flora

A total of 27 threatened flora species and 3 EPs have been identified through database searches, literature reviews and/or baseline surveys for EL6288/ study area. A brief discussion of these species is provided as following in terms of the study areas habitat values, thus permitting an analysis of impact likelihood arising from the MCP.

Threatened Flora Species

White-flower Wax Plant (*Cynanchum elegans*) (E)

Cynanchum elegans has not been recorded locally, with habitat values of the study area and EL6288 considered low to absent (e.g. absence of dry rainforest closed shrublands on basalt). Given the habitat preferences and distribution, it is considered that the study area falls outside the habitat criteria for this species. The likelihood for an impact on viable habitat of this species is considered low given the extensive coverage of targeted threatened species survey

Hoary Sunray (*Leucochrysum albicans var tricolor*) (E)

The Hoary Sunray has been recorded locally in grassy Grey Box dominated vegetation on the Ulan Quartz monzonites geological formation. This type of vegetation is restricted to the western margin of EL6288 on carboniferous granitoides, which do not occur within the study area. Given the habitat preferences and distribution, it is considered that the study area falls outside the habitat criteria for this species. Targeted searches failed to locate this species within the study area, with the likelihood for an impact on viable habitat of this species considered low, particularly given the extensive coverage of targeted threatened species survey and probable absence of known/ potential habitat.

Ozothamnus tesselatus (V)

Tallus slopes have limited occurrences in the study area, predominantly along the western face of the Murragamba valley. Targeted surveys along this landscape failed to detect this species, however the completeness of these surveys were influenced by the steep terrain. Potential habitat exists along this slope, an area that will be impacted by subsidence, with the implication being a moderate to high likelihood for an impact on this species and/or its habitat.

Ausfield's Wattle (*Acacia ausfeldii*) (V)

Ausfields Wattle has been recorded locally in grassy Grey Box – Yellow Box open woodland on the Ulan Quartz monzonites geological formation (igneous granitic geology). This type of vegetation is restricted to the western margin of EL6288 on carboniferous granitoides, which do not occur within the study area. Given the habitat preferences and distribution, it is considered that the study area falls outside the habitat criteria for this species, with targeted searches failing to locate this species within the study area. The likelihood for an impact on viable habitat of this species is considered low given the extensive coverage of targeted threatened species survey.

Acacia flocktoniae (V)

Acacia flocktoniae has not been recorded locally, with habitat values of the study area and EL6288 considered low to absent. Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Kennedia retrorsa (V)

Kennedia retrorsa has not been recorded locally, with habitat values of the study area and EL6288 considered low to absent. Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Swainsona recta (E)

Swainsona recta have not been recorded locally, with habitat values of the study area and EL6288 considered low to absent. Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Cannons Stringybark (*Eucalyptus cannonii*) (V)

Cannon's Stringybark (*E. cannonii*) despite being observed within EL6288 was not identified within the study area during targeted surveys. Potential habitat exists along the outcropping Triassic sandstones and in the valley floor on deeper elevated sand deposits. However, these habitat areas have experienced extensive land clearing, intense livestock grazing and soil alteration, thus potentially leading to local extinctions should it have once existed in this landscape. Habitat of the study area is considered patchy and in moderate condition where current grazing practices are absent. The likelihood for an impact on viable habitat of this species is considered low given the extensive coverage of targeted threatened species survey.

Eucalyptus scoparia (E)

Eucalyptus scoparia was identified within the study area from one specimen located central to the Murragamba Valley. This specimen was identified by the NSW Herbarium and was indicated to be a cultivated specimen as habitat for this species occurs north from Inverell on granites. Further surveys to substantiate this situation have not been undertaken, however, given the proximity of the old school, the current road and historical regional road linking the northern tablelands with Lithgow (i.e. through Carrs Gap) potentially support the herbariums assessment.

No habitats consistent with those prescribed for this species occur within the study area, with the study area considerably distant from known areas of habitat. In light of this and its position within the landscape (i.e .roadside) it is considered that the single specimen is planted and is thus not within a context supporting a viable population. No recruitment was observed at the base of this specimen further confirming this conclusion. The likelihood for an impact on viable habitat for this species is considered low.

Pokolbin Mallee (*Eucalyptus pumila)* (V)

The Pokolbin Mallee has not been recorded locally, with habitat values of the study area and EL6288 considered low to absent. Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Homoranthus darwinioides (V)

Homoranthus darwinioides has not been recorded locally, with habitat values of the study area and EL6288 considered moderate to low. Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Painted Diuris [*Diuris tricolor* (syn *D. sheiffiana*)] (V)

The Painted Diuris (*D. tricolor*) despite being observed within EL6288 was not identified within the study area during targeted orchid surveys. Potential habitat exist downslope from the outcropping Triassic sandstones and in the valley floor on deeper spring fed sands. However, these habitat areas have experienced intense livestock grazing and soil alteration, thus resulting in untenable habitat values. Habitat of the study area is considered patchy and in moderate condition where current grazing practices are absent. The likelihood for an impact on viable habitat of this species is considered moderate to low.

Snake Orchid (*Diuris pedunculata*) (V)

The Snake Orchid has not been recorded locally, with habitat values of the study area and EL6288 considered low to absent. Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Digitaria porrecta (V)

Digitaria porrecta has not been recorded locally, with habitat values considered absent from the study area and EL6288. Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Pomaderris sericea (E)

Targeted surveys failed to detect this species within the study area, with the likelihood for an impact on viable habitat of this species considered low given the extensive coverage of targeted threatened species survey and likely absence of known populations and/or potential habitat.

Pomaderris queenslandica (E)

The Scant Pomaderris (*Pomaderris queenslandica*) has been recorded once within the study area adjacent to proposed O/C 4 and U/G 1 south from a tertiary basalt flow and adjacent to the outcropping Triassic sandstone geological formation. A second specimen has been located within private property to the north in similar habitat, which can be locally described as footslope colluvials near drainage lines.

Extensive surveys of the study area have failed to identify any further populations, however, it is recognised that past habitat areas could have been disturbed/ destroyed by sheep grazing with a soil seed bank potentially remaining. Local populations are disjunct from other known populations and are considered important. The likelihood for an impact on viable habitat of this species and it habitat is considered high.

Denman Pomaderris (*Pomaderris reperta*) (E)

The Denman Pomaderris (*Pomaderris reperta*) is a highly restricted species found only near Denman in the Central Hunter. Its inclusion in this assessment is based on the similarities in habitat values expressed at the outcropping Triassic sandstones and that within known habitat. However, these habitat areas have experienced intense livestock grazing and soil alteration, thus leading to untenable habitat values.

Potential habitat of the study area is considered patchy and in low condition. The likelihood for an impact on viable habitat of this species is considered low given the failure of the extensive targeted surveys to detect this species within the study area and the disjunction between the study area and known habitat at Denman.

Prostanthera discolor (V)

Prostanthera discolor is a species with moderately restricted distribution east of the study area. Its inclusion in this assessment is based on perceived similarities between habitat observed at the outcropping Triassic sandstones and that prescribed by the literature. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Prostanthera cineolifera (V)

Prostanthera cineolifera is a species that “apparently grows in sclerophyll forest.” with “The distribution of this taxon is uncertain.” (http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&showsyn=&dist=&constat=&lvl=sp&name=Prostanthera~cineolifera). Its inclusion in this assessment is based on perceived potential for habitat throughout forests formed on Triassic sandstones as described by the literature. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Prostanthera cryptandroides (V)

Prostranthera cryptandroides is a species with widespread regional distribution, with the study area located at the western limits of this known distribution. Its inclusion in this assessment is based on perceived similarities between habitat observed at the outcropping Triassic sandstones and that prescribed by the literature. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Prostanthera stricta (V)

Prostranthera stricta is a species with highly restricted distribution east of the study area near Sandy Hollow. Its inclusion in this assessment is based on perceived similarities between habitat observed at the outcropping Triassic sandstones and that prescribed by the literature. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Philotheca ericifolia (V)

Philotheca ericifolia grows chiefly in dry sclerophyll forest and heath on damp sandy flats and gullies, in the upper Hunter Valley and Pilliga to Peak Hill district (http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&showsyn=&dist=&constat=&lvl=sp&name=Philotheca~ericifolia) . Its inclusion in this assessment is based on database records and perceived similarities between prescribed habitat values and those observed primarily throughout the Triassic sandstones and outcropping conglomerates. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Commersonia rosea (E)

Commersonia rosea is a species with highly restricted distribution east of the study area near Sandy Hollow where it grows in skeletal sandy soils in scrub or heath vegetation (http://plantnet.rbgsyd.nsw.gov.au/cgi-in/NSWfl.pl?page=nswfl&showsyn=&dist=&constat=&lvl=sp&name= Commersonia~rosea). Its inclusion in this assessment is based on perceived similarities between habitat as described by the literature and potential habitat observed throughout ridgetop Triassic sandstones and lowland conglomerate outcrops. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Lasiopetalum longistamineum (V)

Lasiopetalum longistamineum is a species with moderately restricted distribution east of the study area. Its inclusion in this assessment is based on perceived similarities between habitat observed at the outcropping Triassic sandstones and that prescribed by the literature. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Rulingia procumbens (V)

Rulingia procumbens is a species that grows on sandy sites mainly confined to the Dubbo-Mendooran-Gilgandra region, also in Pilliga and Nymagee areas (http://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&showsyn=&dist=&constat=&lvl=sp&name=Rulingia~procumbens). Its inclusion in this assessment is based on database records and perceived similarities between literature described habitat values and those observed throughout the "Murragamba Sands Woodland" vegetation class. However, targeted surveys failed to detect this species within these predicted habitats. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Thesium australe (V)

Thesium australe has not been recorded locally, with habitat values of the study area and EL6288 considered low to absent. The likelihood for an impact on viable habitat of this species is considered low.

Wollemia nobilis (E)

The Wollemi Pine (*Wollemia nobilis*) has not been recorded locally, with habitat values of the study area and EL6288 considered absent. The likelihood for an impact on viable habitat of this species is considered low.

Endangered Populations

River Redgum of the Hunter Catchment (*Eucalyptus camaldulensis*) (EP)

The study area contains minor creeklines of the upper Goulburn River catchment, this geographically within the area covered by this EP listing. However, the character of these creeklines is not consistent with the habitat requirements of River Redgum (E. camaldulensis) a species that relies on larger more established permanent creeks and rivers such as the mid to lower Hunter River and lower reaches of adjoining major tributaries. On basis it is expected that no specimens would have occurred within the study area and as such it is considered that there is a low likelihood of this species being impacted by the proposed mine.

Weeping Myall (*Acacia pendula*) of the Hunter River Catchment (EP)

Weeping Myall (*Acacia pendula*) occupies moderately fertile floodplain landscapes, which is largely absent from the site. There are no local records of this species, not did the study identify any habitats particularly suiting this species. On this basis it is considered that the proposed development is unlikely to have a direct and/or indirect impact on viable habitat of this species.

Tiger Orchid (*Cymbidium canaliculatum*) of the Hunter River Catchment (EP)

The study area contains most of the host tree and shrub species specified for this species, with the 4,060 ha area of the study area indicating the potential for the occurrence of at least 1-2 plants (i.e. based on the estimated 1 plant / 30 km^2). Targeted surveys failed to detect this species within the study area and site despite the prevalence of potential habitat and ease of detection. On basis that no specimens occur within the site, it is considered that there is a low likelihood of viable habitat for this species being impacted by the proposed mine.

9.1.2.Threatened Species - Fauna

Booroolong Frog (*Litoria booroolongensis*) (E)

The Booroolong Frog is a species with widespread occurrence (i.e. western slopes and tablelands) but contracting range (i.e. no longer present on northern tablelands). Its habitat consists of permanent running streams often with cobbles and fringing vegetation. Targeted habitat surveys have failed to identify these habitat features within the study area, with targeted surveys having the same results. Based on the absence of potential/ known habitat and failure of targeted surveys to detect this species, it is considered that the likelihood for an impact on this species is low.

Giant Barred Frog (*Mixophyes iteratus*) (E)

The habitat Giant Barred Frog is generally described as permanent running cobbled streams with fringing vegetation adjoining wet sclerophyll/ rainforest vegetation. This habitat is absent from the study area, with targeted surveys confirming this conclusion. The likelihood for an impact on this species is considered low given the failure of extensive targeted surveys to detect this species and its habitat within the study area.

Pink-tailed Worm Skink (*Aprasia parapulchella*) (V)

The Pink-tailed Worm Skink is often associated with volcanic lithologies, which have limited occurrence within the study area (i.e. basalt). Survey failed to detect this species, with most of its habitat aligned with areas expected to experience indirect impact (i.e. subsidence). The likelihood for an impact on this species is considered low given the failure of extensive targeted surveys to detect this species and its habitat within the study area.

Collared Whipsnake (*Suta flagellum*) (E)

The Collared Whipsnake is an inland species known to occupy arid landscapes. Local records significantly conflict with the corresponding published habitat and distribution records with the likely explanation being an erroneous record (i.e. confused with *Suta dwyeri*). The likelihood for an impact on this species is considered low given the failure of extensive targeted surveys to detect this species and its habitat within the study area.

Broad-headed Snake (*Hoplocephalus bungaroides*) (E)

The Broad-headed Snake occurs south east from the study, with the nearest reported occurrences in Wollemi National Park and Yengo National Park. This species requires tree hollows, which are present, and exfoliating sandstone (i.e. largely blocky material), with the latter habitat feature critical to the presence of habitat. Surveys indicate the absence of known and potential habitat. The likelihood for an impact on this species is considered low given the failure of extensive targeted surveys to detect this species and its habitat within the study area.

Malleefowl (*Leipoa ocellata*) (E)

The Malleefowl is a species with widespread distribution west of the study area, with anecdotal local reports indicating the presence of a local population within or nearby Goulburn River National Park. There is yet to be confirmation of these records, with local the potential for past observation indicating a remnant declining population that is now locally extinct. Its inclusion in this assessment is based on these past observations. However, targeted surveys failed to detect this species or its mounds within predicted habitats such as Box – Ironbark Forests. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species within the study area.

Bush Stone-curlew (*Burhinus grallarius*) (E)

The Bush Stone-curlew is a species with widespread distribution west of the study area, with anecdotal local reports indicating a historical presence within the general locality. There have been no recent observations within EL6288 or the study area, with past local observations for areas that are now well developed agricultural grazing properties. It’s inclusion in this assessment is based on these past observations. However, targeted surveys failed to detect this species within predicted habitats such as Box – Ironbark Forests. The likelihood for an impact on viable habitat of the habitat of this species is considered low to moderate given the failure of extensive targeted surveys to detect this species within the study area.

Square-tailed Kite (*Lophoictinia isura*) (V)

The Square-tailed Kite was observed on one occasion between the proposed O/C 4 and U/G 1, where it was observed flying over a cleared basalt cap. Local records reliably place this species within Munghorn Gap Nature Reserve, with regional data indicating this reserve as an area of importance to this species. This species is likely to focus its foraging and breeding activity along cleared – wooded interfaces such as the outcropping Triassics and Tertiary basalts. The likelihood for an impact on viable habitat of this species is considered high given its known presence within the study area and distribution of habitat within the local area.

Australian Painted Snipe (*Rostratula australis*) (E)

The Australian Painted Snipe forages and breeds in permanent freshwater wetlands capable of supporting various macro-invertebrate resources and vegetation cover for breeding. These habitat features are absent from the study area, with targeted surveys confirming this observation. The likelihood for an impact on viable habitat of this species is considered low given the failure of extensive targeted surveys to detect this species and its habitat within the study area.

Gang-gang Cockatoo (*Callocephalon fimbriatum*) (V)

The Gang-gang Cockatoo was observed on one occasion within woodlands above the U/G 1 operations, where it was foraging on woody fruits. This species is likely to focus its foraging activity throughout this landscape, however resources are limited. The likelihood of an impact on viable habitat of this species is considered low given the low quantity and distribution of foraging resources and likely preference for offsite breeding locations.

Glossy Black-Cockatoo (*Calyptorhynchus lathami*) (V)

The Glossy-black Cockatoo and/or evidence of this species were frequently observed throughout woodlands/ forests above the U/Gs 1 and 2 operations. Foraging resources are concentrated throughout this landscape (i.e. Sheoak). Trees with adequately sized hollows also occur within mature Grey Gum on upper slopes and incised rocky valleys. The likelihood for an impact on viable habitat of this species is considered high given the abundance of foraging material and likely onsite breeding activity coinciding with development activities.

Swift Parrot (*Lathamus discolor*) (E)

The Swift Parrot exhibits both coastal and inland migratory pathways during winter time migration from Tasmanian breeding grounds, with migratory movements through the western slopes potentially influenced by the effects of drought. Extensive vegetation clearing and habitat loss throughout the western districts could also represent a plausible reason for a decline in western occurrences.

No Swift Parrots were identified within the study despite the presence of suitable foraging resources and extensive targeted surveys during winter. A recent record to the east indicates the potential for this species to occur within the area, although, the low number of local records when compared to those of the Capertee Valley would indicate the Ulan area as potentially of marginal importance to this species. Given the database record and presence of potential foraging habitat it is considered that there is a low to moderate likelihood of this species occurring within the study area and as such there is a low to moderate likelihood of an impact on viable habitat of this species.

Turquoise Parrot (*Neophema pulchella*) (V)

The Turquoise Parrot is reliant on high tree hollow density and grassy woodlands, with the combination of these habitat values patchy and limited within the study area. However, it is noted that substantial records for this species occur to the east within Goulburn River National Park, indicating the site may have once or could potentially become an important habitat area. No observations of this species were collected during the baseline studies despite the plethora of local records to the east. Given the database records and presence of potential foraging habitat it is considered that there is a low to moderate likelihood of this species occurring within the study area and as such there is a low to moderate likelihood of an impact on viable habitat of this species.

Superb Parrot (*Polytelis swansonii*) (V)

The Superb Parrot is not a species that is recognised as occurring within the study area due to its main distribution and habitat requirements occurring well west of the Ulan locality. Notwithstanding this viewpoint, this species was identified by the EPBC Act database search is has been considered within this assessment on this basis. The absence of River Red Gum (*E. camaldulensis*) and/or substitute nesting trees with well developed tree hollows is considered a substantial limitation for this presence of this species within the study area. Whilst seasonal migration may result in infrequent to rare movements throughout the locality, it is considered that these events will be of minor consequence to life cycles. The likelihood of the development having an impact on potential habitat is low as is the predicted magnitude of this impact.

Powerful Owl (*Ninox strenua*) (V)

The Powerful Owl has been recorded on a number of occasions throughout EL6288 primarily in forested landscapes on Triassic ridgetops. No specimens have been observed in the valley floor of midslopes, with call identification being the only method of detection. Foraging resources suiting this species are largely restricted to the upper midslopes and ridgetops where possums are more frequent. Despite the presence of these foraging resources, their abundance is patchy implying a protracted home range for the Powerful Owl. Nesting is likely throughout this landscape. Other landscapes are considered less important in terms of foraging and breeding activity, due in part to the low density of tree hollows, and may only function as movement pathways. The likelihood for an impact on viable habitat of this species is considered high as it is known to forage throughout areas to be affected by underground mining.

Barking Owl (*Ninox connivens*) (V)

The Barking Owl was not recorded within EL6288 despite there being a local record for this species near the Ulan coal mine. Its preferred habitat is primarily throughout the valley floor and midslopes where foraging resources are greatest (e.g. Triassic outcrop and riparian zones). Despite the presence of suitable foraging resources such as woodland birds, its seemingly absent status is probably explained by the low tree hollow density throughout its preferred potential habitat areas. The likelihood for an impact on viable habitat of the potential habitat of this species is considered moderate due to the presence of abundant foraging resources but limited roost habitat.

Masked Owl (*Tyto novaehollandiae*) (V)

The Masked Owl was not recorded within EL6288 nor are there any local records for this species. Its inclusion in the analysis is based on occurrences within Mitchell Landscapes that coincide with the study area. Its preferred habitat is primarily the valley floor and midslopes where foraging resources are greatest (e.g. Triassic outcrop and riparian zones). Its preferred foraging resources within this landscape are limited, perhaps explained by the low tree hollow density throughout this landscape. The likelihood for an impact on viable habitat of this species is considered low due to the poor habitat values of the impact areas.

Gilbert's Whistler (*Pachycephala inornata*) (V)

Gilbert's Whistler is a western species with nearest known distribution limits near Wellington. Records within the study area are within somewhat arid woodland habitats adjacent to Goulburn River National Park, this being broadly consistent prescribed habitat. It is not known if the recorded local presence was attributed to drought conditions further west or a localised disjunct occurrence, however, the latter is possible as there have been records of another species (i.e. Malleefowl) within the district that exhibits similar distribution. Assuming this species occupies Scribbly Gum Ironbark woodlands, it is considered that the likelihood for an impact on viable habitat of this species is high where open cut mining activities coincide with this vegetation formation (e.g. Murragamba Sands Woodland).

Brown Treecreeper (*Climacteris picumnus*) (V)

The Brown Treecreeper is common throughout the study area, particularly near the outcropping Triassic sandstones and valley floor. This species is reliant on trees with hollows, with the presence of this habitat feature greatest along the Triassic outcrop. Data indicates that the grassy and shrubby woodlands of the Permian geological formation are important to the local occurrence of this species, presumably in response to increased foraging resources (i.e. localised elevated insect fauna populations linked to fertility) and presence of rough-barked trees (i.e. Ironbark including Mugga Ironbark which sometimes is an important nectar resource). Tree hollow density may also be important, with this feature found more often in the forested areas near and upslope of the Triassic outcrop. The occupation of grassy habitats, such as those to be impacted by open cut mining, appears complex and could be in response to climatic extremes (e.g. drought) and lifecycles (e.g. dispersal of immature birds – David Gerring *pers com*.). The likelihood for an impact on viable habitat of this species is considered high.

Speckled Warbler (*Pyrrholaemus sagittatus*) (V)

Numerous observations of the Speckled Warbler occur within EL6288 along vegetation boundaries with cleared lands suggesting an importance or reliance on this habitat at a local level. Implied by this are a number of habitat advantages promoted by increased shrub density and height variability (i.e. structural complexity) thus affording protection from predictors and high ‘roughness’ promoting elevated insect populations. Suitable ground nesting areas are also present throughout this interface, particularly where grazing activities are absent (i.e. formation of grass tussocks and low shrubbery). The majority of habitat important to this species is present along the outcropping Triassic sandstones, with extensions into the midslopes of the valley floor particularly where Ironbark dominated woodlands occur. Accordingly the likelihood for an impact on viable habitat of this species is considered high.

Regent Honeyeater (*Anthochaera phrygia*) (E)

Like the Swift Parrot, the Regent Honeyeater embarks on regional migration albeit on a lesser scale. The study area is not known to represent core breeding habitat however is located nearby breeding areas such as Wollar to the east (5-25 km from the study area) and Capertee Valley to the SSE (i.e. core breeding location being approximately 70 km from the study area).

The Regent Honeyeater seeks seasonal nectar resources such as White Box, Yellow Box and Mugga Ironbark during its breeding season (i.e. later winter to spring), with each of these species occurring within the study area. However, on inspection of the study during the breeding period, it was noted that only White Box and Yellow Box exhibited flowering events, with Mugga Ironbark only observed in its flowering state during late summer and autumn. Interestingly, this observation contrasts with Mugga Ironbark flowering habits to the south along Mud Hut Road, where the Regent Honeyeater is known to exploit winter flowering events of this eucalypt species. It is considered that the differences in flowering times between Mugga Ironbark at Mud Hut Road and the study area could be a consequence of geology (i.e. granitic vs Permian geological formations).

Despite targeted surveys conducted during the breeding season no Regent Honeyeaters were identified within the study area. Similarly there are no historical records within the study area despite the many records of this species 5-25 km to the east. Given the presence of potential foraging and breeding habitat, it is considered that there is a moderate to high likelihood of this species experiencing an impact from open cut mining operations.

Black-chinned Honeyeater (*Melithreptus gularis gularis*) (V)

Few records of this species were collected from the study area, with presence data (albeit it limited) indicating association with fertile landscapes (i.e. Tertiary basalts). This is consistent with the need for this species to acquire high energy from the nectar resources it consumes. The impacts of mining activities on foraging habitat will be largely indirect, with potential for direct impacts throughout riparian corridors dominated by Yellow Box. The likelihood for an impact on viable habitat of this species is considered high.

Painted Honeyeater (*Grantiella picta*) (V)

A concentration of records for this species was collected from footslope Box Gum Ironbark Forest where at least two mistletoe species are locally at their greatest density. Records were collected during the summer period coinciding with breeding activity, thus implying the study area as having a high level of importance for this species. Direct impacts are expected on foraging and breeding habitat. The likelihood for an impact on viable habitat of this species is considered high.

Hooded Robin (*Melanodryas cucullata*) (V)

The Hooded Robin, which could be considered a focal species within the study area, exhibited a discrete and consistent distribution during the survey period. Breeding pairs and offspring were frequently observed within the valley floor near/ within grassy woodland remnants connected with upslope Tertiary basalt caps and semi-permanent water resources. The configuration of these habitat values are naturally constrained and by anthropogenic influences (e.g. land clearing). The likelihood for a direct impact is considered high.

Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) (V)

Few records of this species have been collected from the study area and EL6288, with the reason for its infrequent occurrence unknown. It is speculated that fragmentation, remnant size and simplification of vegetation structure throughout the Permian geological formation is largely responsible for the limited habitat availability within the study area. Competition with other woodland bird species may also represent an important consideration in the defining the current extent of this species within the study area. There is a high likelihood for a direct impact on this species as a consequence of open cut mining.

Diamond Firetail (*Stagonopleura guttata*) (V)

Like the Hooded Robin, the Diamond Firetail also exhibits a strong local distribution with the valley floor. Factors considered important to local distribution is the availability of foraging resources (i.e. seed) and permanent water resources. Whilst speculative, it is considered that water quality may also contribute to species distribution and/or density, with ‘better’ water quality also recorded in the western parts of the Murragamba Valley (i.e. elevated salinity levels may increase the energy cost of occupying landscapes affected by diminished water quality). As most of the observed activity for this species is associated with the lowland environs of the Murragamba and Eastern Creeks, it is considered that there is a high likelihood for a direct impact on this species and its habitat.

Spotted-tailed Quoll (*Dasyurus maculatus*) (E)

Populations of the Spotted-tailed Quoll occupy complex overlapping ranges of numerous individuals with females occupying smaller ranges where resources are abundant and males in larger home ranges. Ideal habitat for this species is historically represented by the undisturbed valley floor up to and adjoining the lands characterised by the Triassic outcrop. This area is now largely disturbed and overcleared, with remnant habitat remaining in a fragmented landscape. The presence of the fox also serves an inhibiting influence on Spotted-tailed Quoll populations (Catling and Burt, 1995), which are generally more abundant in these fragmented agricultural landscapes. It is considered that the study area still contains potential habitat, particularly on the northern and southern margins where disturbance is limited and locally offset by large expanses of native vegetation. The proposed development will direct (i.e. habitat removal through open cut mining) and indirect impacts (i.e. reduction of connectivity) on habitat contained within the study area. As such it is considered that there is a moderate to high likelihood for an impact on this species as a consequence of the proposed development.

Koala (*Phascolarctos cinereus*) (V)

The Koala requires specific foraging material to support potential and core habitat (i.e. as defined by SEPP 44). Two tree species named on Schedule 2 of SEPP 44 occur within the study area these being Grey Gum (*E. punctata*) and White Box (*E. albens*), these both being important forage species for the Koala. The abundance of these two species is limited to footslopes and Triassic midslopes, not the valley floor, where subsidence impacts will be experienced. Whilst the density of these trees is variable there are patches were coverage exceeds the SEPP 44 benchmark of 15%, thus under that framework it is considered that potential koala habitat exists within the study area. In this respect it is considered that there is a high likelihood for an impact on potential habitat.

Squirrel Glider (*Petaurus norfolcensis*) (V)

The Squirrel Glider is a species that requires a rich array of resources to form viable populations. The more fertile valley floor represents the main landscape where suitable resources are likely to exist (e.g. tree hollows, seasonal nectar, insects, sap) with the effects of agriculture on this landscape being pronounced (i.e. fragmentation, reduced patch size, tree hollow removal and vegetation simplification). Notwithstanding the existing impact regime, there remains a low potential for a resident population and as such it is considered that the proposed development is likely to have impact on this species and/or its habitat.

Brush-tailed Rock-wallaby (*Petrogale penicillata*) (E)

The Brush-tailed Rock Wallaby is reliant on relatively rocky habitats with few predators such as the Fox. Rocky habitats exist above the proposed U/Gs 1 and 2, but survey for this area failed to detect these species. The study area is considered to contain low to moderate habitat values, with these areas likely to experience indirect impacts from underground mining.

Large-eared Pied Bat (*Chalinolobus dwyeri*) (V)

The Large-eared Pied Bat is known to occur within the study area and region. It occupies caves for roost such as the Triassic sandstones of the locality and will forage along lowland areas where there is an abundance of insect life. It is highly likely that the proposed development will have an impact on viable habitat of this species.

Little Pied Bat (*Chalinolobus pictus*) (V)

The Little-eared Pied Bat is known to occur within the study area and region. It occupies caves for roost such as the Triassic sandstones of the locality and will forage along lowland areas where insect life is greatest. It is highly likely that the proposed development will have an impact on viable habitat of this species.

Eastern Bentwing Bat (*Miniopterus schreibersii*) (V)

The Eastern Bentwing Bat is known to occur within the study area and region. It occupies caves for roost such as the Triassic sandstones of the locality and will forage along lowland areas where insect life is greatest. The proposed development is likely to have an impact on viable habitat of this species.

Large-footed Myotis (*Myotis adversus*) (V)

No records of the Large-footed Myotis occur within the study area although has been recorded to the northeast outside EL6228. It is speculated that this is directly related to the absence of reliable permanent water resources containing suitable foraging material, as confirmed by the aquatic studies (i.e. vertebrate fish species rarely encountered and restricted to Gambousia observations). Due to the ephemeral depaurperate nature of aquatic habitats throughout the study area it is accordingly considered that there is a low likelihood of an occurrence with the impact area hence low likelihood of the development impacting this species.

Eastern Long-eared Bat (*Nyctophilus timoriensis*) (V)

No records of the Eastern Long-eared Bat occur within the study area despite there being records within nearby habitats to the north dominated by Scribbly and Ironbark. Within the study area it is speculated that this species may occur throughout the Murragamba Sands Woodland and potentially various Ironbark dominated vegetation formations. The potential for habitat is considered moderate and combined with the presence of local records it is considered that the likelihood of the development impacting this species is high.

Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) (V)

The Yellow-bellied Sheath-tail Bat has been recorded within the study area, predominantly throughout the valley floor and midslopes. This species occupies similar habitats throughout the locality as demonstrated in the Wilpinjong EIS. The proposed development is likely to have an impact on moderate to high value habitat for this species.

9.1.3. Endangered Ecological Communities (EECs) and Critical EECs (CEECs)

White Box Yellow Box Blakely's Redgum Woodland (WBYBBRW)

Parts of the study area contain WBYBBRW EEC/ CEEC. The distribution of this EEC/ CEEC is throughout selected parts of the ridgetops (i.e. basalt caps), midslopes (e.g. outcrop of weathered Moolarben coal seam) and basalt/ sediment influenced lower reaches of Murragamba and Eastern Creeks. Open cut mining will directly and irreversible remove this EEC/ CEEC. Undergrounding mining will exert an indirect impact through subsidence. Accordingly, it is considered that the proposed mine is highly likely to have an impact on this EEC.

9.1.4. Critical Habitat

A search of the Critical Habitat register for the TSC Act and EPBC Act on 15 July 2008 failed to identify any critical habitat within, adjacent to or overlapping the study area. No measurable direct or indirect interaction is predicted with areas that are mapped as critical habitat.

9.1.5. Groundwater Dependant Ecosystems

As described in **Section 8** the combined open cut and underground mining will result in the direct loss of many springs, seeps and bogs (plus spring fed dams) located on the western slopes of each of the main creeks due to alterations to groundwater levels arising from underground mining. Whilst the loss of these regimes could be argued as short term purely in terms of hydraulic recovery following rehabilitation, what would be irreparably lost is the complexity of the current shallow perched groundwater regime and the associated spatial expression of surface ecological function.

In this respect one of the two significant GDEs identified within the study area would be removed by open cut mining, this being the GDE located near the confluence of Eastern Creek and Wilpinjong Creek. The remaining significant GDE located in the upper catchment of Eastern Creek within the property known as the Powers Property would be retained and consequently embellished by revegetation works planned for this area.

The loss of large sections of the main creek lines would also result in the loss of vegetation associated with surface runoff waters plus seepage groundwater retained in localised creek bed sediment deposits. Impacts will be greatest on vegetation dependant on reliable surface water occurrences and fauna species with small home ranges and water dependency (e.g. Burrowing Frogs and Hooded Robin).

9.2. Matters of Commonwealth Significance (EPBC Act)

The site is not located in a:

- Declared world heritage property;
- Ramsar wetland;
- Commonwealth marine area; or
- Represent a nuclear action.

Further, there are no aquatic species, EPs or EECs listed for the location and accordingly, these matters are not considered relevant to this EIA.

9.2.1. Threatened Species, EPs. EECs, CEECs

Seventeen threatened species and one critically endangered ecological community (CEEC) and/or their habitats listed on the EPBC Act have been reported as occurring within the study area (EPBC Act Protected Matters Report, 2008). White Box Yellow Box Blakely's Redgum Woodland and Derived Grasslands CEEC are located within and adjacent to the site and will be directly/ indirectly impacted by site development. Several listed threatened flora and fauna species are known or are considered to have potential habitat within the study area, these being Large-eared Pied Bat (*C. dwyeri*) and Regent

Honeyeater (*A. phrygia*). These species will be further considered in this report as they are regarded as subject species.

Migratory Species

Four listed migratory species were located within the study area during the seasonal studies, these being the White-throated Needle-tail, Rainbow Bee-eater, Satin Flycatcher and Rufous Fantail. These findings are consistent with the DECC's Wildlife Atlas Database (DECC, 2008), with both survey and atlas data indicating the most frequently occurring species being the Rainbow Bee-eater (8 records) during summer (i.e. October - March).

Based on vegetation mapping and record locations (11 observations in the baseline study and 13 observations in DECC Wildlife Atlas database), local habitat for these migratory species is broadly defined as woodlands dominated by or containing Inland Scribbly Gum (*E. rossii*), Black Cypress Pine (*C. endlicherii*) and Ironbark species. Two observations coincided with open woodland dominated by Grey Box (*E. moluccana*) and Slaty Gum (*E. dawsonii*).

Some records collected during the 18 month survey or records contained within the DECC (2006) database coincide with the impact area. However, broad habitat as defined above is mostly excluded from the impact area, with large tracts of Inland Scribbly Gum (*E. rossii*), Black Cypress Pine (*C. endlicherii*) and Ironbark dominated vegetation to be retained in the post developed landscape without significant adverse impacts. Accordingly, it is considered that the proposed mine will not adversely impact the above listed migratory species and their local habitats.

In regards to the Regent Honeyeater it is considered that the site offers potential foraging and breeding habitat particularly within vegetation containing White Box and Yellow Box. Regionally, the Regent Honeyeater embarks on migration between core breeding areas (e.g. Capertee Valley), coastal districts and other proximal inland districts such as the Wollar area to the east. The study area is not known to represent core breeding habitat however is located nearby breeding areas such as Wollar to the east (5-25 km from the study area) and Capertee Valley to the SSE (i.e. core breeding location being approximately 70 km from the study area).

The Regent Honeyeater seeks seasonal nectar resources such as White Box, Yellow Box and Mugga Ironbark during its breeding season (i.e. later winter to spring), with each of these species occurring within the study area. However, on inspection of the study area during the breeding period, it was noted that only White Box and Yellow Box exhibited flowering events, with Mugga Ironbark only observed in its flowering state during late summer and autumn. Interestingly, this observation contrasts with Mugga Ironbark flowering habits to the south along Mud Hut Road, where the Regent Honeyeater is known to exploit winter flowering events of this eucalypt species. It is considered that the differences in flowering times between Mugga Ironbark at Mud Hut Road and the study area could be a consequence of geology (i.e. granitic vs Permian geological formations).

Despite targeted surveys conducted during the breeding season no Regent Honeyeaters were identified within the study area. Similarly there are no historical records within the study area despite the many records of this species 5-25 km to the east. Given the presence of potential foraging and breeding habitat, it is considered that there is a moderate to high likelihood of this species experiencing an impact from open cut mining operations.

9.2.2. Critical Habitat

No mapped critical habitat registered by the EPBC Act occurs within or adjacent to the study area.

9.2.3. Bilateral Agreement

The project is considered a controlled action and will be assessed as such in accordance with the Bilateral Agreement between NSW and the Commonwealth.

9.3. Ecological Risk Analysis

An ecological risk analysis was completed to determine the likely level of threat posed by the proposed development against matters of ecological significance as defined by **Section 9** of this assessment. The results of this analysis were used to identify ‘Subject Species’ thus specifying the scope for impact management strategies. The ecological risk analysis is provided in **Table 37**, with ‘Subject Species’ determination aided by the analysis of study area habitats relative to the prescribed habitats for those species, as previously discussed in this section of the EIA.

This ecological risk analysis is to determine the focus of the impact management approach. The impact management approach is outcome focused involving a combination of specific and landscape based initiatives to achieve a “Maintain and Improve” outcome. Detailed monitoring and feedback loops into management planning will be proposed to maximise the connectivity of impact management works.

Table 37: Ecological Risk Analysis - Flora

Common Name	Scientific Name	Study Area Occurrence (Level of Certainty)	Study Area Presence of Viable Habitat	Likelihood	Consequence	Ecological Risk Analysis	Subject Species
	*Cynanchum elegans**	None (high)	Absent	E	3	Low	No
Hoary Sunray	*Leucochrysum albicans var tricolor***	None (moderate)	Absent	E	3	Low	No
	*Ozothamnus tessellatus**	None (moderate)	Medium	C	2	Medium	Yes
Ausfield's Wattle	*Acacia ausfieldii*	None (high)	Absent	E	2	Low	No
Flockton Wattle	*Acacia flocktoniae*	None (high)	Absent	E	3	Low	No
Weeping Myall of the Hunter Catchment	*Acacia pendula*	None (high)	Low	E	3	Low	No
	*Kennedia retrorsa**	None (high)	Absent	E	2	Low	No
	*Swainsona recta**	None (high)	Low- Medium	D	3	Medium	Yes
Cannons Stringybark	*Eucalyptus cannonii**	None (high)	Moderate	C	2	Medium	Yes
River Redgum of the Hunter Catchment	*Eucalyptus camaldulensis*	None (high)	Absent	E	3	Low	No
	Eucalyptus pumila	None (high)	Absent	E	2	Low	No
	Eucalyptus scoparia	Known (high)	Absent	E	3	Low	No
	*Homoranthus darwinioides**	None (high)	Low- Medium	D	2	Low	No
Tiger Orchid of the Hunter Catchment	*Cymbidium canaliculatum*	None (high)	High	C	3	High	Yes
Painted Diuris	*Diuris tricolor (syn D. sheiffiana)**	None (moderate)	Moderate	C	2	Medium	Yes
	*Diuris pedunculata**	None (high)	Absent - Low	D	3	Low	No
	*Digitaria porrecta**	None (high)	Absent	E	3	Low	No
Silky Pomaderris	*Pomaderris sericea**	None (high)	Absent - Low	E	3	Low	No
	Pomaderris queenslandica	Known	High	A	3	Extreme	Yes
Denman Pomaderris	*Pomaderris reperta**	None (high)	Absent - Low	E	4	Low	No
	*Prostanthera discolor**	None (high)	Low - Medium	D	2	Low	No
	*Prostanthera cineolifera**	None (high)	Low - Medium	D	2	Low	No
	*Prostanthera cryptandroides**	None (high)	Low - Medium	D	2	Low	No
	*Prostanthera stricta**	None (high)	Low - Medium	D	2	Low	No
	*Philotheca ericifolia**	None (high)	Low	D	2	Low	No
	*Commersonia rosea**	None (high)	Absent - Low	E	3	Low	No
	*Lasiopetalum longistamineum**	None (high)	Low	D	2	Low	No
	*Rulingia procumbens**	None (high)	Absent - Low	E	3	Low	No
Austral Toadflax	*Thesium australe**	None (high)	Low - Medium	D	2	Low	No
Wollemi Pine	*Wollemia nobilis**	None (high)	Absent	E	4	Low	No

* Dual listed on the State and Commonewealth Acts ** Listed solely on the Commonwealth Act

The level of certainty for 'study area occurrence' is rated high for nearly all threatened plant species. This assessment was based on extensive widespread systematic and targeted surveys over a number of seasons in addition to the detailed desk top analysis. It must be noted that the majority of these species are readily identified from non-flowering material, with only four species considered cryptic (most of which have been assigned a moderate level of certainty).

Table 38: Ecological Risk Analysis - Fauna

Common Name	Scientific Name	Study Area Occurrence (Level of Certainty)	Study Area Habitat Value	Likelihood	Consequence	Risk Analysis	Subject Species
Booroolong Frog	*Litoria booroolongensis**	Absent (High)	Absent	E	3	Low	No
Giant Barred Frog	*Mixophyes iteratus**	Absent (High)	Absent	E	3	Low	No
Worm Skink	*Aprasia parapulchella**	Absent (High)	Absent	E	3	Low	No
Sydeny Broad-headed Snake	*Hoplocephalus bungarioides**	Absent (High)	Absent	E	3	Low	No
Collared Whip Snake	*Suta flagellum*	Absent (High)	Absent	E	3	Low	No
Mallee Fowl	*Leipoa ocellata**	Absent (High)	Low - Absent	E	3	Low	No
Square-tailed Kite	*Lophoictinia isura*	Known	High	A	2	High	Yes
Bush Stone-curlew	*Burhinus grallarius*	Absent (Moderate)	Moderate	C	3	High	Yes
Australian Painted Snipe	*Rostratula australis**	Absent (High)	Absent	E	3	Low	No
Gang-gang Cockatoo	*Callocephalon fimbriatum*	Known	Moderate	B	2	Medium	Yes
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	Known	High	A	2	Extreme	Yes
Swift Parrot	*Lathamus discolor**	Absent (Moderate)	Moderate	D	3	Medium	Yes
Superb Parrot	*Polytelis swainsonii**	Absent (High)	Low	E	2	Low	No
Turquoise Parrot	*Neophema pulchella*	Absent (Moderate)	Medium	C	2	Medium	Yes
Barking Owl	*Ninox connivens*	Absent (Moderate)	High	C	2	Medium	Yes
Powerful Owl	*Ninox strenua*	Known	High	A	2	Extreme	Yes
Masked Owl	*Tyto novaehollandiae*	Absent (High)	Low	D	2	Low	No
Brown Treecreeper	*Climacteris picumnus*	Known	High	A	2	Extreme	Yes
Speckled Warbler	*Pyrrholaemus sagittatus*	Known	High	A	2	Extreme	Yes
Painted Honeyeater	*Grantiella picta*	Known	High	A	2	Extreme	Yes
Black-chinned Honeyeater	*Melithreptus gularis gularis*	Known	High	A	2	Extreme	Yes
Regent Honeyeater	*Anthochaera phrygia**	Absent (Moderate)	Medium	C	3	High	Yes
Gilbert's Whislter	*Pachycephala inornata*	Absent (Low)	Medium	C	2	Medium	Yes
Hooded Robin	*Melanodryas cucullata*	Known	High	A	2	Extreme	Yes
Grey-crowned Babbler	*Pomatostomus temporalis*	Known	Low - Medium	A	2	Extreme	Yes
Diamond Firetail	*Stagonopleura guttata*	Known	High	A	2	Extreme	Yes
Spotted-tailed Quoll*	*Dasyurus maculata**	Absent (Moderate)	Medium - High	A	3	Extreme	Yes
Koala	*Phascolarctos cinereus*	Absent (High)	Low	D	2	Low	No

Common Name	Scientific Name	Study Area Occurrence (Level of Certainty)	Study Area Habitat Value	Likelihood	Consequence	Risk Analysis	Subject Species
Squirrel Glider	*Petaurus norfolcensis*	Absent (Moderate)	Low - Medium	C	2	High	Yes
Brush-tailed Rock-wallaby	*Petrogale penicillata**	Absent (High)	Low	D	4	High	Yes
Large-eared Pied Bat	*Chalinolobus dwyeri**	Known	High	A	2	Extreme	Yes
Little Pied Bat	*Chalinolobus picatus*	Known	High	A	2	Extreme	Yes
Eastern Bentwing Bat	*Miniopterus schreibersii*	Known	Moderate	B	2	High	Yes
Eastern Long-eared Bat	*Nyctophilus timoriensis**	Known	High	A	2	Extreme	Yes
Large-footed Myotis	*Myotis adversus*	Absent (High)	Low	D	2	Low	No
Yellow-bellied Sheath-tailed Bat	*Saccolaimus flaviventris*	Absent (Low)	High	C	2	Medium	Yes

* Dual listed on the State and Commonewealth Acts ** Listed solely on the Commonwealth Act

The level of certainty is rated high for nearly all threatened fauna species, an assessment based on extensive widespread systematic and targeted surveys over a number of seasons. The majority of these species are readily identified through standard survey methodologies such as those implemented as part of the baseline studies. Species having seasonal occurrences were appropriately targeted such as the Regent Honeyeater and Swift Parrot.

9.4. Ecological Sensitivity

The study area contains a range of ecological attributes and values at the landscape level, from well established intact and complex natural areas to cleared, intensely grazed agricultural lands of ecological simplicity. Notwithstanding this range of observed landscapes, this investigation demonstrates that the main driving factors influencing floral biodiversity (and by extension the fauna associated with the flora) such as fertile landscapes and water availability remain, with the fundamental building blocks required for the re-emergence of underlying ecological function possible for much of the study area. That is, the seemingly disturbed surface or visual appearance of parts of the study area belies an ecosystem with the potential for recovery. However, in the context of past land uses and current land tenure, this recovery would have to be assisted by deliberate land management actions (e.g. tree plantings, removal/ reduction/ spatial management of grazing activities, exclusion of mechanical impacts such as tilling etc). Creek and drainage line rehabilitation would require extensive rehabilitation works due to the progressive infilling of many creek and drainage line sections plus the extensive lateral and longitudinal erosion of other sections of creek.

Spatially, the localised occurrence of perched surface intercepted groundwater expressions appears important to the local viability of species such (for example) as the Hooded Robin. Throughout the study period the Hooded Robin demonstrated a clear preference for grassy woodland remnants in the central parts of the Murragamba Valley, for example, where water availability and localised soil fertility are well integrated with or adjacent to remnant vegetation. From these observations it is interpreted that much of the ecology of the Murragamba Valley most likely has an inherent capacity to recover from the effects of a long history of anthropogenic influence, even though this area has been heavily influenced by agricultural activities.

The question of impacts arising from a development is classically measured by the resultant disruption of easily measurable existing surface environments (i.e. the preservation of current biodiversity values). Accordingly, the sensitivity of future plant and animal populations in this locality is likely to be intrinsically linked with rehabilitated landscapes of the open cut mining area where there is a proportionally higher removal of grassy woodlands (i.e. productive landscapes). Therefore, there is also the question of the disruption of underlying environmental factors which would be required to support the re-establishment of ecological function. That is, to reintroduce the ecological values currently expressed within the Murragamba Valley, it is considered that the rehabilitated landscape would need to include fundamental landscape features such as soil fertility and water availability. The mimicking of these features with spatial integrity would maximise the possibility of the re-emergence of appropriate ecological function.

Whilst the conventional approach to open cut void rehabilitation would result in the establishment of some surface intercepted shallow groundwater resources over time (Aquaterra, 2008), this happens in a random unstructured manner, with no guarantee that the desired spatial complexity would occur in suitable locations within a suitable timeframe. An improve outcome, over and above the conventional approach, would be to "build-in" some targeted shallow groundwater resources that attempt to mimic prior perched groundwater occurrences. In this respect trial rehabilitation methods that seek to increase the occurrence of spatially desirous water resources within the rehabilitated landscape would be integrated into the conventional approach. The recovery of post mining rehabilitated surfaces with integrated spatial complexity, as implied, would substantially improve the timely re-occurrence of fauna dependant on ecological function derived the availability of water in the landscape (e.g. focal species such as the Hooded Robin).

In this example the Hooded Robin is restricted by a preference to small home ranges centred on productive lands where all lifecycle needs are contained. This represents the main challenge for rehabilitation. For the species to re-occur within the rehabilitated landscape, it is considered that specific ecologically driven rehabilitation objectives are implied. For instance the integration of chain of ponds and subsurface water retention structures, achieved through specific rehabilitation trials, could hasten landscape recovery, with the increased spatially certainty implied by planning and design potentially leading to the timely recovery of habitats suitable for this species.

In this respect a microcosm representative of this scenario could be investigated in the early stages of mining through the revegetation of currently cleared lands where key ecological function are present (i.e.

surface intercepted groundwater resources). Located in the upper portion of the Eastern Creek valley on a property formerly referred to as the "Powers property" is an area where there is an abundance of surface intercepted groundwater expressions within a currently cleared landscape. Revegetation works with the specific aim of establishing suitable habitat for woodland birds such as the Hooded Robin can be trialled at this location in preparation for defining future mine site rehabilitation works. In this regard, this site would also represent an important monitoring location as part of measuring key performance criteria.

10. IMPACT MANAGEMENT

The impact management approach has in the main adopted a landscape perspective designed to achieve short, medium and long term “Maintain and Improve” outcomes. The approach is outcome focused where it is the fulfilment of objectives designed to increase sustainable biodiversity representation throughout the locality and region for the long term. Accordingly, a local and regional context has been established as the spatial framework for impact management approach, with such a framework designed to overcome temporal short to medium term local impacts through regional initiatives. As the approach is outcome focused on a local and regional stage there is accordingly no distinction drawn between species, populations and ecological communities listed on State (i.e. TSC Act and FM Act) and Commonwealth Act (EPBC Act) as it is intended to ensure positive outcomes for all affected threatened and non-threatened biodiversity.

10.1. Introduction

From the combined ecological assessments it is concluded that prior to European development, the two main study area sub-catchments (Murragamba and Eastern Creeks) would have supported a complex mosaic of terrestrial, aquatic and GDE ecosystems reliant on an equally complex water supply from surface stormwater runoff, local stormwater infiltration into soils, and local shallow (perched) sub-surface groundwater systems, plus expressed groundwater from hard rock and coal aquifers.

Following clearing of trees for agriculture, the actual amount of surface spring expression within the two main study area sub-catchments (Murragamba and Eastern Creeks) is most likely higher than it would have been pre-clearing, as the local water table resulting from the combined shallow groundwater systems in the valleys would have risen. However, the natural surface expression (i.e. retention) of stormwater runoff plus groundwater seepage within drainage lines and creeks is currently low in the cleared agricultural lands, due to a combination of past and current agricultural practices (e.g. additional clearing of riparian vegetation, tilling of drainages, in-line capture of both surface runoff and groundwater seepages). Much of the remaining spring water expression has been further compromised by direct tilling of the springs. Further, these land use practices have accelerated sediment erosion and transport mechanisms within the catchments, further compromising present in-stream aquatic ecological function.

These practices and outcomes would appear to have tipped the balance between water retention and evapotranspiration such that there is now little water left to sustain any meaningful aquatic ecological function within the main creek lines and what aquatic ecological function remains in the study area is mainly reliant on the constructed dams, principally those dams constructed to collect spring waters.

With the proposed open cut mining, the integrity of much of the remaining aquatic and shallow groundwater based ecosystem will be sequentially lost as the progressive mining footprint will require the removal of springs, spring fed dams and the main creek lines within the footprint. The proposed underground mining is likely to alter (in part and also sequentially) the quantity, quality and connectivity of groundwater in aquifers above the mine footprint.

Whilst the mine rehabilitation process can successfully incorporate known engineered solutions to provide a mosaic of ponded waters (via established creek rehabilitation and creek construction/diversion measures (see for instance NSW Fisheries 1999b, Rutherford et al 2000 and DITR 2006b), these measures would generally only apply to the control and management of the surface water runoff component of the water equation for the study area. However, the long-term integrity of rehabilitated terrestrial vegetation suitable for providing ecological function for woodland birds within the Murragamba valley would benefit from the strategic reintroduction of some shallow sub-surface water systems for the maintenance of associated productive landscapes such as grassy woodlands (e.g. see DRET 2008).

That is, to provide some sort of realistic integrated ecosystem function to the study area to meet the 'maintain and improve' requirement on the local level within the Murragamba valley would require additional engineering solutions to restore both surface and strategically located shallow perched groundwater supplies for the maintenance of the combined terrestrial and aquatic ecosystem.

This requirement would likely necessitate a higher degree of engineering planning for rehabilitation materials recovery plus stockpiling works for the creek/drainage-line and strategic shallow sub-surface groundwater retention structure reconstruction within the overburden (i.e. retention and stockpiling of suitable rock, cobbles, coarse sand, clay and large woody debris).

The rehabilitation works would also require the integrated planning of the sequential during-mining clean-water storage and diversion works for environmental flows with the sequential rehabilitation and post-rehabilitation surface water management requirements for rehabilitation water plus environmental flow. The importance of this approach is integral to addressing the spatial requirements of higher order focal species such as for example the Hooded Robin and microchiropteran bat species. The importance of this interdependence is most pronounced during breeding events where the absence of adequate foraging resources such as those sponsored by pulse insect life derived from aquatic ecosystems resources could irreversibly drive sensitive species to local extinctions.

All suggested creek diversion and drainage rehabilitation measures are costly and engineering solutions for providing strategically located perched groundwater retention systems for overburden ecosystem rehabilitation are likely to be experimental and equally costly. However, the actual and perceived combined ecological impacts (costs) on the locally scale within the Murragamba valley arising from the scale and combination of open cut mining, underground mining plus major creek diversions from this proposal in this location are such that these costs will most probably need to be met to meet the 'maintain and improve' requirement for this location.

In summary impact management is required to demonstrate a ‘Maintain and Improve’ outcome compliant with the principles of ecological sustainable development and inter-generational equity. In applying these principles inequity between local impacts and management response (i.e. local impact management strategies fail to achieve an improve outcome) could in part justify the adoption of wider regional strategies (i.e. demonstrate the improve outcome at a regional scale). However, an over reliance on wider regional context could prove costly at a local level if fundamental ecological function is accordingly sacrificed.

Accordingly, whilst it can be demonstrated that a 'Maintain and Improve' outcome for the proposed mine is achievable at the regional level, it is recommended that the required "vision statement" for the key issue of conceptual plans for the proposed relocation of Murragamba and Eastern Creeks and their associated tributaries (as required by the DGRs) include the following commitments:

- To **both** maintaining and improving surface water runoff control and use within the rehabilitated landscape, **and**
- Trialling the feasibility (plus implementing, if successful) rehabilitation of strategically located shallow (perched) surface groundwater systems to support ecological function establishment.

This Vision Statement commitment is in line with "Leading Practice Sustainable Development Program" (LPSDP) for The Mining Industry recommendations as outlined in DTIR (2006a) and follows the specific recommendation of LPSDP on Water Management (DRET 2008):

> "Mining results in permanent changes to the landscape which can alter its hydrological function. This, in turn, may have significant long-term consequences for the surrounding environment following closure. Leading practice operations plan and construct final landforms (their shape, geochemical and geophysical attributes) with a view to minimising the long-term impact of the mining operation. A whole-of-mine-life planning and implementation strategy is required to effectively achieve this. Leading practice water outcomes from final landforms cannot be achieved by manipulating the landscape only after mining ceases" DRET (2008 Section 6.3.1 p52).

10.2. Overall Approach

The generally approach supporting the ‘Maintain and Improve’ philosophy is outlined as follows in descending order of importance:

- Avoidance of ecologically important matters;
- Establish, restore and reinstate ecological function in terrestrial and aquatic corridors for the locality;
- Increase the net native vegetation plus aquatic habitat cover within the locality;

- Enhance the ecological values of retained native vegetation cover, of retained aquatic ecosystems and of retained GDEs and associated habitats;
- Increase the certainty of impact management strategies through sustainable actions;
- Conserve terrestrial and aquatic fauna habitats through managed salvage and compensatory works;
- Establish and enhance wildlife plus aquatic connectivity between conservation reserves and adjoining unreserved native vegetation cover;
- Undertake actions that may facilitate and/or support the development of long term conservation outcomes in the locality and region; and
- Dedication of significant ecological values to the conservation reserve network as an immediate offset for local losses.

It should be noted that the engagement of a wider regional context are of lower priority (i.e. last two points). These in part also address cumulative impacts.

10.3. Sensitivity Analysis

The main sensitivities of the impact area, particularly the open cut mine, are associated with the loss of local ecological function, as this is the fundamental determinant for the presence and spatial occurrence of matters of ecological significance defined by this report. In the most part, the in-pit placements of overburden material and resultant conventional rehabilitation works are likely to be beneficial for overall local biodiversity only in the long term. However, an integrated strategy consisting of early revegetation works and specific rehabilitation measures, which are designed to establish a spatially desirous sustainable landscape in a timely manner, would provide sufficient recovery potential for the range of ecologically sensitive values identified in this report (e.g. re-emergence of complex habitats suitable for species reliant on grassy woodlands).

In this sense, mimicking shallow surface (perched) groundwater resources and soil fertility with spatial purpose represents the main challenge. Through this approach a local improve outcome is probable, as the integration of a shallow perched groundwater regime with conventional rehabilitation strategies would improve the integration of environmental gradients responsible for local ecological function. Ongoing management of the landscape would be required to ensure ecological succession moves in the desired direction, this including the management of matters such as exotic species and colonisation of overly competitive natives such as the Noisy Minor.

Table 39 identifies the anticipated relationships between the overall management approach, ‘biodiversity hotspots’, impact type and management focus required to achieve a ‘Maintain and Improve’ outcome. Biodiversity Hotspots identified in bold represent areas that are mostly or entirely retained in the post developed landscape. Management opportunities that exist for these areas may involve actions prior to, during and after mining activities to provide local ‘Maintain and Improve’ outcomes. However, where permanent losses outweigh the potential to provide adequate local solutions, offsets and other measures of regional scale will be required to deliver the desired ‘Maintain and Improve’ outcome.

Table 39: Impacts and Management Approach for Biodiversity Hotspots

Biodiversity Hotspot	Impact Type	Management Approach		Management Actions
		Local	Regional	
1	Direct permanent	Maintain through Rehabilitation	Maintain through Offset	Revegetate PRIOR to mining; Integrate water retention structures in rehabilitation that may mimic shallow groundwater resources; Offset loss of WBYBBRW EEC and woodland bird habitat.
2	Indirect temporary	Maintain	Maintain	Control weeds; monitor and manage Glossy-black Cockatoo/ Powerful Owl; manage tree hollows/ rock
3	Direct permanent	Maintain through Rehabilitation	Improve	Revegetated cleared lands PRIOR to mining; Control weed populations PRIOR to mining; Manage fauna during clearing event; Offset vegetation loss
4	Direct	Maintain through	Maintain	Control weed populations PRIOR to mining; Manage fauna

Biodiversity Hotspot	Impact Type	Management Approach Local	Management Approach Regional	Management Actions
	permanent	Rehabilitation		during clearing event; Rehabilitate mostly within Western Slopes Dry Sclerophyll Forests species; Offset vegetation loss.
5 - 7	Indirect temporary	Improve through Revegetation	Improve	Revegetate with White Box; control weeds; control competitive native fauna; repair subsidence cracking
8	Direct permanent	Maintain through Rehabilitation	Maintain through Offset	Rehabilitate into riparian environment with WBYBBRW species; Offset loss of WBYBBRW EEC.
9	Indirect temporary	Improve	Improve	Revegetate with White Box; control weeds; control competitive native fauna; repair subsidence cracking
10	Indirect temporary	Improve	Improve	Revegetate with supporting woodland birds; Monitor manage threatened plants; control competitive native fauna; Repair subsidence cracking
11	Direct permanent	Maintain through Rehabilitation	Maintain	Rehabilitate within Western Slopes Dry Sclerophyll Forests species; Offset vegetation loss
12	Direct Permanent	Maintain through Rehabilitation	Maintain	Revegetate PRIOR to mining; Integrate water retention structures in rehabilitation that may mimic shallow groundwater resources; Offset loss of WBYBBRW EEC and woodland bird habitat.
13	Direct permanent	Maintain through Rehabilitation and revegetation	Maintain	Revegetate PRIOR to mining; Integrate water retention structures in rehabilitation that may mimic shallow groundwater resources; Offset loss of WBYBBRW EEC and woodland bird habitat.
14	Direct permanent	Maintain through Rehabilitation	Maintain	Rehabilitate; Offset vegetation loss
15	Direct permanent	Rehabilitation	Maintain	Rehabilitate. Offset vegetation loss; Revegetate lands not impacted by mining
16	None	Improve through revegetation	Improve	Revegetate WBYBBRW tree canopy; control weeds; control competitive native fauna.
17	Direct permanent	Maintain through Rehabilitation	Maintain	Rehabilitate. Offset vegetation loss; Revegetate lands not impacted by mining
18	None	Improve	Improve	Revegetate native vegetation; Improve GDEs with species from elsewhere in the catchment
19	None	Improve	Improve	Control weeds; monitor and manage Glossy-black Cockatoo/ Powerful Owl habitat; manage tree hollows/ rock

Measures such as the ‘integration of water retention structures in rehabilitation’ are somewhat unconventional rehabilitation practices designed to reconnect the rehabilitated landscape with important environment gradients such as water and fertility. The revegetation of cleared lands prior to mining also represents a unconventional practice designed to improve the native seed bank of topsoils prior to mining, hence increase the timely success of rehabilitation. Such measures would be explicitly defined within the Rehabilitation Management Plan, with compatible monitoring protocols also defined to measure the success of these works. The framework of this plan would follow the sequenced mining approach, with the timing of various works such as revegetation, topsoil conditioning/ collection/ stockpiling and management of other rehabilitation resources to be explicitly defined in a manner that meets a ‘Maintain and Improve’ outcome for local biodiversity (see **Section 10.7.1** for details).

In the following sections there is a description of local and regional impact management strategies derived from the above analysis required to achieve the desired ‘Maintain and Improve’ outcome.

10.4. Local Impact Management Strategies

Impact management strategies designed to minimise the local impacts of mining activity are discussed as follows.

10.4.1. Native Vegetation Loss

Management actions minimising the affects of native vegetation removal are listed as follows:

Action 1

Develop and implement a management plan for the revegetation of cleared landscapes under the control of MCMs both within and outside the study area. This plan is to be mindful of the limited availability of resources, the importance of environmental factors (i.e. water and soil fertility) and the temporal challenges placed on the revegetation effort by sequential mining activities. This will extent to the temporary revegetation of lands inside the mine footprint using native vegetation (i.e. grasses and herbs) to increase the biodiversity contained within the seed bank prior to topsoil harvesting and relocation.

Rationale

The complexities associated with ecological function of the study area command an understanding of environmental factors (i.e. gradients) prior to the development of appropriate and relevant revegetation and/or rehabilitation methods. The framework for the re-introduction of native vegetation must simultaneously consider terrestrial, riparian and aquatic ecosystems and the eventual balance required between these systems.

Ecological stability will require an ongoing representation of habitat, such as those represented by biodiversity hotspots, throughout the duration of mining (i.e. maintain, improve, create and restoring connectivity between hotspots). Complexity is the key to achieving this objective, with protocols supporting native vegetation re-introduction requiring a careful consideration of the following matters, but not necessarily restricted to:

- Planting densities and regimes (e.g. woodland densities and random plantings);
- Spatial distributions of plantings (i.e. woodland, open woodland and grassland mosaics);
- Spatial extent of plantings (e.g. minimum 10 ha woodland patches to promote woodland bird recovery);
- Species composition (e.g. defined by overburden values and influence of groundwater resources);
- The use of shrubs as a pioneer species to rapidly restore structural complexity and soil organic matter;
- The development of a seed bank within ‘undisturbed topsoils’ prior to mining to enhance the response of emplaced topsoils; and
- Increase the organic matter content of topsoils prior to stripping using native plant species, particularly those capable of enhancing the soil seed bank.

Note: some of the lands that are to be revegetated do fall within the mine footprint and as such will be mined. The purpose of these works is to:

a) Improve the native seedbank of the topsoil;

b) Reduce exotic plant composition;

c) Increase organic matter thereby reduce available nitrogen; and

d) Create a temporary buffer for wildlife contained within the study area during mining activities.

Action 2

Rehabilitate areas directly impacted by open cut mining and indirectly impacted by underground mining. Rehabilitation works are to seek the sustainable establishment of native biodiversity consistent with the locality using a mosaic of grassy and shrubby woodlands, open woodlands, shrublands and grasslands that is mindful of limitations in available water resources and soil fertility.

Rationale

The marginal agricultural values of the Murragamba Valley combined with the proximity of Goulburn River National Park and Munghorn Gap Nature Reserve implicate a preferential objective for the re-establishment of native vegetation and habitat throughout the impact area. This object would over time increase the connectivity between these two conservation reserves in addition to providing a greater quantum of habitat throughout a currently cleared fragmented landscape.

Action 3

Integrate and embellish in a timely manner selected existing and created biodiversity hotspots throughout the study area to facilitate biodiversity retention and 'seed' future rehabilitation works.

Rationale

Avoidance is by nature a compromise between competing interests, which in this case is between the extraction of coal and biodiversity conservation. For this project, avoidance has been achieved for a number of strategic locations throughout the valley floor, primarily for the purpose of assisting the re-establishment of ecological function in the post developed landscape (i.e. long term initiative) and secondly for minimising the short term local impacts of mining (i.e. refuge habitat for 'source' biodiversity).

Representations of most relevant and important ecological structures have been retained in various parts of the study area, with the spatial distribution of these retained areas being an important consideration. For instance, an important part of the Murragamba Creek characterised by intact vegetation cover and geomorphic values is to be retained. Another important landscape retained includes lands influenced by the Moolarben coal seam outcrop, which as discussed in this report appears to be intrinsically linked to the presence of White Box Yellow Box Blakely's Redgum Woodland and derived grasslands (e.g. Biodiversity Hotspot 16). Both cleared and partially cleared examples of this landscape are also retained, with opportunity to undertake revegetation works on undisturbed geological strata considered important to the retention of ecological function within the catchment.

Selected areas known to promote woodland bird activity, in particular the Hooded Robin, would also be retained (i.e. Biodiversity Hotspots 5). These hotspots are the best examples of retained habitats/ avoidance (i.e. the footslopes of Carrs Gap and Redhills) where the occurrence of water and fertile basalt influenced soils sponsor a rich array of species including woodland birds. Connectivity between these sites and similarly natured adjoining hotspots reduces the sensitivity of the protected landscapes where woodland birds, for instance, may freely move between these localities (i.e. uninterrupted connectivity).

Action 4

Undertake targeted revegetation and progressive mine rehabilitation works to support retained biodiversity hotspots.

Rationale

Lands excluded from mining activities that are currently void of treed native vegetation cover (i.e. areas mapped as secondary grasslands and shrublands) represent opportunity over the medium to long term to locally increase native vegetation cover. The revegetation works would require active management in the areas of plantings, weed removal and erosion/ sediment control, with the benefits of these works indirectly supporting mine site rehabilitation and maintenance/ re-establishment of wildlife connectivity. The extent of land use impacts throughout these areas entails greater effort in re-establishing ecological function, however the importance of these works over the long term is considered high (i.e. revegetation on undisturbed geological strata where baseline ecological function will remain intact).

Effort can be minimised by establishing the revegetation works at the onset of mining activity, with cumulative effect of early works benefiting other initiatives (i.e. imparting partial temporal local offsets in the context of the mine life and long term habitat alternative for relocated and/or colonising plant and animal populations). In this respect there are a number of priority areas for which targeted grassy woodland revegetation should immediately precede once mining approvals are gained; including areas under MCP control termed the Powers lands and portions of the Red Hills property not already committed for works under the Stage 1 approvals.

Action 5

Establish permanent and maintain temporary movement corridors of sufficient width and ecological condition between Munghorn Gap Nature Reserve and Goulburn River National Park to maintain genetic flow at a regional scale.

Rationale

Mining activity will increase the severance of connectivity between these two conservation reserves during the mining operations. Mine sequencing would temper this impact thus representing opportunity to establish alternative interim and/or long term movement pathways to partially offset short term discontinuity. The approach will involve vegetation retention within biodiversity hotspots 4, 8 and 15 whilst revegetation works are implemented within and north of biodiversity hotspot 13 at project inception. These actions will connect biodiversity hot spot 9, thus create movement pathways between the conservation reserves. The revegetation of lands to be cleared for mining activities, as part of the specific rehabilitation works, would also aid in the temporary offsetting of mine impacts. There are also opportunities for rehabilitation of riparian lands along the Wilpinjong Creek corridor which are under the control of MCP plus opportunities for direct creek rehabilitation in the upper Wilpinjong Creek within lands under MCP ownership and in crown lands (if directed by consent conditions).

Action 6

Implement management plans to seek to exclude listed regional and/or noxious weeds from lands under the control of MCMs, particularly species known to adversely impact rehabilitation and/or native vegetation such as Galena (<u>Galena pubscens</u>), Rhodes Grass (<u>Chloris gayana</u>*) and Coolati Grass (<u>Hyparrhenia hirta</u>*).*

Rationale

The Hunter Valley is exposed to numerous noxious species capable of disrupting and/or permanently damaging revegetation and/or rehabilitation activities. The study area is contained within an area largely disjunct from these influences, as evidenced by the relatively low exotic species richness and abundance. However, unintentional introduction between mine sites is possible and should be vigorously controlled particularly in light of the relatively low exotic species cover within the area and proximity of the mine to conservation reserves.

Action 7

Implement a detailed monitoring program of design consistent with the 'Before After Impact Control' (BACI) approach.

Rationale

Designing an impact management response with intent to re-establish ecological function at a landscape scale also requires a monitoring program to measure its success/ failures. A scientifically orientated objective based monitoring is a measurable approach providing feed back loops that can translate into modified management actions. Similarly, long term data gained from such monitoring would greatly assist other projects requiring large scale impact characterisation, thus improving impact predictions and certainty of associated management aided outcomes.

Quantitatively measuring floristics using cover abundance and fauna populations represents an appropriate framework for such a monitoring program. Current data collected from baselines studies for EL6288 would form the basis for developing the BACI monitoring program, with additional sites required for before and control sampling (i.e. replication) to increase the rigour of impact measurements.

Sampling may have regard for sites within the adjoining conservation reserve network and other monitoring programs such as those conducted for Wilpinjong and Ulan coal mines. Integration with these monitoring programs will enhance overall interpretability of monitoring results and increase the certainty of these interpretations.

Sampling should focus on biodiversity hotspots to measure the response to indirect impacts on retained landscapes and those with pending impacts. Descriptive analysis should be accompanied with statistical approaches to increase the scientific rigor of the monitoring works.

Action 8

Re-establish localised floristic assemblages characterised by water dependant species such as those described as localised groundwater dependant ecosystems.

Rationale

The majority of groundwater soaks throughout the study area will be permanent removed and/or affected by mining activity. Of the many that are impacted, the few that will receive reduced impacts occur in the headwaters of Eastern Creek. These represent potential opportunities for the retention of a representative sample of this landscape feature, thus conservation within the final landscape. The translocation of lost/ affected GDE derived biodiversity values to 'unaffected' soaks, such as those in the headwaters of Eastern Creek, is considered an appropriate measure given the local importance of these features. Biodiversity hotspot 18 also offers opportunity for the implementation of this management action.

Action 9

Offset the direct loss of native vegetation as a result of mining, including EECs/ CEECs and non-endangered vegetation, in a manner as directed by the Consent Authority and relevant government agencies.

Rationale

Whilst this is regarded as the last option for impact management it is required for this development as a 'Maintain and Improve' outcome is not possible without its inclusion in the impact management approach. A 'like for like' philosophy is considered a desirable approach (e.g. vegetation of similar geology and Mitchell landscapes). The establishment of offsets within overcleared landscapes would preferentially include the consideration of the Liverpool Range Valleys and Footslopes and/or Talbragar – Upper Macquarie Terrace Sands Mitchell Landscape, with offsets establishment within these landscapes representing significant regional improvements in biodiversity conservation.

10.4.2. Loss of Threatened Fauna and their Habitats

Management actions minimising the direct affects of mining on threatened fauna and their habitats:

Action 1

Undertake ecological research in consultation with DECC/ NPWS to support the focus provided by the Actions described in Section 10.4.1, with a focus on the direct impact area, to further investigate the local environmental factors that drive ecological function and its relationship with the threatened species population viability.

Rationale

Ecological research will serve to provide information having both immediate and long term importance for this project borne through the development of effective rehabilitation programs. Other projects and biodiversity conservation in general would also benefit from the derivation of detailed lifecycle dependencies at the local scale. Appropriate research objectives would seek to enhance knowledge in matters such as:

- Mine site rehabilitation design and/or refinement, particularly when focused on delivering sustainable ecological function;
- Population ecology particularly for threatened species within a rehabilitated landscape;
- Relationships between groundwater flows and terrestrial ecological function in a rehabilitated landscape; and
- Biological interactions between residual native vegetation, revegetated lands and rehabilitated lands.

Numerous Priority Action Statements developed by the DECC for threatened biodiversity also underpin this rationale. Species that may particularly benefit from this initiative at a local and regional level include rare and under-studied cave dwelling bats such as the Large-eared Pied Bat and Little Pied Bat (both of which are known to occur within the study area). In this respect, studies on these species should be broadened to include an objective focused on locating the roost location(s) for these species, with any direct impacts (i.e. mine subsidence) to be mitigated accordingly (i.e. removal of animals prior to subsidence impacts). Woodland birds such as Hooded Robin are also likely to benefit from an increased research focus.

Action 2

Undertake ecological research on threatened woodland birds and microchiropteran bat species known to be impacted by the development. The research should be conducted in consultation with DECC/ NPWS and be aligned with DECC's Priority Action Statements for threatened biodiversity.

Rationale

This action is considered important as the further understanding of threatened species lifecycles may result in improved and / or focused recovery efforts that are superior to current techniques. This has local, regional, State and National implications. Relevant Priority Action Statements for microchiropteran bats include:

1. Identify the effects of fragmentation on the species in a range of fragmented landscapes.

2. Research the degree of long-term fidelity to roost trees and roosting areas in order to assess their importance and the effects of their removal.

3. Research the effectiveness of rehabilitation measures intended to increase bat populations in degraded landscapes, such as revegetating and installing bat boxes.

4. Research the roosting ecology of tree-roosting bats. For example identifying the attributes of key roosts.

5. Study the ecology, habitat requirements and susceptibility to logging and other forestry practices of this little-known species.

6. Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes. (Medium priority)

7. Use radio-tracking to identify important foraging range and help interpret density of records.

Action 3

Prepare a management plan that details methods used and timing of management for fauna resources of areas to be cleared or subsided by mining as well as peripheral unaffected lands (i.e. cleared and vegetated).

Rationale

The mechanics of this impact management action are complex. For instance, it is recognised that the recolonisation of fauna displaced by land clearing event into adjoining habitats (e.g .movement of Common Brush-tailed Possum) may in fact result in negative impacts on other species including threatened species (e.g. completion for tree hollow resources that may negatively impact Glossy-black Cockatoo breeding sites and/or impact on fledglings). Other competitive species that will require management in the Noisy Minor, this being partly achieved through the management of vegetation structure.

Action 4

Undertake strategic revegetation works throughout those areas characterised by basalt geological formations for the purposes of increasing local woodland bird habitat.

Rationale

Key biodiversity hotspots are centred on basalt caps located on the western margin of the study area, with the majority of these basalt surfaces once covered by a woodland and/or open woodland White Box (*E. albens*) tree canopy. The absence of this tree canopy has diminished the fauna values of this area particularly for woodland birds such as honeyeaters and potentially birds of prey reliant on woodland bird populations (e.g. Square-tailed Kite).

Re-introduction of White Box (*E. albens*) at the onset of the proposed mining activities will significantly contribute to any temporal adjustments made by local fauna populations to the loss of habitat resources arising from sequential mining activities. These areas may act as refuge during periods of mining activity where valley floor habitats are being adversely affected. In the longterm, these works will permanently enhance the extent of productive landscapes, thus increasing the carrying capacity of peripheral landscapes. These adjustments are expected to have significant short term benefits by balancing habitat losses thus reducing the likelihood of local extinctions.

Action 5

Undertake extensive progressive fauna habitat salvage works throughout the impact areas for reinstatement within rehabilitated lands and retained landscapes.

Rationale

Perhaps the most important resources available to post mining rehabilitation/ revegetation is the vegetation being removed for the purpose of mining. Trees containing hollows, which are rare in the affected area, should be salvaged, restored and reintroduced into retained biodiversity hotspots to counteract local habitat decline. Whole tree sections may be used in the recreation of streams (i.e. woody snags) thus create instream complexity and reduce erosion (as per the Treat Abatement Plan for Removal of Large Woody Debris from NSW Rivers and Streams - DPI (2006).Not immediately obvious is the general importance of organic matter. Whilst larger woody material can be removed and emplaced as fallen timber or woody snags, finer material is equally important in aiding the redevelopment of soil structure for rehabilitation purposes. Fine vegetation material is to be mulched and blended with topsoils prior to topsoil stripping as a part of a conditioning process designed to deplete available nitrogen thus hasten the development of soil structure, increase native plant germination and decrease exotic plant germination.

Action 6

Bias the focus of the ‘Before After Impact Control’ (BACI) monitoring program on focal threatened species.

Rationale

A suitably designed BACI monitoring program will essentially stratify across the landscape to measure relevant land units. However, given the extent of threatened species occurrences within the local area, namely woodland birds, the BACI monitoring program must incorporate targeted monitoring practices for these threatened biodiversity. A ‘focal species’ approach may be adopted whereby specific ‘sensitive’ species are selected for indepth monitoring. Research within NSW indicates frequently implies the Hooded Robin as a suitable focal species, this being relevant to the study area. Other focal species may include threatened microchiropteran bats such as the Eastern Long-eared Bat (i.e. tree hollow dependant) and Large-eared Pied bat (i.e. cave dependant), with such focus having substantial overlap with the objective of DECCs “Priority Action Statements” for these species (e.g. monitoring the success of artificial habitats as a substitute for natural habitat).

Action 7

Undertake targeted conservation works within the locality for the Glossy-black Cockatoo to provide an improve outcome in response to subsidence impacts on core habitat and any indirect impacts arising from open cut mining.

Rationale

Whilst it is expected that the impacts of subsidence will be minor (i.e. modify the extent of foraging habitat) and have no specific adverse impact on breeding hollows of the Glossy-black Cockatoo, the requirement for a improve outcome advocates further works. Local conservation outcomes together with extensive surveys to locate breeding sites are to be undertaken, with the latter forming part of a monitoring program designed to minimise competition by displaced fauna (e.g. possums) for habitat resources (e.g. tree hollows). Relevant priority actions include:

1. Investigate the establishment of voluntary conservation agreements at key sites (e.g. inholdings of the Goulburn River National Park).

2. Encourage the restoration of foraging habitat that has been cleared or degraded by previous impacts.

3. Identify and map key breeding and foraging habitat, similar to the mapping done by Robinson (2004) at St Georges Basin.

10.4.3. Loss of Riparian Corridors and Function

Management actions minimising the affects of mining on riparian corridors and their function:

Action 1

Reinstate streams with suitable alignment and cross-sectional character that is capable of supporting refuge habitat and 'pulse' events over the long term.

Rationale

Streams are to be removed from the landscapes via open cut mining, with re-establishment requiring considered engineered solutions. Landscape ecological function is intrinsically related to the development of complexity, with streams of the locality integral to the viability of much local biodiversity. Streams will be required to retain ponded water, in sections, as refuge for aquatic fauna during low rainfall and/or high evapotranspiration periods. Capacity must also be integrated into the streams to enable the maximum translation of spring and summer rainfall events into additional aquatic habitats to support 'pulse' aquatic fauna lifecycle responses. This additional capacity is viewed as critical to the re-establishment of foraging resources for Hooded Robins and microchiropteran bats in a manner that coincides with breeding events (i.e. period of high nutritional demand).

Action 2

Use natural materials, where possible, to re-instate instream roughness thereby promoting localised habitat complexity.

Rationale

Woody snags, boulders, cobbles and gravel are considered important to the establishment of localised instream habitat complexity. However, the role of such natural materials also serves to increase instream resilience to erosion events through velocity dissipation. The lighter gravel and small cobble resources can also be placed in the upper reaches of the rehabilitated streams to drift down-stream under flood events thus mimicking natural transport of these resources through the creek system.

Action 3

Establish tree canopy cover of woodland structure for a minimum width of 100 m along stream sections retained in the mined landscape.

Rationale

The establishment of tree cover along riparian corridors will significantly enhance foraging habitat for microchiropteran bats and woodland birds and shading will aid in slowing down evapotranspiration. The Square-tailed kite would also be advantaged by the revegetation works. Movement corridors of minimum 100 m width represent the minimum effective width, with wider revegetation works completed where possible.

10.4.4. Loss of Ecological Function

Action 1

Incorporate within the BACI monitoring program the measuring the population dynamics for specific 'indicator' species such as desired (e.g. Hooded Robin) and undesired (e.g. Noisy Minor) species for the purposes of triggering specific management responses to 'imbalanced' populations.

Rationale

The monitoring of impact response is critical to maintaining the predicted outcomes. Sensitive species such as the Hooded Robin and potentially the Brown Treecreeper are focal species that are predicted to return and/or remain within close proximity to the impact area. Conversely, the Noisy Minor is predicted to prosper in the altered landscape, with interventionary management required at times to ensure the competitive influence of this species does not undermine the re-establishment of ecological function and biodiversity conservation.

10.5. Regional Impact Management Strategies

10.5.1. Loss of Threatened Biodiversity, Connectivity and Ecological Function

Management actions minimising the impacts of mining on Subject Species:

Action 1

Undertake a detailed roadside significant environment study for the greater Mudgee – Ulan District (e.g. Mid-western Regional Council local government area) particularly in areas where significant ecological values may occur. The study could include a threats analysis together with long term management works.

Rationale

The knowledge of the distribution and condition of significant ecological values represents a fundamental resource for the protection and management of these matters. This concept is echoed in the advice provided to the Minister of DEH supporting the listing for White Box Yellow Box Blakely's Redgum Woodland CEEC where it states:

> *"Areas of high understorey biodiversity tend to occur on public land that has not been utilized for domestic stock grazing or cropping. Examples include cemeteries and road verges, some town commons, or travelling stock routes or reserves."*

Other publications also recognise the value of the regions roadside environments as the spatial distribution of rare and threatened species, populations and endangered ecological communities is commonly encountered within this environment (Prober, 1996; Symbiosis Environmental Consulting Services, 2001).

Implementing a co-ordinated regional study focused the mapping of vegetation within roadside environments and in particular the detection and valuation of White Box Yellow Box Blakely's Redgum Woodland EEC/ CEEC remnants would significantly enhance the resources available to minimise unabated detrimental impacts on overcleared landscapes containing this ecological community. The establishment of 'enhancement sites' and 'monitoring sites' throughout this road reserve network, which may or may not coincide with each other, should also be examined as part of a longer term management strategy.

A study commissioned by the Rylstone District Environment Society titled "Roadside Vegetation in the Rylstone Shire Part 1 – Information Portfolio" (Symbiosis Environmental Consulting Services, 2001) is one such model relevant to this action. Some of the relevant aims and objectives of this study were:

> *Undertake consultations with the local landholders, members of the community, the Society, Rylstone Shire Council and relevant Government bodies, in order to obtain information on the known occurrence of plant species and vegetation communities, and to determine community views and priorities for the management of roadsides in the Rylstone Shire.*

Carry out a detailed, scientific survey of the roadside environment, within lands managed by the Rylstone Shire Council or jointly managed by the Rylstone Shire Council and the Roads and Traffic Authority of New South Wales.

Survey the roadside environment in order to assess the health of the environment, to identify plant communities, and to document any rare or endangered plant species that may be present. Weed species will also be included in the survey.

Locate and map the occurrence of Eucalyptus cannonii within the roadside environment of the Rylstone Shire.

Produce a final scientific report documenting the results of the Project, along with appropriate maps, appendices, and recommendations for the future management of roadside vegetation in the Rylstone Shire.

As the former Rylstone Shire local government area is now part of the Mid-Western Regional Council local government area, it is considered that an extended coverage of this study over the remaining parts of the Mid-Western Regional Council local government area is a logical progression in the improvement of natural resource management tools for this area. The immediate benefits of such a study would include the establishment of sustainable roadside management practices particularly where such works interface with significant roadside environments. Such information could be used to avoid adverse impacts on the environment, which regularly arises from ill informed routine roadside management works.

DECCs priority recovery and threat abatement actions identified for the listed ecological community, which should form part of the objectives, include:

- Protection of remnants of the listed ecological community through the development of conservation agreements and covenants;
- Protection of remnants from weeds, particularly Coolatai Grass, by preventing soil disturbance in and around remnants, and the speedy eradication of any new invasion;
- Avoid the use of fertilisers in or near remnants;
- Avoid soil disturbance in or near remnants, such as ripping planting lines and road grading;
- In very small derived grassland sites, avoid planting trees as they may reduce the floral diversity through competition for light, nutrients and water;
- Planting and other rehabilitation-focussed disturbance should focus on the edges of patches, expanding them, rather than within the patches;
- Expansion and connection of existing remnants;
- Exclusion of continuous grazing from remnants is important, coupled with weed management and control;
- Use strategic grazing (incorporating rest at appropriate times) in areas still containing a diverse native understorey; and
- Burning or slashing if native tussock grasses have built up to a high level, to open intertussock spaces for tree seedlings, forbs and shrubs to establish.

The implementation of any of these suggested actions would ideally involve Mid-Western Regional Council, the Road and Traffic Authorities Roadside Environment Committee and the Grassy Woodlands Conservation Management Network. Resultant proactive actions arising from this knowledge base would reduce unabated cumulative impacts on this and other threatened biodiversity, thus increase the certainty of biodiversity conservation initiatives both locally and regionally.

Action 2

Establish a 'like for like' offsite offset for all vegetation cleared from the direct impact area with the extent of this offset to be determined by the Consent Authority and government agencies after having regard for the benefits derived from offsite revegetation works. These are to be dedicated to the conservation *reserve network and/or integrated into a landbank with permanent planning outcomes favouring the conservation of biodiversity values.*

Rationale

The proponent and the DECC will negotiate the terms of an offset for dedication to a local conservation reserve network to provide immediate mitigation for the loss of EECs/ CEECs. This dedication is likely to be based on ‘like for like’ biodiversity values (i.e. species composition), with the dedication to also consider a condition analysis between what is being removed by mining and the vegetation being included within the conservation reserve network. The extent of the offset is yet to be defined, however, this will be determined by the consent authority through the conditions of consent for the project. Offsets are to include non EEC/ CEEC vegetation as part of achieving the ‘Maintain and Improve’ objective.

10.6. Impact Amelioration

Impacts of vegetation clearing would be minimised through the implementation of various ameliorative works within the framework of agency approved management plans. Ameliorative works are to include, but not be limited to, the following themes:

- Revegetation of lands under the control of MCMs that are to be mined;
- Removal/deterrence of native fauna from an area prior to clearing;
- Timing of clearing to avoid threatened fauna breeding seasons and microchiropteran bat hibernation seasons, where possible;
- Collection of endemic seed for propagation and use in proposed revegetation schemes;
- Retention and stockpiling of significant hollows for use in rehabilitation and retention; and
- Stockpiling of cleared native vegetation as whole sections for use in rehabilitation and erosion control.

Ongoing management of impacts and associated monitoring of rehabilitated/revegetated landscapes and other indirectly impacted vegetation will occur, through the implementation of targeted management with measurable key performance indicators monitored to determine the success of mitigation works.

Impacts from the construction of culverts and other infrastructure within creek riparian habitats and over creeks would be minimised by adherence to standard construction guidelines and additional construction guidelines published by DPI Fisheries (NSW Fisheries 1999). Any necessary rehabilitation works would be undertaken using recommended guidelines (Rutherford et al 2000).

10.7. Revegetation of Offsite Lands

Proposed are two forms of revegetation these termed temporary and permanent. Temporary revegetation refers to the revegetation of landscapes that are proposed to be mined by open cut techniques, with such works restricted to lands under the control of MCMs. Residual lands or offsite lands that are currently cleared are not proposed to be mined are also capable of being revegetated with these works considered permanent. A discussion of the benefits of these works is provided in as follows.

10.7.1. Temporary Revegetation Works

Substantial areas of cleared lands exist throughout the proposed open cut mine, with the majority of these cleared lands described as secondary grasslands or shrublands that exhibit varying responses to the impacts of agricultural activities. These lands are generally characterised by low native plant species richness and cover abundance, elevated exotic plant cover abundance and dominance by select native species tolerant of the agricultural regimes. Implied is a seed bank and top soil supportive of this environment where sensitive native plant species characteristic of local grassy woodlands being generally absent.

The seemingly paradoxical strategy of revegetating lands that are to be cleared for mining is best understood by translating the expected response of the above described topsoils within a rehabilitated landscape. The transferral of unmanaged topsoil materials in their current condition to a surface subject to rehabilitation works is likely to favour a response by the more undesirable components of this topsoil such as the mass germination of the seed bank (i.e. exotic and disturbance tolerant native), this being particularly undesirable when considering the final objectives identified for this landscape (e.g. a diverse landscape supporting the development of ecological function for a variety of sensitive and common native species).

Other factors to consider include the levels of available nitrogen and phosphorous with western grassy woodlands naturally having low available levels (Prober and Thiele, 2005). Increased soil organic matter content is one way of reducing the availability of these macro nutrients, with the depletion of organic matter through topsoil handling preferentially improving the conditions for an exotic seed bank response to the detriment of native species (Smallbone et al 2007). Smallbone et al (2007) identified a postive relationship between increased organic carbon and native plant diversity at the expense of exotic annuals and broad leaf species. Kangaroo Grass (*T. australis*), this being a natural dominant of western grassy woodlands that is believed to play a key role in ecological function in these environments (Prober and Thiele, 2005), was found to be one of the most successful native grass species capable of competing with annual exotics.

The core outcome expected from the temporary revegetation strategy is a significantly reduced exotic and disturbance tolerant native seed bank through various manipulations including the planting (cropping) of Kangaroo Grass (*T. australis*) in combination with other practices such as herbicides (i.e. control perennial exotics), spring burning (i.e. control annual exotics), pulse grazing, soil scalping and slashing (Prober and Thiele, 2005). Some of the beneficial results expected from these manipulations would include:

- Successful competition between Kangaroo Grass (*T. australis*), which can grow in open environments, and exotic and disturbance tolerant native species thus leading to a lower seed bank of these ‘undesirable’ species.
- The presence of Kangaroo Grass (*T. australis*) would favour successional vegetation states with improved natural recruitment of sensitive native species, thus improving the diversity of the native seed bank;
- Increasing vegetation cover through ‘cropping practices’ with species such as Kangaroo Grass (*T. australis*) would lead to increased soil organic matter content, which would inversely affect the availability of macro nutrients such as nitrogen and phosphorous. This reduced availability of macro nutrients would further inhibit the capacity for a seed bank response by exotic annuals and broad leaf species; and
- Increased recruitment of desirable native species into the seed bank of the pre-stripped topsoil under the influence of Kangaroo Grass (*T. australis*). This would increase the likelihood of a desirable natural response by this seed bank on emplacement within the rehabilitated landscape, particularly given that topsoil transferral to rehabilitation landscape is to involve minimal stockpiling (i.e. progressive rehabilitation).

The timing of temporary revegetation works and associated preparatory works is another factor for consideration. The longevity of grassy woodland seedbanks is believed to be short with a substantial decline in the viability of herb species increasing beyond 6 years. As such the following timeframe represents a potential approach for the application of these concepts.

Table 40: Potential Revegetation Timeline for Lands to be Mined under the control of MCMs

Year	Actions
Year 0	Establish baseline monitoring points and initial collect data; apply herbicides to perennial exotics; scalp topsoils or undertake spring burns to reduce annual exotics; distribute Kangaroo Grass (*T. australis*) seed throughout revegetation area; consider merits of irrigation;
Year 1	Apply herbicides to perrential exotics; distribute select ‘desirous’ native grass and herb seed throughout revegetation area that are in low abundances/ absent with < 3 year maturity lifecycle; collect monitoring data.
Year 2	Slash in early spring to discourage annual exotic growth; collect monitoring data.
Year 3	Slash in early spring to discourage annual exotic growth; collect monitoring data.
Year 4	Harvest Kangaroo Grass (*T. australis*) seed; collect monitoring data.
Year 5	Collect monitoring data; consider spot herbicide applications targeting exotics
Year 6	Collect monitoring data; consider spot herbicide applications targeting exotics
Year 7	Harvest topsoil and relocate to rehabilitation site.

Notwithstanding the likely suitability of the above revegetation strategy for lands to be mined, it should be noted that the precise timeline and associated actions would be defined in a revegetation management plan prepared as part of a Mine Operations Plan. Should further investigations show that this proposed timeline be considered suitable, it would follow that temporary revegetation works could only be started on cleared lands with at least 7 years of no proposed mining activity.

Whilst this strategy could be considered a paradigm in rehabilitation, it is effectively no different to the past landuse history, which includes among other practices cropping with oats. Whilst a monoculture is not the objective, the dominance of a native grass species such as Kangaroo Grass (*T. australis*) would substantially aid the establishment of ecological processes driving a succession of vegetation states that supports the development of a sustainable diverse natural landscape.

In the interim there also exists the potential for these works to temporarily buffer the impacts of mining on the existing fauna populations of the valley, particularly those that restrict most activity to the proposed open cut area. Species such as woodland birds could be temporarily buffered by habitat creation thus permitting the movement of home ranges in step with mining. Species such as Diamond Firetails, Speckled Warblers and Hooded Robins could substantially benefit from this strategy.

Other benefits include, but are not restricted to the following:

- The development of tailored revegetation/ rehabilitation approaches that best suit the conditions of the Murragamba Valley, thus increase the success of future rehabilitation works; and
- The creation of substantial seed producing 'native plant crops' that can be harvested and used to augment rehabilitation works.

Lands under the control of MCMs that can be revegetated with temporary timeframes such as period of at least 7 years preceding open cut mining are quantified as follows in Table 41 .

Table 41: Lands Available for Temporary pre-Mining Revegetation Works – Controlled by MCMs

Landcover Type	Vegetation Structure	Area (ha)
Secondary Grasslands and Shrublands	Open Woodland	11.49
	Shrubland	11.89
	Grassland	353.86
Crops/ Plantations	Grassland	50.55
Total		427.79

10.7.2. Permanent Revegetation Works

It is anticipated that the principles behind the temporary revegetation works, as discussed in the above section, would in be applied to areas excluded from open cut mining activities as this would similarly achieve a relatively weed free landscape with increased native plant species diversity. However, as these revegetation works are to be permanent fixtures within the landscape, minor differences in the methodology would be introduced in line with the longer term strategy for these lands. Such as activities are to include works that seek to increase complexity in vegetation structure such as clumped tree and shrub plantings to enhance the development of heterogeneous landscapes capable of supporting over time the displaced ecological values (e.g. woodland bird habitats) of adjoining areas cleared of native vegetation.

A secondary objective applicable to the permanent revegetation works is to discourage the dominance of competitive species such as specific native fauna (e.g. Pied Currawong and Noisy Minor) and presence of exotics (e.g. Black Birds and Starlings). Highly competitive species and/or exotic fauna may overly consume habitat (e.g. resources or space), thus displace more sensitive species such as Hooded Robins and Grey-crowned Babblers. For example studies have shown that increased shrub density within a woodland environment positively impacts avian species diversity, with the populations of competitive species such as the Noisy Minor often controlled by this increased shrub cover. Such examples are clearly evident in the central Hunter Valley where shrubbier vegetation remnants are more often occupied by a greater range of bird species, in particular the Grey-crowned Babbler, with grassier parkland formations often dominated by the Noisy Minor to the detriment of the Grey-crowned Babbler (pers obs Mark

Aitkens). Thus, in this respect vegetation structure through the encouragement of shrub development would form an important feature in the revegetation of offsite cleared lands.

Lands under the control of MCMs that can be revegetated with permanent timeframes are quantified as follows in Table 42 .

Table 42: Lands Available for Permanent pre-Mining Revegetation Works – Controlled by MCMs

Landcover Type	Vegetation Structure	Area (ha)
Secondary Grasslands and Shrublands	Open Woodland	5.57
	Shrubland	4.48
	Grassland	307.6
Total		317.71

10.8. Mine Site Rehabilitation

Mine site rehabilitation is an expectation. As a minimum the landscape disturbed by open cut operations would be re-formed through in-pit overburden placements, with the comparatively homogenous overburden layer capped by topsoil material. This is followed by conventional rehabilitation works, which on application deliver vegetated landscapes generally with biologically simplistic outcomes. These landscapes are often susceptible to stochastic events (e.g. disturbances such as fire, weed invasion, grazing) as there general disjunction from natural ecological function.

Another departure from convention could be represented by an objective for carbon capture. Should carbon capture through above surface biomass creation and soil storage be considered part of the impact management approach for the MCP proposal then considered thought is required as to the development of an ecologically sustainable landscape capable of performing this function. These represent challenges to the conventional objectives of mine site rehabilitation.

Where conventional rehabilitation works lack specific biodiversity orientated objectives there is inherent limited capacity to mimic environmental gradients conducive to the establishment of ecological function (e.g. interaction between biota, soil fertility and water). In the case of grassy woodlands ecological function is generally founded from the inter-dependence between water resources (e.g. localised perched groundwater) and fertility, this being an appropriate construct for developing greater sophistication in rehabilitation objectives.

Locally, the effect of high evapotranspiration (i.e. availability of water) and geology (i.e. patchy soil fertility based on basalt and to a lesser extent the Moolarben coal seam) is considerable and important to the spatial arrangement of biodiversity values. The interruption of the valley and midslope landscapes through mining would have onflow effects on the dispersal mechanisms of groundwater flows and nutrient movement through the landscape where the integration of factors is ignored.

Accordingly, in restoring grassy woodlands it is considered that the conventional mine site rehabilitation approach would require a greater integration of function and diversity (Prober and Thiele, 2005), with emphasis on mimicking the main environmental factors that influence local grassy woodland ecology required. Re-establishing basic ecological function in the final landscape using an integrated approach would build a greater robustness and resilience to the effects of stochastic events such as fire, flood, and drought.

Whilst from a practical viewpoint it is not possible to completely re-establish ecological function in a manner consistent with the current environment, efforts to simulate/ mimic the kinds of environmental gradients important to sustainable landscape function and ecological complexity should be trialled and implemented if successful. By adequately incorporating engineered rehabilitation techniques that distribute important environmental gradients throughout the landscape, it is argued that sustainable ecological succession can be created, hence achieving an acceptable complexity in ecological function over time, and on the required local scale. In this sense the arrival at the ‘desired’/ predicted ‘climax’ community (i.e. grassy woodland) is a too simplistic objective given the constraints, with the development of a variety of ecological ‘states’ (e.g. vegetation structure) that implies a non-equilibrium outcome considered a prudent objective (i.e. diversity through patches and time).

In this sense the trials are to investigate ways to retain water within the landscape, both at surface and underground, with spatial configurations that supports the survival of terrestrial and aquatic ecosystems such as those affiliated with grassy woodlands. For instance, aquatic ecosystems dependant on both surface and subsurface (i.e. groundwater) water flows are considered important in delivering timely foraging resources (mainly insects) for many fauna species. On this basis it could be argued that without a reliable and meaningful occurrence of aquatic ecosystem resources (i.e. chain of ponds) many microchiropteran bat and woodland bird species which feed on insects would vacate the area. The role of insects derived from aquatic ecosystems in other landscape function is also likely to be substantial (e.g. pollination).

10.8.1. Rehabilitation Concepts

Firstly it should be recognised that a successful rehabilitation program with the objective of re-introducing ecological function is intrinsically linked with the surrounding landscape. In this circumstance, the surrounding landscape contains water resources/ fertile soils (e.g. derived from basalt and outcropping coal resources) and remnant biological resources, these requiring active management for effective integration within the rehabilitated landscape. These existing biological/ natural resources are considered particularly important as these ‘seed’ the rehabilitated landscape (e.g. seed bank, stable biomass) thus support the development of sustainable ecological succession and function.

From the data it can be demonstrated that existing surface ecological function is strongly tied to water and soil fertility. In response, rehabilitation design should acknowledge this and focus on ensuring an appropriate redistribution and availability of these resources in the modified landscape.

The rehabilitation of the mine site, in particular the open cut area, would involve the design of specific rehabilitation methods. Concepts considered important in the development of detailed trails and/or approaches are encapsulated within the following principles:

- Integration of ‘chain of ponds’ to increase and/or make available surface water resources;
- Integration of subsurface water resources similar to ‘localised perched groundwater’, with the trial of these structures preferably linked with ‘chain of ponds’;
- Rehabilitation of ‘grassy woodland’ patches of minimum 5-10 ha area, with distance separations between patches no greater than 300 m. These are to be ‘keyed’ in with surface/ subsurface water retention structures;
- Rehabilitation of shrubby woodlands of minimum 5-10 ha area that connect ‘grassy woodland’ patches;
- Rehabilitation of an open woodland/ shrubland/ grassland mosaic throughout the residual landscape;
- Revegetation of existing cleared lands in a manner that keys in with proposed rehabilitation works;
- Use of salvaged habitat (i.e. fallen timber, tree hollows, rock, cobbles and gravel) to increase habitat roughness / complexity for fauna and invertebrates;
- Depletion of available nitrogen of topsoils through carbon additions for areas proposed to be mined to reduce the recovery capacity of exotic grass and/or broad-leaf herbs (Prober and Thiele, 2005; Smallbone et al 2007);
- Exclusion of frequent fires from the landscape, particularly in rehabilitated landscapes, to reduce the stimulation of exotic perennials (Smallbone et al, 2007);
- Control of Sifton Bush (*C. arcuata*) prior to topsoil recovery, thus reduce its capacity to ‘overun’ rehabilitated landscapes; and
- Revegetation and management of cleared lands prior to mining with perennial native grasses such as Kangaroo Grass (*T. australis*) and Snow Grass (*P. seiberiana*) (Smallbone et al, 2007).

Consideration to the shape of woodland patches would also be required. Designs that minimise the effects of predation on small birds and reptiles would be best achieved through reducing edge to area ratio (i.e. patches of circular shape have the best edge to area properties) and increasing shrub patches.

10.8.2. Is this Impact Management?

Understanding the importance of water and soil fertility on surface ecological function, in combination with retained ecological values, is of paramount importance when considering the rehabilitation approach. However, this is not a unique circumstance. The ecology of the Australian landscape is commonly linked to such environmental gradients. In this sense it could be generally argued that impact assessments for projects of this nature often understate the importance of re-establishing environmental gradients, the importance of which as demonstrated in this project is considered high.

As previously stated, rehabilitation is an expectation. Much science exists in delivering rehabilitation outcomes and in this sense the approach suggested above implies a degree of complexity that exceeds convention. Thus the paradigm of departing from conventional surface orientated rehabilitation approaches (e.g. topsoil management, contour banking etc) in preference for an approach integrated with biodiversity driven initiatives implies a sense of impact management. Such an approach also represents opportunity to establish a carbon sink resilient to stochastic events such as drought or fire.

Justifying through methodology the potential to create a vegetated landscape is academic, however, doing so with the consideration of stability over time in light of external stochastic impact regimes is more complex. Thus, by setting long term sustainable ecological function as a primary objective in the mine site rehabilitation approach matters such as carbon capture and the resultant balance achieved (i.e. net increase/ decrease) can be measured and accounted.

10.9. Maintain and Improve Test

The overall objective is to ensure that the proposed mine sufficiently offsets the predicted impacts in a manner resulting in a 'Maintain and Improve' outcome. The management actions proposed in **Sections 10.4 and 10.5**, when combined with impact avoidance, the proposed impact amelioration, revegetation/ rehabilitation framework would establish the following outcomes supportive of the "Maintain and Improve" objective at the local and regional level:

- An improved knowledge base of regional threatened biodiversity occurrences and habitat condition, thus strengthening strategic land use planning initiatives through the identification of lands with high priority conservation values;
- Increased public awareness of significant environmental issues throughout the Mid-Western Regional Council local government area, thus foster a positive stewardship of other areas of high ecological significance contained within private lands;
- Increased certainty of conservation outcomes for threatened biodiversity at the landscape level, particularly for ecological communities that are under represented in the conservation reserve network through impact offsets and dedications to the conservation reserve network;
- Increased native vegetation cover through a combined revegetation and rehabilitation program that is to apply to the majority of mined and unmined cleared landscapes that are under the control of MCMs;
- Increased understanding of biodiversity responses to revegetation and rehabilitation works, thus improve the success of future revegetation and rehabilitation programs designed to establish biodiversity outcomes; and
- Increased understanding of species impact responses, thus leading to improved impact management and rehabilitation techniques.

The mechanics supporting the impact management approach, thus the predicted 'Maintain and Improve' outcome, would be defined within a variety of management plans that are to be approved by the relevant government agencies prior to the initiation of relevant parts of the project. Management plans are to include, but not be restricted to the following:

- Revegetation Management Plan (i.e. temporary and permanent works);
- Rehabilitation Management Plan;
- Ecological Monitoring and Improvement Management Plan (i.e. BACI monitoring program);

- Ecological Research Management Plan (i.e. co-ordination of species, population and community research projects);
- Habitat Salvage Management Plan;
- Biodiversity Offsets Management Plan; and
- Groundwater Dependant Ecosystems Management Plan.

11. ASSESSMENT AGAINST DECC/ DPI DRAFT GUIDELINES

The proposed development will impact threatened biodiversity and their habitats. An assessment in accordance with the draft Guidelines for Threatened Species Assessment (DEC & DPI, 2005) is prepared as follows for subject species to determine the extent of the developments impact incorporating the positive aspects outcomes from the proposed impact management strategies.

11.1. EP&A Act

Presented in the following section is a landscape impact assessment based on ecological communities described in **Section 7.7**. **Appendix 7** provides individual summaries for each subject species in support of this assessment.

11.1.1. How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Lifecycle elements important to the viability of a species and/or population include aspects such as foraging/ breeding resources and access to these resources, predation, completion, anthropogenic derived threats and disease. Many of these aspects are identified in **Appendix 7**.

The following is a discussion of these lifecycle elements for subject species relative to the impacts of Stage 2 of the MCP and cumulative impacts from proximal land uses.

Ozothamnus tessellatus

No known habitat is expected to be impacted by Stage 2 of the MCP. However should this species occur within the study it is expected that it would be impacted by underground mining activities.

Typically, *Ozothamnus tessellatus* occupies dry talus slopes with underground mining potentially disrupting the growth of this species by locally altering hydrological regimes and increased erosion. Localised ponding resulting in the water logging of the root zone, even under temporary circumstances, would have the potential of limit growth and increase the risk of plant death (e.g. disease). The soil seed bank may also be disrupted by these impacts.

Assuming a rapid recovery from surface cracking and associated altered surface water influences and erosion, it is considered that the sequenced mining approach will have a temporal impact where lifecycle function will be progressively impacted across the local extent of potential habitat. In this circumstances, it is considered that the impacts will be temporary and of minor consequence.

Swainsona recta

No known habitat is expected to be impacted by Stage 2 of the MCP. However should this species occur within the study it is expected that it would be impacted by open cut mining activities.

The habitat of this species is typically contained within the ‘Western Grassy Woodlands’ vegetation class where a large percentage of this vegetation will be permanently removed. This impact will serve to remove any potential soil seed bank and any specific micro-habitat values pertinent to the presence of this species. Local impacts on the lifecycle of known populations of this species would be substantial and irreversible in the absence of deliberate impact management.

As this species is more typically found on soils derived from igneous rock formations such as granite, it is considered that the presence of potential habitat lies further to the west of EL6288 will limit the cumulative impacts of coal mining and other land use activities (i.e. roads, power transmission easements and agriculture) on this species.

Cannon’s Stringybark (*Eucalyptus cannonii*)

No known habitat is expected to be impacted by Stage 2 of the MCP. However should this species occur within the study it is expected that it would be impacted by open cut mining activities.

Local records indicate that this species would occupy ecotones between Lowland Ironbark Forest and Lowland Grey Box – Narrow-leaved Ironbark Woodland/ Forest or Lowland Box – Redgum Woodland. Most of these potential habitats are to be removed by mining, with minor remnant areas to be retained within areas associated with biodiversity hotspots 10, 12, 14 and 16. In this sense, the local lifecycle for this species would be impacted, with retained landscapes containing potential habitat modifying this influence.

Tiger Orchid (C. canaliculatum) EP

No known habitat is expected to be impacted by Stage 2 of the MCP. However should this species occur within the study it is expected that it would be impacted by open cut mining activities.

The main host tree species used by the Tiger Orchid (*C. canaliculatum*) are White Box (*E. albens*) and Grey Box (*E. moluccana*) with representations of these and other potential host species such as Yellow Box (*E. melliodora*) and Narrow-leaved Ironbark (*E. crebra*) to be retained within the post mining landscape at biodiversity hotspots 9, 12, 13, and 17. Habitat creation through the revegetation of specific landscapes would potentially increase the habitat for this species, without considering the benefits of widespread ecologically driven rehabilitation works.

In this sense, the local lifecycle for this species would be indirectly impacted in the short term through the loss of potential habitat, with retained landscapes and revegetation works improving local potential habitat values over the long term.

Painted Diuris (D. tricolor)

No known habitat is expected to be impacted by Stage 2 of the MCP. However should this species occur within the study it is expected that it would be impacted by open cut mining activities.

The habitat preferences for this species would place potential populations predominantly within cleared landscapes that are currently grazed and or cropped. It is predicted that this species would have probably occurred at the interface between Lowland Grey Box – Narrow-leaved Ironbark Woodland/ Forest and Lowland Box Redgum Woodland, an area that is broadly delineated by the presence of soaks and springs.

Given the influence of past and presence agricultural activities it is considered that the impact of the proposed mine on life cycles of this species is low as the habitat to be removes has been chronically modified and altered.

Scant Pomaderris (Pomaderris queenslandica)

Known habitat exists for this species within the study area, with impacts expected to occur on at least one of the two specimens observed. Impacts will be restricted to subsidence and related disturbances as a consequence of underground mining. Open cut mining will not directly impact this species, although localised groundwater drawdown of the upper Permian may locally influence habitat for this species in short term.

The lifecycle elements supporting the occurrence of this species are not well known. However, most occurrences are within sheltered ephemeral creeks, particularly on gentle slopes near the foot of steeper creekline gradients. Subsidence may result in an increased deposition of soil material within close proximity of the single plant specimen observed within the impact area, thus potentially acting to smother the soil seed bank. Recruitment of new individuals may be temporary affected by this impact, with the survival of the parent plant critical to the re-establishment of seed material. In this respect, translocation and seed propagation techniques may be applied to minimise impacts and increase certainty of retention within the landscape.

Changes to surface and groundwater regimes over the long term are unlikely to have any measurable negative impact on the lifecycle of this species as it is predicted that groundwater levels are likely to return to current levels within 30-40 years post mining (Aquaterra, 2008).

The local specimen located offsite was observed within an area that is to be dedicated to the Goulburn River National Park (part of the 'Redhills' offset solution for the approved Stage 1 of the MCP). This specimen would not be impacted by the proposed mine.

Square-tailed Kite (Lophoictinia isura)

The Square-tailed Kite (*L. isura*) was observed once during the baseline studies. Foraging values include woodlands and their margins with grasslands and shrublands where it can freely prey on small woodland birds. Breeding habitat is usually found along riparian vegetation.

Stage 2 of the MCP will result in a sequenced loss of foraging areas and breeding habitat (i.e. Murragamba Creek). This will coincide with a cumulative loss of foraging habitat within adjoining landscapes as a consequence of coal mining and power line construction/ management. Increased pressure will be placed on residual proximal habitats, where the response of prey species to the increased predation pressure as well as the mining impacts may further exacerbate the direct habitat losses.

Post mining recovery planned for areas reclaimed through inpit overburden placements would need to occur sequentially as the coal face progressively moves through the Murragamba Valley. Short term losses of foraging resources and breeding areas would be offset over time through the recovery of rehabilitated landscapes having specifically designed woodland patches interspersed with open woodland and riparian woodlands. Mine site monitoring at Ulan for areas affected by open cut mining would indicate that landscape recovery that includes the re-emergence of small woodland bird populations (i.e. principal prey items) is likely.

Bush Stone-curlew (Burhinus grallarius)

No known habitat is expected to be impacted by Stage 2 of the MCP. However this species has the potential to occur within the study area and should it occur, it is expected open cut mining activities would impact on its habitat through the removal of grassy woodlands.

Gang Gang Cockatoo (Callocephalon fimbriatum)

The Gang Gang Cockatoo (*C. fimbriatum*) was observed during the baseline studies. Local foraging values would generally include drier shrubby woodlands and forest on ridgetops and midslopes, particularly near the Triassic outcrop, where woody fruits and acacia seeds occur. Breeding habitat is not typically found in the local area and is unlikely to be impacted by mining.

The mines impacts on this species lifecycles would be a temporary localised loss of wildlife connectivity to the north and potential adjustment of foraging resources, which would be offset by targeted the combined revegetation works and progressive rehabilitation of open cut landscapes.

Glossy Black-cockatoo (Calyptorhynchus lathami)

The Glossy Black-cockatoo (*C. lathami*) was observed during the baseline studies. Local foraging values within the study area would generally include drier shrubby woodlands and forest on ridgetops and midslopes, particularly near the Triassic outcrop, where Sheoak foraging resources occur. Breeding habitat is found in close association with these areas and is generally located within the upper drainage lines near ridgetops (i.e. mostly large mature Grey Gum's with tree hollows).

Mining impacts relevant to this species are generally restricted to underground operations where surface cracking may influence the abundance of Sheoak resources and surface water features required for drinking. The mines impacts on this species lifecycles would also include a temporary localised loss of north-south wildlife connectivity.

Water resources are important to the Glossy-black Cockatoo, with the presence of this resource in close proximity to breeding sites particularly important. In this context, surface cracking may result in the loss of perched surface water (i.e. farm dams) along the eastern flank and above U/G 1. As it is speculated that breeding occurs within the area to be affected by U/G 1, the continuance of water resources in this area must be assured to maintain this lifecycle component.

Tree hollow presence is unlikely to be adversely impacted in the short term, with the potential occasional tree death from surface cracking potentially increasing tree hollow resources over time. However, an indirect impact arising from competition for tree hollow resources may occur as a consequence of open cut operations where displaced Brush-tailed Possums, for instance, may potentially have a negative impact on breeding sites.

Swift Parrot (Lathamus discolor)

No known habitat is expected to be impacted by Stage 2 of the MCP.

The lifecycle of this species within the locality would be restricted to foraging activity only within the fertile landscapes (i.e. grassy woodlands), as breeding occurs within Tasmania. Connectivity with north south regional movement corridors will be temporarily impacted, however, these impacts are of minor consequence given the capacity of this species to traverse open conditions (i.e. Bass Strait). The temporary loss of potential foraging grounds will have a negligible impact on this species lifecycle requirements (i.e. revegetation and rehabilitation with grassy woodland species including White Box and Yellow Box).

Turquoise Parrot (Neophema pulchella)

No known habitat is expected to be impacted by Stage 2 of the MCP.

The lifecycle of this species within the locality would be primarily restricted to foraging activity only within the fertile landscapes (i.e. grassy woodlands), as the presence of suitable breeding habitat (i.e. tree hollows) within these landscapes are currently rare. Connectivity throughout the locality and region would be impacted in the short term, with impacts arising from this including an increased risk of predation. Mining and associated habitat enhancement works (i.e. control of feral animals such as the feral cat) could improve local conditions for this species over the long term.

Barking Owl (Ninox connivens)

No known habitat is expected to be impacted by Stage 2 of the MCP.

The lifecycle of this species within the locality would be primarily restricted to foraging activity within the fertile landscapes (i.e. grassy woodlands), as the presence of suitable breeding habitat (i.e. tree hollows) within these landscapes are currently rare. Connectivity throughout the locality and region would be impacted in the short term, with impacts arising from vegetation clearing being temporary and of minimal consequence.

Powerful Owl (Ninox strenua)

The Powerful Owl (*N. strenua*) was recorded in a number of locations throughout the study area. Observations indicate key breeding habitats to be located within Goulburn River National Park, Munghorn Nature Reserve and lands west of the approved Underground No. 4, thus implying connectivity as a key issue for this species within the area.

Access to lands contained within the study area by this species is considered important for foraging purposes and dispersal (i.e. genetic movement), with impacts from mining expected to have some short term implications. Breeding events are unlikely to be adversely impacted, unless breeding pairs rely heavily on the grassy woodlands of the site. This prediction, however, is an unlikely scenario as most prey species such as the Brush-tailed Possum and Ring-tailed Possum appear to be preferentially occupying the Western Slopes Dry Sclerophyll Forests where tree hollow densities are greater than the valley floor grassy woodlands.

Brown Treecreeper (Climacterus picumnus)

Numerous records of the Brown Treecreeper have been logged for the study area, with many records indicating a shared preference for Western Slopes Dry Sclerophyll Forests near the outcropping Triassic geological formation (i.e. tree hollows) and grassy woodlands downslope (foraging).

Landscape occupation by this species appears complex with widespread occurrence not necessarily implying a species capable of completing lifecycles within any single area of habitat. High densities were observed in areas where rough-barked eucalypts occur (i.e. Lowland Ironbark Forest), presumably a consequence of increased roughness (increased habitat surface) sponsoring increased availability of foraging resources. Secondly tree hollow resources exhibit their greatest densities in these areas.

However, numerous records within the grassy woodlands also suggest an importance of this habitat type. Whilst it is thought that habitats once contained within this vegetation class, prior to European disturbance, it is possible that utilisation of these habitats may be in response to drought conditions (e.g. refuge habitat) or an area of dispersal for immature birds (David Gerring *pers. com*.). Notwithstanding, the number of records from this area imply a reliance on these habitats at some stage of the Brown Treecreeper's lifecycle, with open cut mining have an ongoing sequential impact throughout the mine life.

Speckled Warbler (Pyrrholaemus sagittatus)

Numerous records of the Speckled Warbler have been logged for the study area, with many records indicating a preference for the interface between Western Slopes Dry Sclerophyll Forests near the outcropping Triassic geological formation and downslope grassy woodlands.

Landscape occupation by this species is a generally attributed to habitat complexity of the groundcover and shrub stratum where a high degree of variability in vegetation floristics and structure is required. The highest densities were observed in areas where secondary grasslands and shrublands interface with shrubbier western dry sclerophyll forests and woodlands. It is considered that the microhabitats fostered within these localities, such as taller grasses mixed with an uneven shrub density, sponsors habitat suitability for a wider range of woodland birds with reduced influences from competitive and predatory species. Lifecycles contained within these areas are unlikely to experience any lasting detrimental impacts from progressive open cut mining activities, especially given the timeframe of this mining activity and proposed revegetation/ progressive rehabilitation works.

Painted Honeyeater (Grantiella picta)

The lifecycle of the Painted Honeyeater is predominantly centred on the presence of mistletoe, this being mostly occurring on Grey Box and Yellow Box, thus implying an affiliation with Lowland Box – Redgum Woodland and Lowland Grey Box – Narrow-leaved Ironbark Woodland/ Forest.

Survey data indicates this species migrates to the Ulan district in late spring specifically for the purpose of breeding, where breeding activity occurs onsite and coinciding with the flowering and/or fruiting of Box Mistletoe. The lifecycle of the Painted Honeyeater would be interrupted by open cut mining in the short term, with suitable habitat and revegetated landscapes retained within biodiversity hotspots 10, 12 and 15 becoming more important in satisfying the local requirements of this species.

Black-chinned Honeyeater (Melithreptus gularis gularis)

Known habitat expected to be impacted by Stage 2 of the MCP by underground mining (i.e. U/G 1). Potential habitat is likely to be impacted by mining throughout the O/C 4 footprint.

The lifecycle of the Black-chinned Honeyeater is commonly associated with woodlands containing box-ironbark associations and River Red Gum. Black-chinned Honeyeaters are also known from drier coastal woodlands of the Cumberland Plain, Western Sydney and in the Hunter, Richmond and Clarence Valleys (NSW Scientific Committee, 2001).

Survey data indicates this species is a rare species for the study area whre it has only been reliable recorded once during the survey period. This observation however appears consistent with the extremely low populations densities reported for this species (NSW Scientific Committee, 2001). Given the low desnsities recorded within the study area and the sensitivity of this species to land clearing events it is considered that the Black-chinned Honeyeater would be impacted over the short to medium term, with long term vegetation re-establishment and conservation outcomes likely to reverse this prognosis.

Regent Honeyeater (Anthochaera phrygia)

No known habitat is expected to be impacted by Stage 2 of the MCP.

The Regent Honeyeater is a regional migratory species, with core breeding areas in the Capertee Valley, this being approximately 70km to the SSE of the study area. Records of past breeding events have been recorded within Cumbo Creek to the east (10 km) and Munghorn Gap Nature Reserve to the south east (4 km), with no recorded breeding activity known for within the study area.

The worst case scenario is that open cut mining would displace breeding habitat (i.e. Lowland Box – Redgum Woodland containing spring flowering Yellow Box), with underground mining having an impact on potential core breeding habitat (i.e. Grassy White Box Woodlands on basalt flowering in later winter).

Mugga Ironbark, whilst recognised as a known winter foraging species, does not appear to flower during winter in this locality and may potentially be of lower importance to this species.

Movement corridors would be affected for individuals moving north from the Capertee Valley, however, it is noted that this species has few occurrences to the north and northwest when compared to recorded activity east from the study area to the coast. In this sense it is considered that movement to and from known core habitats (i.e. Capertee to Wollar and further east) would not be greatly impacted, a conclusion potentially supported by the seemingly unsuitable vegetation north from the study area (i.e. dry Triassic sandstone vegetation formations).

Gilbert's Whistler (Pachycephala inornata)

No known habitat is expected to be impacted by Stage 2 of the MCP.

The Gilberts Whistler is a western species that occupies a variety of dry vegetation types with those that may occur within the study area including taller drier scubs, woodland with dense understorey; cypress pine and buloake (e.g. Murragamba Sands Woodland). The nearest record to the study area is from the Redhills property to the north where it was observed in "woodland with dense understorey" characterised by Scribby Gum and Cypress Pine.

The proposed mine would result in a localised contraction of potential habitat (i.e. Murragamba Sands Woodland), with known habitat to the north within the REdhills property unaffected by this development. Further, the habitat containing the local observation of this species has been dedicated to Goulburn River National Park and is thus protected by the management regimes for this conservation reserve.In this respect it is considered that the Gilberts Whistler is a sensitive species (i.e. low number of local records at eastern limit of distribution) with local conservation, progressive revegetation and rehabilitation works offsetting the short term impacts arising from mining.

Hooded Robin (Melanodryas cucullata)

The lifecycle of the Hooded Robin occurs within small patches of grassy woodlands generally less than 14 ha in area. This appears true for the study area, with Hooded Robin activity well established at biodiversity hotspots 1, 8, 5, 12, and 13. However, the implication of five separate populations is not proven, with movements between these hotspots by a single breeding pair possible. In this respect it is known that there are at least two breeding pairs with successful breeding events observed during baseline studies for both these pairs at Redhills (offsite to the north) and the central Murragamba valley (i.e. biodiversity hotspot 1).

The sensitivity of this species to lasting habitat alterations such as open cut mining is high. The literature suggests that habitat complexity is important for a variety of lifecycle components, with the re-establishment suitable micro habitats likely to take considerable time. Breeding and foraging habitats are to be removed by open cut mining along with direct movement routes between observed locations.

In the short to medium term it is predicted that the pressure emplaced on the local population would result in a significant contraction of the local distribution to residual landscapes such as biodiversity hotspot 5, with the suitability of hotspot 5 (i.e. Carr's Gap) questionable during mining operations (i.e. increased peripheral activity, noise and changes to bird cohort dynamics).

Thus, catering for the continued presence of this species within the locality would involve long term visions involving the establishment of ecological function within a spatially desirous arrangement of micro habitat features. In this respect, early revegetation works at biodiversity hotspot 19 would represent an important contribution to the maintenance of lifecycles within the locality for the term of the project.

Grey-crowned Babbler (Pomatostomus temporalis)

The few records of this species within the study area and wider locality would indicate that the locality is generally unsupportive of lifecycles for this species. Records have been temporally spasmodic, with attempts to reconfirm records for the central Murragamba Valley being unsuccessful.

The Grey-crowned Babbler is a relatively common understorey woodland bird of regenerating shrubby woodlands in the central Hunter Valley east from Muswellbrook with the vegetation of known habitat in this area having a well developed leaf litter and sparse grass cover. Low trees and shrubs represent the ideal position for nesting, this being largely absent from atypical landscapes contained within the study area (i.e. Permian lithology), with litter development also being moderately poor throughout.

In contrast with the known habitat values throughout more easterly occurrences in the Hunter Valley, it is considered that the generally grassier habitats in combination with poor leaf litter development, low shrub heights and sheep grazing it is considered that the Grey-crowned Babbler is not a reliable resident species.

Diamond Firetail (Stagonopleura guttata)

The Diamond Firetail is a relatively abundant species of the lower slopes and riparian environs, particularly where the grass understorey is diverse with native grasses. Foraging on these diverse grasslands, in combination with close proximity to water resources, are important in the completion of basal lifecycles, with ‘pulse’ foraging events coinciding with breeding (i.e. increased presence of insects) considered important for successful breeding.

These lifecycles would be impacted by the mine as it passes through biodiversity hotspots 1, 4, 8, 12, 13, 15 with the maintenance and/or improvement of ecological conditions in biodiversity hotspots 5, 6, 7, 9, 12, 13, 16 during and after mining works is likely to maintain core functional areas supportive of this species and its lifecycle needs.

Spotted-tailed Quoll (Dasyurus maculatus)

No known habitat is expected to be impacted by Stage 2 of the MCP.

Key elements of this species lifecycle, as they relate to the study area, are movement corridors that sponsor genetic flow, foraging grounds within grassy woodlands (i.e. birds), areas for potential dispersal and to a lesser degree potential breeding habitat.

The core areas of habitat for this species are mostly located within the adjoining conservation reserves, with offsite habitats such as those contained within the study area largely supporting the breeding lifecycles contained within these adjoining reserves. Mining would have a progressive impact on north south movement corridors, particularly through the Murragamba Sands Woodland vegetation, with peripheral areas also considered seasonally important foraging areas.

Key habitats are to be retained and enhanced such as those contained within biodiversity hotspots 2, 5, 6, 7, 9, 13, 16, 18 and 19 with the losses expected to be moderated by these retained habitats. The maintenance of movement corridors throughout the mining activities is also proposed, thus minimising disruption over the long term. Rehabilitation works, which are focused on establishing ecological function to support the development of a complex of heterogenous grassy and shrubby woodlands, would have the effect of creating new foraging grounds for this species (i.e. woodland birds).

Squirrel Glider (Petaurus norfolcensis)

No known habitat is expected to be impacted by Stage 2 of the MCP.

The Squirrel Glider is dependant on tree hollows as den sites (i.e. a diurnal refuge) and complex seasonal foraging resources (i.e. sap, nectar and arthropods) with relatively high protein/ energy requirements when compared to the smaller more common Sugar Glider. Preferred habitat is therefore defined as the more productive landscapes that coincide with trees with hollows and neighbouring habitat complexity where infrequent usage for a variety of purposes is likely.

It is therefore expected that impacts would occur on important habitat features supportive of this species, particularly throughout the grassy woodlands near the interface with the Murragamba Sands Woodland vegetation class (i.e. localised presence of foraging resources such as Banksia). The impacts will be substantial, with any populations located within the impact area requiring substantial impact management (i.e. restoration of den habitat and pre-emptive revegetation works) to minimise the impacts of open cut mining in particular.

Brush-tailed Rock-wallaby (Petrogale pencillata)

No known habitat is expected to be impacted by Stage 2 of the MCP.

Extensive areas of low rocky outcrops and escarpment occur along the upper eastern slopes of the Murragamba and Eastern Creek valleys, with the areas representing low potential habitat for this species. However, various lifecycles of this species are also interrelated with proximal foraging areas such as the footslopes, with the presence of feral dogs and foxes having substantial negative impacts on the utilisation of these areas. In conclusion it is considered that the proposed mine would have minimal impact on the life cycles of this species.

Large-eared Pied Bat (Chalinolobus dwyeri)

Considering that the Large-eared Pied Bat usually roosts in the 'twilight zone' of caves, such as are common in sandstone cliff lines, and does not require deep dark caves such as those associated with limestone formations, this species is likely to roost in sandstone cliffs throughout rocky outcrops of the study area.

The proposed underground mine (U/Gs 1 and 2) is therefore likely to affect roosting habitat for the Large-eared Pied Bat. Subsidence impacts for this area are likely to include cracking (MSEC 2008), thus de-stabilise some cliff areas. Some small caves and crevices may be damaged or lost, whilst others would be created. It is expected that there would be no net loss of potential roosting features for the Large-eared Pied Bat in the study area.

The proposed mine is not likely to affect caves of particular value for this species for breeding. There is, however, some potential for individual bats to be injured or killed during rock falls or cave closures, particularly during winter hibernations.

Foraging habitat appears to be restricted to productive landscapes such as grassy woodlands, with the totality of open cut miming impacts likely to have a significant cumulative impact. However, proposed is a sequenced mining approach with progressive rehabilitation using specific methods to re-introduce ecological function supportive of grassy woodlands. Thus in the long term it is considered that the mines impacts on the foraging habitat of this species would be minimised.

Little Pied Bat (Chalinolobus picatus)

The Little Pied Bat is capable of roosting in a variety of roosts of varying values (i.e. tree hollows, caves, houses) where they form small colonies (Churchill, 1998). With the presence of this species in the study area, it is expected that this species has the capacity to complete its entire lifecycles within this area.

The impacts of mining would result in the removal of potential roost sites and foraging habitat, with habitat retention and enhancement to coincide with these impacts. Longer term solutions involving ecologically driven rehabilitation outcomes supporting habitat complexity within a grassy woodland complex is considered a beneficial outcome for this species over the long term.

Eastern Bentwing Bat (Miniopterus shreibersii)

The Eastern Bentwing Bat is not expected to roost or breed in the study area given the nature of caves present (i.e. prefers limestone structures with domed inverts in the cave roof). As such the proposed mine is unlikely to result in any disturbance to specific nursery sites. However, this species is present within the study area and as such may experience impacts through the removal of foraging habitat. Sequential mining activities combined with progressive mine site rehabilitation and various avoidance strategies/ revegetation works are considered critical to the maintenance of foraging resources, these being generally associated with grassy woodlands.

Eastern Long-eared Bat (Nyctophilus timorensis)

The Eastern Long-eared Bat appears critically dependant on mature hollows to support the presence of this large bat species, with such a resource in rare supply within the locality. The majority of potential habitat within the open cut area in diminished in value by the very densities of suitable tree hollows, with most suitable habitat for this species located within the adjoining Goulburn River National Park. Assuming the presence of this habitat resource, it is considered that the resultant combined habitat values of the

'Murragamba Sands Woodland', for example, would represent an important area of local habitat for this species to occupy.

The proposed mine would have the effect of removing this 'latent' habitat from the local area, with the return of fully functioning habitat values requiring specific rehabilitation methods such as the reintroduction of tree hollows in combination with habitats similar to those of the Murragamba Sands Woodland and Redhills property. These represent long term objectives that are proposed to be met through the re-introduction of ecological function supporting the development of complex microhabitats within a grassy woodland complex.

Yellow-bellied Sheath-tail Bat (Saccolaimus flaviventris)

The Yellow-bellied Sheath-tail Bat is a generalist microchiropteran bat species that is known to use tree hollows for roost, but is also adapted to a variety of roost styles including under rocks and in cracking clays (Churchill, 1998). Combined with the wide variety of habitats used by this species, it is considered that much of the study area represents potential habitat, this confirmed by baseline surveys and surveys to the east in the Wilpinjong coal mine area. Breeding occurs within the summer months, with occurrences in the locality during and after breeding events indicating either breeding activity and/or post breeding foraging grounds.

The proposed mine would impact roost and foraging areas thus influence breeding cycles. These impacts are progressive and will be moderated by habitat retention and revegetation works, followed by specific rehabilitation to target the reintroduction of ecological function supporting grassy woodland development. Given the variety of habitats used by this species, including the roost sites, it is considered that the impacts on this species would be minimal throughout the duration of mining activities.

11.1.2. How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The following table identifies the type and value of habitats contained within the four vegetation classes defined within the study area for threatened species, populations and ecological communities.

Table 43: Impacts on Threatened Species Habitats

	Secondary Grasslands and Shrublands			Western Slopes Grassy Woodlands			Western Slopes Dry Sclerophyll Forest			Murragamba Sands Woodland			Predicted Impact
	Core	Foraging	Value	Core	Foraging	Value	Core	Foraging	Value	Core	Foraging	Value	
**Ozothamnus tessellatus*							✓		L				No impact of concern
**Swainsona recta*	✓		L	✓		L							No impact of concern
*Cannon's Stringybark	✓		L				✓		M				No impact of concern
**Eucalyptus scoparia*	-	-	A	-	-	A	-	-	A	-	-	A	No impact of concern
Tiger Orchid	✓		L	✓		M	✓		L				No impact of concern
*Painted Diuris	✓		L	✓		M	✓		L				No impact of concern
Scant Pomaderris							✓		K				Impact of concern on known habitat
Square-tailed Kite		✓	M	✓		K		✓	K	✓		M	Impact of concern on known habitat
Bush Stone-curlew		✓	L	✓		M		✓	M	✓		M	Impact of concern on potential habitat
Gang Gang Cockatoo								✓	K				No impact of concern
Glossy Black-cockatoo							✓		K				No impact of concern
*Swift Parrot					✓	L		✓	L				No impact of concern
Turquoise Parrot		✓	L	✓		L					✓	L	No impact of concern
Barking Owl		✓	L	✓		M				✓		M	Impact of concern on potential habitat
Powerful Owl					✓	L	✓		K		✓	M	No impact of concern
Brown Treecreeper					✓	K	✓		K	✓		K	Impact of concern on known habitat
Speckled Warbler	✓		L	✓		K	✓		K	✓		M	No impact of concern
*Regent Honeyeater					✓	M		✓	L				Impact of concern on potential habitat
Painted Honeyeater				✓		H	✓		K	✓			Impact of concern on known habitat
Black-chinned Honeyeater				✓		K	✓		M				Impact of concern on known habitat
Gilbert's Whislter										✓		H	No impact of concern
Hooded Robin		✓	K	✓		K					✓	K	Impact of concern on known habitat
Grey-crowned Babbler		✓	L	✓		M	✓		H		✓	L	Impact of concern on known habitat

	Secondary Grasslands and Shrublands			Western Slopes Grassy Woodlands			Western Slopes Dry Sclerophyll Forest			Murragamba Sands Woodland			Predicted Impact
	Core	Foraging	Value	Core	Foraging	Value	Core	Foraging	Value	Core	Foraging	Value	
Diamond Firetail		✓	H	✓		H		✓	L		✓	M	Impact of concern on known habitat
*Spotted-tailed Quoll					✓		✓				✓		No impact of concern
Squirrel Glider				✓		L				✓		M	No impact of concern
Brush-tailed Rock-wallaby							✓		L		✓	L	No impact of concern
*Large-eared Pied Bat					✓	K	✓		H		✓	M	Impact of concern on known habitat
Little Pied Bat							✓				✓	M	Impact of concern on known habitat
Eastern Bentwing Bat					✓	K	✓	H			✓	M	No impact of concern
*Eastern Long-eared Bat				✓		M	✓		K	✓		H	Impact of concern on potential habitat
Yellow-bellied Sheath-tail Bat				✓		K	✓		M	✓		M	No impact of concern

Note: A=Absent; K=Known habitat; H = High habitat; M = Moderate Habitat; L = Low Habitat * = Dual listing on the EPBC Act

Species identified as having a predicted impact that is of concern are primarily those that depend on Western Slopes Grassy Woodlands. A discussion for species predicted to be affected in this manner is as follows:

Scant Pomaderris

One specimen observed within the study area will experience an impact from subsidence and associated alterations in surface hydrology and soil conditions. In terms of this species it is difficult to predict the likely consequence and as such where uncertainty lies, it is assumed that the specimen would be adversely impacted. Impact management involving intervention and offsets may be required to minimize the potential loss of this species and its habitat.

An offset for this purpose exists locally to the north of the study area adjoining Goulburn River National Park, with the inclusion of this known habitat within this park enhancing the wider conservation of this species. Impact management should also consider seed collection, insitu and exsitu propagation, habitat restoration and impact monitoring. Wider studies seeking the discovery of new populations may also represent long term beneficial outcomes.

Square-tailed Kite

Whilst only sighting of this species was recorded within the study area, database records indicate the Munghorn Gap Nature Reserve as an important location for the regional population. This species relies on wide landscape usage, particularly productive landscapes such as grassy woodlands and riparian corridors, with large areas of this habitat type to be removed from the study area. Whilst mobile, its capacity to remain viable would be tested by this habitat loss. Sequential habitat restoration through targeted revegetation works on peripheral lands unaffected by the mine together with the sequenced rehabilitation of overburden material using specific methods to mimic current ecological function is required to attain long term habitat integrity for this species within the locality and potentially the region.

Bush Stone-curlew

No records of the Bush Stone-curlew were obtained during baseline studies for EL6288 despite targeted survey for its predicted occurrence. The protection of this species habitat, whether it is known or potential, is an objective of the recovery plan with large parts of the study area that are generally consistent with preferred habitat for this species to be impacted by mining.

Mining impacts would have a negative short to medium term influence on this species capacity to recover within the locality, thus emphasizing the need for targeted impact management solutions to remedy this predicted outcome. Mosaics of grassy and woody woodlands are required to provide the foundation for the development of complex microhabitats for this species (i.e. fallen timber combined with terrestrial invertebrates), which would not occur for some decades after the cessation of mining.

Barking Owl

No records of the Barking Owl were obtained during baseline studies for EL6288 despite targeted survey and predicted occurrence. This species will predominantly occupy riparian vegetation and grassy woodlands where both foraging and breeding lifecycle elements will occur. At present potential breeding habitat is of limited supply (i.e. medium to large sized tree hollows), which contrasts with the availability of foraging resources such as small woodland birds.

Mining impacts would have a negative short to medium term influence on this species capacity to recover within the locality, thus emphasizing the need for targeted impact management solutions to remedy this predicted outcome. Mosaics of grassy and woody woodlands are required to provide the foundation for the development of complex microhabitats for this species (i.e. tree hollows combined with a stable community of woodland birds), which would not occur for some decades after the cessation of mining.

Brown Treecreeper

Numerous records at various locations were obtained for this species during the baseline studies. Initial data analysis indicated this species showed preference for Western Slopes Dry Sclerophyll Forests near the Triassic outcrop. However on examination of tree hollow density and distribution it became evident that data was biased by the increased presence of these habitat values near the Triassic outcrop, with the near absence of hollow bearing trees throughout the Western Slopes Grassy Woodlands masking the true landscape usage by this species. The analysis indicates a reliance on Grassy Woodlands for lifecycle completion, with increased utilization of the adjoining Western Slopes Dry Sclerophyll Forests potentially a symptom of habitat loss throughout the Murragamba Valley.

The NSW Scientific Committee's final determination indicates this species as declining in the Munghorn Gap Nature Reserve for unknown reasons. It is considered that the loss of preferred breeding habitat and foraging areas throughout the grassy woodlands that adjoin Munghorn Gap Nature Reserve could represent significant factor in this decline.

To avoid negative local impacts on this species, it is considered that targeted habitat restoration and rehabilitation works are required particularly during the initial stages of the project to help offset the habitat deficits occurring during mining activities. Whilst populations may continue to decline in the face of local landuses in the short to medium term, it is anticipated that the revegetation and rehabilitation of the study area using specific methods to restore ecological function will in part arrest this decline and enable recovery to occur. Methods would need to include the recover and emplacement of tree hollows throughout the landscape and revegetation of unaffected proximal lands early in the project.

Regent Honeyeater

The habitat values for this species within the study area are predominantly associated with grassy woodlands and adjoining dry sclerophyll forests where Yellow Box and White Box occur. Much of this habitat will be removed by mining, with only selected areas to be retained in the post mining landscape as unaffected habitat.

Potential breeding habitat is considered to occur within the study area, as evidenced by breeding records of this species with Yellow Box and White Box. Should this species breed at this location it would represent an uncommon periodic event as the regularly frequented breeding location is generally restricted to Capertee Valley and less so the Wollar Valley. Habitats supporting such activity should be retained where possible, with potential habitat within Redhills (i.e. part of the offset for the approved Stage 1 of the MCP) soon to represent an inclusion of potential breeding habitat within the local conservation network. The minimisation of habitat loss of the long term would require revegetation and progressive rehabilitation works using key species such as White Box and Yellow Box.

Painted Honeyeater

The habitat values for this species within the study area are predominantly associated with grassy woodlands and adjoining dry sclerophyll forests where Box Mistletoe occurs in higher densities. Much of this habitat will be removed by mining, with only selected areas to be retained in the post mining landscape as unaffected habitat.

Breeding habitat is considered to occur within the study area, as evidenced by records collected during the breeding season. Breeding at this location may be regionally important particularly during drought conditions that may be occurring further to the west. Habitats supporting such activity should be retained where possible, with known habitat within Redhills (i.e. part of the offset for the approved Stage 1 of the MCP) soon to represent local conservation for this species. The minimisation of habitat loss would require pre-emptive revegetation works and progressive rehabilitation.

Black-chinned Honeyeater

The habitat values for this species within the study area are predominantly associated with grassy woodlands and dry sclerophyll forests particularly those that adjoin remnants containing Yellow Box and White Box. Much of this habitat will be removed by mining, with only selected areas to be retained in the post mining landscape as unaffected habitat (i.e. vegetation on basalt caps).

Known breeding habitat occurs within the study area where this species was observed foraging on White Box on basalt within Biodiversity Hotspot 9. Should this species breed at this location it would represent an important breeding location as few breeding areas are known. Habitats supporting such activity should be retained where possible, with this desired outcome to be achieved for basalt vegetation types overlying the underground mine areas. The impact on habitat would over the long term require revegetation works using key species such as White Box on basalt caps, Yellow Box along creek lines and box woodlands near the Permian – Triassic interface.

Hooded Robin

A number of locations are known to support this home range and habitat restricted species within the study area. There are two confirmed local breeding pairs, with potential for a further three breeding pairs identified. Habitat for this species appears to be a mix of agriculturally disturbed lands with grassy woodland remnants in association with creeks and/or farm dams, with the general absence of human activity also a theme.

Mining would result in the removal of habitat from biodiversity hotspots 1, 8, 12, 13 and 15. Biodiversity hotspot 5, which has a known resident population, is to be retained along with a breeding pair to the north within the Redhills property. Habitat would be retained in biodiversity hotspots 5 and enhanced within 10, 13, 16 and 18 through targeted revegetation works.

Progressive rehabilitation would be a key factor in the minimisation of local habitat loss/ modification. Specific rehabilitation works keying in ecological function in a spatially explicit manner would greatly assist the timely recovery of habitat for this species, thus long term usage of local landscapes by this species. In totality, the open cut mining impacts would be significant on this species, however, in a sequenced event such impacts are moderated.

Grey-crowned Babbler

The Grey-crowned Babbler is highly sensitive to local impacts as baseline and database records would confirm the rare and disjointed local occurrence and abundance of this species.

The preferred habitat of this species, which is best observed within the central Hunter districts, is a mix of woodlands and forests with shrubby understorey, well developed litter layer, fallen timber and sparse to open grass cover. These habitat features are sparsely distributed throughout the landscape, with the affects of fragmentation by agricultural activities (i.e. slashing and grazing of regenerating shrublands) combined with the limited occurrence of taller shrubs (except for Black Cypress Pine, which appears to favour the White-browed Babbler) appears to be strong limiting factors in the successful occupation of the study area. The usage of rehabilitated lands within the Ulan open cut rehabilitation area would indicate the importance of tall shrubs as important habitat for this species.

Throughout the duration of mining, it is anticipated that this species would initially experience a negative impact, with the progressive rehabilitation of the landscape resulting in the emergence of suitable habitats with potentially greater habitat complexity and spatial integrity than the current existing environment. Whilst the Grey-crowned Babbler may temporary vacate the area, if not already, its return to the rehabilitated landscape is likely assuming the implementation of ecologically driven rehabilitation methods.

Large-eared Pied Bat

The operation of the mine may result in indirect impacts upon peripheral Large-eared Pied Bat habitat, through increased noise, light, traffic and dust. These impacts would be temporary as the mining face progresses through the valley floor, with these impacts being relatively minor for a wide-ranging species such as the Large-eared Pied Bat.

However, of greater concern are the impacts of underground mining on potential roost sites and of open cut mining on foraging habitat, with landscape utilisation seemingly shared between roost areas and valley floor ‘grassy woodlands’. In this respect a greater degree of certainty over the predicted impacts is required such as the identification of known roosts prior to mining, with removal and relocation required where the risk of adverse impacts occur (i.e. coincides with underground mining). Progressive mine site rehabilitation combined with revegetation of unaffected landscapes and avoidance of some grassy woodlands are also critical to the long-term minimisation of habitat disruption.

Little Pied Bat

The impacts of the proposed mine on habitat are widespread for this species including both roost and foraging habitat. Local potential cave roosts are likely to be impacted by subsidence in areas immediately above U/Gs 1 and 2, with open cut mining to affect foraging grounds.

In totality the impacts of mining on this species are considered significant if completed over a short timeframe. However, in sequenced mining and rehabilitation works combined with revegetation works of various retained hotspots, as proposed, it is considered that the total impact is tolerable for this species.

Eastern Long-eared Bat

The habitat of the Eastern Long-eared Bat appears to be linked with shrubby woodlands containing Scribbly Gum nearby streams containing mature Blakely's Redgum. The Murragamba Sands Woodlands represents an area of future habitat potential with the development of tree hollow habitat complexity. These values combine with nearby known habitat to the north in the 'Redhills' property (DECC, 2008).

Impacts on local potential habitat are likely, however, the core areas of known habitat would be excised from mining operations as they have been dedicated to the conservation reserve network as part of the approval for Stage 1 of the MCP. The implementation of specific rehabilitation methods, revegetation works and habitat enhancement would have a positive long term impact on the return of habitat values of this species.

11.1.3. Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

In addressing the impacts of threatened species and populations at their limit of distribution an understanding of local and regional abundance is required. The following provides an account for each subject species in this respect.

Ozothamnus tessellatus

<u>Local Abundance</u>

No specimens of the *O. tessellatus* occur with the study area or locality.

<u>Regional Abundance</u>

The regional abundance of *O. tessellatus* appears restricted to habitat located 40 – 85 km east of the study area within Goulburn River National Park and north of Anvil Hill. Records within the locality would represent a range extension for known habitat.

<u>Impacts on Distributional Limits</u>

Ozothamnus tessellatus is restricted to the HCR CMA region where the Ulan district potentially represents the northwestern limit of distribution. No impacts on known habitat are expected, however, potential habitat is likely to be impacted by subsidence impacts from underground mining. It is considered that Stage 2 of the MCP may have an impact on the distributional limit of this species.

Swainsona recta

<u>Local Abundance</u>

No specimens of the *S. recta* are known to occur with the study area or locality.

<u>Regional Abundance</u>

No specimens of the *S. recta* are known to occur with the region (i.e. HCR CMA). Known habitat occurs west and south from the study area.

<u>Impacts on Distributional Limits</u>

Swainsona recta would be located at its eastern limit of distribution in the Ulan district should it occur within this locality. No impacts on known habitat are expected, however, potential habitat is likely to be impacted through the permanent removal of grassy woodlands by open cut mining. As a consequence Stage 2 of the MCP may have an impact on the distributional limit of this species.

Cannon's Stringybark (*Eucalyptus cannonii*)

Local Abundance

No specimens of the Cannon's Stringybark (*E. cannonii*) are known to occur with the study area. However, there are known specimens located to the southeast adjacent the Wilpinjong coal mine and west where it is partially impacted by the approved Stage 1 of MCP. Database records indicate populations distributed to the south of the study area, with the nearest herbarium lodged record approximately 15km to the south. There are also records of this species within close proximity of the Wilpinjong coal mine, with the impacts of that mine having no adverse effect on this species (Resource Strategies, 2005).

Regional Abundance

Cannon's Stringybark *E. cannonii* is predominantly distributed between Rylstone and the Upper Wolgan valley of the Central Tablelands and Central West Slopes botanical subdivisions. Hunter and White (1999) confirm this by stating the distribution between east of Mudgee and east of Bathurst.

Throughout its distribution, Cannon's Stringybark (*E. cannonii*) is locally frequent but restricted, in sclerophyll woodland on shallow soil on rises. This species is represented in conservation reserves including Avisford Nature Reserve, Gardens of Stone National Park, Wollemi National Park and Winburndale Nature Reserve, with the population size in the latter conservation reserve numbering approximately 6,000 individuals (Briggs and Leigh 1995; Hunter and White, 1999). The total population of this species throughout its entire range is estimated to be greater than 10,000 individuals and is adequately conserved (Hunter and White, 1999).

Impacts on Distributional Limits

Cannon's Stringybark (*E. cannonii*) is located at its northern limit of distribution in the Ulan district. No impacts on known habitat are expected as a consequence of Stage 2 of the MCP, however, potential habitat is likely to be permanently removed by open cut mining or indirectly impacted by subsidence from underground mining. Stage 2 of the MCP may have an impact on this species distributional limit.

Tiger Orchid (C. canaliculatum)

Local Abundance

No specimens of the Tiger Orchid (*C. canaliculatum*) occur with the site, study area or locality.

Regional Abundance

The geographic range that applies to this EP listing is estimated to contain 1 plant / 30km^2 (NSW Scientific Committee, 2006) with Umwelt (2006) estimating the number of individuals being between 200-500 individuals. Umwelt (2006) indicate that at least 90% of known sites are within private lands, an estimate not reflected in the Wildlife Atlas database (DECC, 2008). This is a very low abundance/ density having serious implications on genetic flow and population viability. Perhaps the most dense stand known is at Anvil Hill approximately 85 km to the east of the site where there are 17 sites known to contain this species. Five of these 'sites' (individuals?) are expected to be removed as a consequence of mining with the balance to be retained within the 'offset area'. Assessments that supported this impact consider the impact management as an acceptable outcome.

Impacts on Distributional Limits

In the context of the national distribution of this species, the Tiger Orchid (*C. canaliculatum*) is at its southeastern limit of distribution within the Hunter Valley. Within the Hunter Valley Ulan does not represent the limit of distribution for this species as it is known to occur west from a line between Jerry's Plains and Gresford. Stage 2 of the MCP is not unlikely to have an impact on this species distributional limit.

Painted Diuris (D. tricolor)

Local Abundance

Two individual specimens of the Painted Diuris (*D. tricolor*) occur to the west and southeast of the study area, where they were encapsulated within the area assessed for Stage 1 of the MCP. One of these plants is expected to be lost to the development of the approved Stage 1 of MCP, with the remaining specimen unaffected by the development of the coal mine.

Regional Abundance

Regionally, the Painted Diuris is known from a number of locations within Muswellbrook LGA including Mt Arthur rail loop, Woodlands Ridge Estate (east of Muswellbrook), Yarrawa district (near Denman), Anvil Hill and Wybong. Within this area there are at least eight local populations.

Table 44: Known Regional Abundance of *Diuris tricolor*

Location	Comments	Tenure
1. Woodlands Ridge Estate	200+ individuals	Private, proactively managed
2. Muswellbrook Pistol Range	3 individuals	Private, potentially retained in the long term due to landuse
3. Mt Arthur Rail Loop	unknown, but reported to be the largest in the Hunter Valley (BHP, 2007)	Private, potentially retained and managed
4. Anvil Hill coal mine	14 ‘groups’ with population size anticipated to be at least 50 individuals but likely to exceed 100	Private. At risk over 95% of known population expected to be removed
5. Wybong	a population of approximately 100-200 individuals	Private, potentially retained in the long term due to landuse. No formal management in place
6. SE of Limb of Addy	unknown population size	Private, unknown population size at risk
7. Yarrawa district	500+ individuals	Private, at risk
8. The Site (MRE)	1 individual	Private, at risk

Impacts on Distributional Limits

The Painted Diuris (*D. tricolor*) is not located near its limit of natural distribution in the Ulan locality. Known populations occur approximately 100 km to the east at Muswellbrook, this being the species known limit of distribution. Stage 2 of the MCP is not unlikely to have an impact on this species distributional limit.

Scant Pomaderris (Pomaderris queenslandica)

Local Abundance

Prior to the baseline studies for EL6288, the Scant Pomaderris (*P. queenslandica*) was not known to occur in the locality, with the nearest populations located 75-80 km east of Ulan near Sandy Hollow.

Baseline studies have resulted in the identification of two specimens, one within the study area with the other specimen located on a property known as ‘Redhills’, which lies adjacent the northern boundary of the study area next to Goulburn River National Park. The local population is restricted to two individual specimens.

Regional Abundance

The Scant Pomaderris (*P. queenslandica*) exhibits a low abundance within the region, with the greatest density of known plant centered on the Sandy Hollow – Wybong district. Most specimens exist as isolated individuals or small clumps with numbers rarely exceeding 5-10 plants. Based on known records it is estimated that the regional population would be no greater than 100 individuals.

The habitat of this species is described as footslope colluvials derived from Triassic geological formations (i.e. conglomerate and sandstones) in protected gullies and creeklines. Regional occurrences appear restricted to the Anvil Hill area 85km east of the study area where such habitats are well represented.

Impacts on Distributional Limits

The Scant Pomaderris (*P. queenslandica*) is not located near its limit of natural distribution in the Ulan locality. Known populations occur to the east near Peak Hill, this being the species southern limit of distribution. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits this species.

Square-tailed Kite (Lophoictinia isura)

Local Abundance

The Square-tailed Kite is infrequently observed throughout the locality and region, with many records in coastal and sub-costal districts. Notwithstanding, it is a woodland species and is known to occur within the study area where it would focus its foraging and breeding activity in productive landscapes along the interfaces between cleared and woodland areas such as the Murragamba and Wilpinjong Creek corridor. Records of this species have been collated from the baseline survey above proposed U/G 1 (i.e. interface between open grassy white box woodland on basalt and Triassic sandstones dry sclerophyll forests), Munghorn Gap Nature Reserve and Goulburn River National Park, with the number and location of records in the latter conservation reserves implying vegetation on basalt as locally important to important this species.

Regional Abundance

Records of this species are scarce and widespread throughout the HCR CMA. Most records are coastal, however, the concentration of records in the upper Goulburn River catchment would indicate this area to be an important part of the region's population. Database records (Birds Australia, 2008; DECC, 2008) would indicate connectivity between coastal and western records is severed.

Impacts on Distributional Limits

At a State and national level, the Square-tailed Kite is widespread with mining impacts within the study area having limited consequence on this species at that scale. However, locally and regionally, the proposed coal mine has the potential to influence regional movements and connectivity with distributional limits such as coastal areas.

Bush Stone-curlew (Burhinus grallarius)

Local Abundance

No records of the Bush Stone-curlew (*B. grallarius*) occur with the site, study area or locality.

Regional Abundance

The Bush Stone-curlew is a rare species with widespread distribution throughout the HCR region. Records indicate a historical and recent presence within the region, particularly along the coast. This species is known to occupy habitats such as those contained within the study area, this being grassy woodlands and forests, with the increasing absence from these habitats in the west generally related to the action of various locally active key threatening processes such as land clearing, fox predation and removal of fallen timber. Notwithstanding the potential favourable habitat values of the site, targeted surveys failed to detect this species within the study area.

Impacts on Distributional Limits

The Bush Stone-curlew is a widespread species generally of dry grassy woodlands from coastal to inland districts. The Ulan locality does not represent a distributional limit for this species. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits of this species.

Gang Gang Cockatoo (Callocephalon fimbriatum)

Local Abundance

One record of the Gang Gang Cockatoo (*C. fimbriatum*) occurs within the study area.

Regional Abundance

Records of the Gang Gang Cockatoo (*C. fimbriatum*) occur within the HCR CMA west from near coastal locations (e.g. Werakata National Park) to the study area. Over 99% of regional records are situated along the southern escarpment of the Hunter Valley and within Wollemi National Park, Goulburn River National Park and Yengo National Park.

Impacts on Distributional Limits

The Gang Gang Cockatoo (*C. fimbriatum*) is typically a species of tableland districts, with coastal occurrence observed during seasonal migrations. The Ulan district would represent a northern limit of distribution for this species. Impacts are likely to be restricted to those arising from undergrounding mining, with foraging resources likely to experience on minor disruption. The proposed development is unlikely to adversely affect distributional limits. With database records (DECC, 2008; Birds Australia, 2008) supporting this view (i.e. natural northern limit of distribution is the Hunter Valley region).

Glossy Black-cockatoo (Calyptorhynchus lathami)

Local Abundance

Numerous records have been collated for this species during baseline studies, which is reflected in DECC (2008) database records and to a lesser extent Birds Australia (2008) records. Local abundance is primarily restricted to ridgetop and midslope terrain where foraging and breeding requirements occur, these being more abundant in the adjoining Goulburn River National Park than elsewhere in the locality. Habitats within the western half of locality significantly contrast with those of the Goulburn River National Park, despite this species being widespread to the west.

Regional Abundance

There is an abundance of Glossy Black-cockatoo records within the HCR CMA region, with many contained within conservation reserves, particularly those formed on infertile geological formations such as Wollemi National Park and Goulburn River National Park.

Impacts on Distributional Limits

In general, the proposed coal mine is unlikely to have any lasting impact on the distributional limits of this species.

Swift Parrot (Lathamus discolor)

Local Abundance

No records of the Swift Parrot (*L. discolor*) occurs within the study area, with one record 16 km to the east indicating the potential occurrecnce within the locality (BirdsAustralia, 2008). This local record is a recent record for Wollar in 2005 (Birds Australia, 2008), which indicates the potential for this species to migrate through inland districts near the study area.

Regional Abundance

The Swift Parrot exhibits both coastal and inland migratory pathways for NSW with increased observations of coastal migration predominating recent winter migratory habits. The Capertee Valley is a core area of winter foraging habitat, where this species is likely to be found co-existing with Regent Honeyeaters as they both seek nectar rich White Box blossum. From database records (DECC, 2008; Birds Australia, 2008) it appears that the current usage of the Upper Hunter Valley as part of its seasonal migratory pathway is either of limited importance and/or is not well understood. The effects of drought (i.e. impacts on nectar flows) and physical barriers such as the Liverpool Range and Barrington Tops may represent factors that influence the occurrence of this species north from the study area, with less demanding passage represented by the Goulburn River and its connection with the rolling hills and footslopes adjacent the Hunter River.

Impacts on Distributional Limits

The Swift Parrot is known to occur along coastal districts north to Queensland and south to Tasmania. The western slopes represent the western limit of distribution for this species, with the proposed coal mine potentially having a temporary influence on regional movements through this area.

Turquoise Parrot (Neophema pulchella)

Local Abundance

The Turquoise Parrot is reliant on high tree hollow density, grassy woodlands and water resources, with the combination of these habitat values being of restricted patchy occurrence within the study area. No observations of this species were collected during the survey period despite the plethora of records 15-20 km to the east within Goulburn River National Park (DECC, 2008; BirdsAustralia, 2008). The local abundance of this species is likely to be substantially moderated by the low abundance of trees with hollows, extent of land clearing in productive landscapes and presence of feral cats.

Regional Abundance

The Turquoise Parrot is a western species generally west from a line between Jerry's Plains and Howes Valley, with only a few records further east. Most records appear to be associated with the southern escarpment of the Hunter Valley (i.e. Wollemi National Park and Yengo National Park) in association with footslopes and basalt (i.e. productive landscapes). These landscapes are restricted throughout this part of the region.

Impacts on Distributional Limits

The study area is not located at the distributional limits for this species and in this sense it is considered that the proposed coal mine is unlikely to have an impact on this species distribution.

Barking Owl (Ninox connivens)

Local Abundance

The Barking Owl has been recorded once within local area within Goulburn River National Park. It's preferred habitat is primarily throughout the valley floor and lower midslopes where foraging resources are greatest (e.g. woodland birds in woodlands and riparian zones). Despite the presence of suitable foraging resources such as woodland birds, its seemingly absent status is probably explained by the low tree hollow density throughout its preferred potential habitat areas and habitat fragmentation – particularly riparian environs. The local abundance is only likely to increase inline with the increased occurrence of nesting habitat.

Regional Abundance

The Barking Owl is almost absent from Permian geological formations in the Hunter Valley, with most records contained within Wollemi National Park and Werekata National Park. Regional abundance is probably an artefact of this species preferred western distribution and reliance on productive riparian corridors, many of which are overcleared within the Hunter region.

Impacts on Distributional Limits

The study area is located within a regional movement corridor aligned with the Goulburn River. The impacts on this movement corridor are considered minor for this species. It is considered that the proposed development would not adversely impact the distributional limits of this species.

Powerful Owl (Ninox strenua)

Local Abundance

The Powerful Owl is known to occur within the locality as it has been recorded during baseline studies and is also on various wildlife databases (DECC, 2008; Birds Australia, 2008). Potential foraging resources that exist within the study area are considered important to local populations, despite the patchiness of this resource. Should a Powerful Owl be a resident within the study area it is likely that its home would extent into either or both adjoining conservation reserves. Nesting is likely to be restricted to midslopes and ridgetops where connected habitats and tree hollows exist.

Regional Abundance

There is an abundance of Powerful Owl records within the HCR CMA region, with many contained within conservation reserves, particularly those formed on infertile geological formations such as Wollemi National Park and Goulburn River National Park.

Impacts on Distributional Limits

The local and regional abundance of this species in the context of its overall distribution would indicate a low likelihood for an adverse impact on the distributional limits of this species.

Brown Treecreeper (Climacterus picumnus)

Local Abundance

The Brown Treecreeper has been observed within the study area and locality, with the number of records implying a high local abundance.

Regional Abundance

A high number of Brown Treecreeper records occur within the region west from Raymond Terrace in the Lower Hunter Valley. There are many concentrated records within close proximity to the footslopes of the Wollemi National Park, Goulburn River National Park, Manoboli Nature Reserve, Yengo National Park and Werakata National Park with far fewer records from central districts within the Hunter Valley. The regional abundance appears affiliated with lands that adjoin productive landscapes where tree hollows still remain.

Impacts on Distributional Limits

The Brown Treecreeper is a widespread species generally of dry subcoastal and inland districts. The Ulan locality does not represent a distributional limit for this species. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits of this species.

Speckled Warbler (Pyrrholaemus sagittatus)

Local Abundance

The Speckled Warbler has been observed within the study area and locality, with the number of records implying a high local abundance. Vegetation of the site presents habitat advantages for this species such as increased shrub and grasscover density and height variability (i.e. structural complexity) thus affording protection from predictors and high ‘roughness’ promoting elevated insect populations for foraging. Suitable ground nesting areas are also present throughout the grassland/ shrubland/ woodland interface, particularly where grazing activities are absent (i.e. formation of grass tussocks and low shrubbery).

Regional Abundance

A high number of Speckled Warbler records occur within the region west from Buchanan in the Lower Hunter Valley. There are many concentrated records within close proximity to the footslopes of the Wollemi National Park, Goulburn River National Park, Manoboli Nature Reserve, Yengo National Park and Werakata National Park with far fewer records from central districts within the Hunter Valley.

Impacts on Distributional Limits

The Speckled Warbler is a widespread species generally of dry subcoastal and inland districts. The Ulan locality does not represent a distributional limit for this species. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits of this species.

Painted Honeyeater (Grantiella picta)

Local Abundance

The Painted Honeyeater has a seasonally high local abundance during the early summer months, with local occurrences coinciding with breeding cycles. Records are known from the upper and central Murragamba valley and Redhills property.

Regional Abundance

The Painted Honeyeater is a western species and as such has a limited occurrence within the HCR CMA. Only a handful of records occur within this region, with nearly all located outside the conservation reserve network. Nearly all records are from spring to summer indicating breeding activity within the region.

Impacts on Distributional Limits

The movement of Painted Honeyeaters from western districts to suitable habitat west from Warkworth (distribution limit) could potentially be impacted during mining operations, with medium to long term impacts moderated by rehabilitation works. This prediction is based on the proximity of the development to narrow movement corridors preferred by this species such as major rivers (e.g. Goulburn River).

Black-chinned Honeyeater (Melithreptus gularis gularis)

Local Abundance

Few records of the Black-chinned Honeyeater were recorded during the baseline studies, with most records associated with winter flowering White Box on basalt. Locally, it appears this species is dependant on high productive landscapes such as those characterised by basalt geological formations.

Regional Abundance

The Black-chinned Honeyeater appears to have a similar regional distribution to the Brown Treecreeper and Speckled Warbler (i.e. from the wester parts of the region to Werekata National Park in the Lower Hunter Valley). There are concentrated records within close proximity to the footslopes of the Wollemi National Park, Goulburn River National Park, Manoboli Nature Reserve, Yengo National Park and Werakata National Park with few records from central districts within the Hunter Valley.

Impacts on Distributional Limits

The Black-chinned Honeyeater is a widespread species generally of dry subcoastal and inland districts. The Ulan locality does not represent a distributional limit for this species. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits of this species.

Regent Honeyeater (Anthochaera phrygia)

Local Abundance

From database records it appears that the known local occurrence of the Regent Honeyeater is restricted to habitats east and southeast of the study area near Wollar and within Munghorn Gap Nature Reserve (DECC, 2008; Birds Australia, 2008). These local occurrences range from 5-25km east of the study area with no database records coinciding within the study area boundary or within potential habitats to the west and north. Detailed seasonal baseline studies completed for this project and monitoring surveys for the Ulan Coal Mine potentially implicate the study area as part of a boundary for the population known to use the Capertee Valley and Wollar districts. Notwithstanding, the habitats that this species occupies do occur within the study area (i.e. Western Slopes Grassy Woodlands), and as such imply the potential for an occurrence within this area.

Regional Abundance

Regionally, the Regent Honeyeater exhibits is its greatest abundances in the Wollar and Central Coast Districts, with occurrences in Widden Valley and Cessnock also regionally important. These locations are generally populated by this species in the autumn to winter months, with migrations to the Capertee Valley in the adjoining central tablelands districts to the south during late winter spring for breeding being a notable feature of this species lifecycle.

Impacts on Distributional Limits

The Regent Honeyeater exhibits a wide distribution from north coast NSW to corresponding inland districts south through to the central Victoria. Populations located at these distributional extremities are largely disconnected from the main Capertee Valley population. In this context, the proposed mine may have an impact on the potential for inter-regional dispersal between these populations, although there is not evidence to suggest that this would be of significance.

Gilbert's Whistler (Pachycephala inornata)

Local Abundance

The Gilberts Whistler has been observed once to the north of the study area within the Redhills property where it was observed in shrubby woodlands dominated by shrubby Scribbly Gum and Black Cypress Pine on deep sands, this indicating a local abundance linked with the distribution of "Murragamba Sands Woodland". These habitat values are restricted to the tertiary paleochannel throughout the northern part of the study area. The local density of this species is considered extremely low.

Regional Abundance

The Gilberts Whistler exhibits a western distribution west from the Warrambungles National Park. It is known to occur throughout dry scrubby habitats including those of the Piliga. Few records have been documented for the Sydney Basin Bioregion. As the primary distribution of the Gilberts Whistler is outside the Sydney Basin Bioregion, it is considered that the abundance of this species within this region is extremely low.

Impacts on Distributional Limits

The Gilberts Whistler is a widespread species western districts. The Ulan locality represents the eastern distributional limit for this species. It is considered that Stage 2 of the MCP could potentially have an impact on the distributional limits of this species.

Hooded Robin (Melanodryas cucullata)

Local Abundance

The Hooded Robin has been observed at five locality in the study area, with an additional observation of this species noted further to the north within EL6288. The local abundance of this species is intrinsically linked with grassy woodlands and water availability, with these values predominantly restricted to the overcleared valley floor and lower midslopes, with occasional usage of basalt caps also noted.

Regional Abundance

The Hooded Robin exhibits a similar regional distribution to the Brown Treecreeper and Speckled Warbler (i.e. from the wester parts of the region to Broke in the central Hunter Valley. There are concentrated records within close proximity to the footslopes of the Wollemi National Park and Goulburn River National Park particularly within riparian corridors of the main tributaries of the Goulburn River and Hunter Rivers. Few records exist in the central and northern districts of the Hunter Valley where land clearing and agriculture has had a significant impact on this species habitat.

Impacts on Distributional Limits

The Hooded Robin is a widespread species generally of dry subcoastal and inland districts. The Ulan locality does not represent a distributional limit for this species. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits of this species.

Grey-crowned Babbler (Pomatostomus temporalis)

Local Abundance

Few records of the Grey-crowned babbler exist within the locality, with most associated with naturally regenerating lands to the south or rehabilitated landscapes within the Ulan open cut rehabilitation area. One record has been collated from the study area (i.e. central Murragamba Valley), with repeat sampling failing to confirm habitat usage in this area.

Regional Abundance

The main distribution of this species within the HCR CMA region is within the subcoastal districts of the Hunter River Cessnock to Muswellbrook. Abundances within this area are variable, with high population densities recorded in the Singleton area west through the Jerry's Plains and Camberwell. The Hunter Valley is recognised as an important area of this species as its population within this area is not declining as rapidly as elsewhere throughout its NSW distribution.

Impacts on Distributional Limits

The Grey-crowned Babbler is a widespread species generally of dry subcoastal and inland districts. The Ulan locality does not represent a distributional limit for this species. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits of this species.

Diamond Firetail (Stagonopleura guttata)

Local Abundance

Numerous database records and records from the baseline studies would indicate the locality as having a high abundance of this species. The local abundance of this species appears restricted to the Permian geological formations on the valley floor where foraging resources occur in association with riparian environs that are required for breeding.

Regional Abundance

The Diamond Firetail exhibits a similar regional distribution to the Brown Treecreeper and Speckled Warbler (i.e. from the wester parts of the region to Broke in the central Hunter Valley). There are concentrated records within close proximity to the footslopes of the Wollemi National Park and Goulburn River National Park particularly within riparian corridors of the main tributaries of the Goulburn River and Hunter Rivers. Few records exist in the central and northern districts of the Hunter Valley where land clearing and agriculture has had a significant impact on this species habitat.

Impacts on Distributional Limits

The Diamond Firetail is a widespread species generally of drier inland districts. The Ulan locality does not represent a distributional limit for this species. Stage 2 of the MCP is not unlikely to have an impact on this species distributional limit.

Spotted-tailed Quoll (Dasyurus maculatus)

Local Abundance

Few records of this species occur within the upper Hunter Valley, with most records occurring in the east and north of this region. No known records occur within the study area or locality.

Regional Abundance

On the strength of records alone, it is considered that the Spotted-tailed Quoll is abundant in the region, particularly in the northeast where moist productive forests are widespread. The western parts of the Hunter have fewer records, partly owing to reduced ecological survey in this area, but mainly due to the extent of habitat clearing for agriculture. Records appear to end within Wollemi National Park, with no records west from Bylong.

Impacts on Distributional Limits

The Spotted-tailed Quoll is a widespread species from the western slopes to eastern coastal districts. Distributional limits occur further west from the study area, with the impacts of Stage 2 of the MCP unlikely to have an impact on this species distributional limit.

Squirrel Glider (Petaurus norfolcensis)

Local Abundance

Numerous records of the Squirrel Glider occur to the north of the study area within lands managed by Ulan Coal. The abundance of this species in that area is not known.

Regional Abundance

The Squirrel Glider is a species that requires a rich array of resources to form viable populations, with these habitats traditionally found in productive fertile drainage lines and lower slopes where habitat resources are likely to exist (e.g. tree hollows, seasonal nectar, insects, sap). The effects of agriculture on this landscape have been pronounced (i.e. fragmentation, reduced patch size, tree hollow removal and vegetation simplification), thus affecting the regional distribution and abundance of this species.

In western districts, this species appears to have contracted to riparian habitats of the major tributaries of the Goulburn River where habitat removal has been limited. The broader habitat values that were likely throughout the central Hunter Valley are heavily influenced land clearing and have thus effectively reduced regional abundances in these area. Coastal stronghold remain important to the regional abundance of this species including populations throughout Wyong and Lake Macquarie.

Impacts on Distributional Limits

The Squirrel Glider is a widespread species of inland and coastal districts. The Ulan locality does not represent a distributional limit for this species. Stage 2 of the MCP is not unlikely to have an impact on this species distributional limit.

Brush-tailed Rock-wallaby (Petrogale pencillata)

Local Abundance

One record of this species occurs to the north of the study area, with record collected in 2001 indicating the potential presence of a small population within the locality. The abundance of this species in the locality is likely to be low.

Regional Abundance

The Brush-tailed Rock-wallaby exhibits a discrete disjunct distribution throughout the HCR CMA region, with concentrated records occurring near Martindale, Jerry's Plains, Pokolbin, Wollemi National Park and Manoboli Nature Reserve. Abundances is generally linked to the presence of rocky habitats that are relatively undisturbed by the influence of predators and other human influences.

Impacts on Distributional Limits

The Brush-tailed Rock Wallaby exhibits a disjunct distribution along the NSW eastern seaboard. Most populations are now isolated from each other, with intervening land developments only partially responsible for this disconnected distribution (e.g. predation by the fox and feral dog considered on of the main factors for the decline of this species). The proposed Stage 2 of the MCP would not further exacerbate the main casual factors of species decline and would thus not adversely impact the distributional limits of this species.

Large-eared Pied Bat (Chalinolobus dwyeri)

Local Abundance

A number of local records exist for the Large-eared Pied Bat within the locality (DECC, 2008), which is confirmed by baseline survey results which included the capture of this species in the upper Murragamba Creek catchment. There appears to be a relatively high abundance of this species within the locality when compared to the region in general.

Regional Abundance

The Large-eared Pied Bat exhibits a subcoastal and inland distribution west from the Cessnock area, with numerous records contained within the HCR CMA region. Regional abundance appears to be strongly associated with conservation reserves dominated by Triassic geological formations (i.e. Wollemi National Park and Goulburn River National Park) where roosts are known to occur. Discontinuity in database records is likely to be attributed to the absence of roost sites rather than any other factor.

Impacts on Distributional Limits

The Large-eared Pied Bat is a widespread species generally of inland dry tableland and western slopes districts. The Ulan locality does not represent a distributional limit for this species. Stage 2 of the MCP is not unlikely to have an impact on this species distributional limit.

Little Pied Bat (Chalinolobus pictus)

Local Abundance

One record of the Little Pied Bat was collected during the baseline surveys, with this record collected from habitats contained within the Redhills property in the north of the study area.

<u>Regional Abundance</u>

No database records other than for that collected from the study are known from the HCR CMA region.

<u>Impacts on Distributional Limits</u>

This species is at its southeastern limit of distribution within the HCR CMA region. Impacts on this species within the locality have the potential of disrupting and/ or impacting the distributional limits of this species.

Eastern Bentwing Bat (Miniopterus shreibersii)

<u>Local Abundance</u>

Five database records of the Eastern Bentwing Bat occur within the locality, which were collected during baseline studies for the EL6288 with most of these located adjacent the study area to the south and north. An analysis of these records would indicate this species prefers riparian vegetation presumably due to the occurrence of rich foraging resources, with the spatial distribution of these habitat values being of restricted occurrence and largely peripheral to the site (e.g. Wilpinjong Creek). Potential roost sites exist within the wider locality, with the likelihood of these being maternity roosts being very unlikely.

<u>Regional Abundance</u>

The Eastern Bentwing Bat exhibits a coastal and subcoastal distribution east from the Great Dividing Range, with numerous records contained within the HCR CMA region. Regional abundance appears to be strongly associated with conservations reserves dominated by Triassic geological formations where roosts are known to occur. Discontinuity in database records such as those between Singleton and Maitland would indicate the absence of roost sites within these areas rather than decline.

<u>Impacts on Distributional Limits</u>

The Eastern Bentwing Bat exhibits a coastal and subcoastal distribution east from the Great Dividing Range, with the study area located nearby the western limit of distribution for this species. It is considered that Stage 2 of the MCP may potentially have an impact on the distributional limits of this species during the mining operations.

Eastern Long-eared Bat (Nyctophilus timorensis)

<u>Local Abundance</u>

The Eastern Long-eared Bat was recorded from one location within EL6288 as part of the baseline studies, in a small patch dominated by Blakely's Red Gum Woodland. Other known locations include similar habitats within the 'Redhills' property to the north adjacent the Goulburn River National Park.

<u>Regional Abundance</u>

The Eastern Long-eared Bat is known to occur in the Goulburn River National Park, Wollemi National Park and Manoboli Nature Reserve, with regional records indicating an abundance linked to these reserves and similarly large infertile vegetated landscapes west from Muswellbrook.

<u>Impacts on Distributional Limits</u>

This species is approaching its southeastern limit of distribution within the HCR CMA region, with numerous records occurring within Goulburn River National Park and Manoboli Nature Reserve to the east. Impacts on this species within the locality have the potential of disrupting and/ or impacting this species with the resultant impact on distributional limits considered unlikely.

Yellow-bellied Sheath-tail Bat (Saccolaimus flaviventris)

<u>Local Abundance</u>

The Yellow-bellied Sheath-tail has been recorded during baseline studies and fauna surveys to the east within the Wilpinjong coal mine area. The local abundance would indicate the study area as being an important location for this species.

Regional Abundance

Numerous records of the Yellow-bellied Sheath-tail Bat occur throughout coastal and subcoastal districts of the HCR CMA region. It appears to favour the landscapes formed on the Permian geological formation, with the extent of land clearing throughout this landscape potentially having the effect of reducing regional abundances.

Impacts on Distributional Limits

The Yellow-bellied Sheath-tail Bat is a widespread species of inland and coastal districts. The Ulan locality does not represent a distributional limit for this species. It is considered that Stage 2 of the MCP is unlikely to have an impact on the distributional limits of this species.

11.1.4.How is the proposal likely to affect current disturbance regimes?

Secondary Grasslands and Shrublands

Anthropogenic and exacerbated disturbance regimes are at their greatest within the secondary grasslands and shrublands of the study area. Livestock grazing for most parts of the study area continues, which acts to suppress the recovery of biodiversity and habitat complexity. Slashing of Sifton Bush (*C. arcuata*) is another example of ecological succession being disturbed (i.e. the recovery of vegetation structure and floristics). Also there currently is an increased risk of predation for woodland birds within these habitats through the presence of feral cats, foxes and native raptors.

Mining will potentially concentrate these impacts as it progresses through the landscape, thus potentially intensifying the action of some of these disturbance regimes (e.g .predation). In this respect, it is considered that proactive mitigation is required to minimize the impact of these disturbance regimes such as feral animal control programs particularly for feral cats and foxes, although a wider application to feral goats, pigs and dogs may also be warranted.

Western Slopes Grassy Woodlands

Forest and woodlands located on the Permian geological formation are influenced by a raft of current disturbance regimes including livestock grazing, unregulated vegetation clearing (e.g. firewood harvesting), erosion and feral fauna populations including goats, cats, pigs, European Fox and Rabbit. As this area is to be permanently modified by open cut mining, it is considered that the effects of these current disturbance regimes would also be removed from the landscape with the passing of open cut mining operations. Should proactive management actions be successful in limiting the re-occurrence of these influences, it is considered that that post mining landscape will contain a reduced extent of the mentioned disturbance regimes.

Western Slopes Dry Sclerophyll Forest

Forests and woodlands located on the Triassic geological formation are influenced by few current disturbance regimes. Perhaps the greatest impact on these vegetation formations is the presence of feral fauna populations such as goats, cats and pigs where herbivory and predation is having an adverse impact on native flora and fauna. In consideration of the project as a whole, which includes the proposed impact management strategies, it is considered that the project would have a positive impact on these current disturbance regimes. Proactive management of feral fauna populations would have a lasting positive impact on the biodiversity values contained within this landscape.

As is the case for Western Slopes Grassy Woodland, it is considered that there will be limited re-occurrence of the current disturbance regimes within the forests and woodlands classified as Western Slopes Dry Sclerophyll Forests, particularly those formed on the Permian geological formation. This is supported by the usage of specific rehabilitation techniques and proactive management works.

11.1.5.How is the proposal likely to affect habitat connectivity?

A landscape approach has been adopted to assess the projects impact on habitat connectivity.

In general, the impacts of mining on habitat connectivity will be most pronounced by open cut operations, with underground mining having limited relatively inconsequential impacts. Sequenced mining would have some benefit in limiting the loss of habitat connectivity during the mine life, with the benefit of this sequenced mining reducing over time. However, the recovery of rehabilitated surfaces would not offset the overall medium term impacts.

Secondary Grasslands and Shrublands

The majority of secondary grasslands and shrublands are located within the open cut mining area and will therefore be permanently removed from the Murragamba Valley. Whilst the loss of vegetation cover in its current form is of minor consequence its potential to be upgraded to native vegetation would be lost. In this respect these secondary grasslands and shrublands offer a potential buffer to peripheral areas of intact vegetation and habitat from disturbance regimes fostered by agricultural landuses. The influence of these losses could affect lifecycles dependant on these peripheral habitat areas (i.e. woodland birds) through, for instance, an increased risk of predation or decreased access to foraging grounds.

These issues are addressed through widespread revegetation works for cleared lands such as those classified as secondary grasslands and shrublands, with the spatial context for these revegetation works having no regard for the impacts of future mining. The revegetation of secondary grasslands and shrublands with native species is proposed as part of a deliberate topsoil and seedbank improvement strategy, with the temporary benefits derived from these works considered to offset the sequential impacts of open cut mining.

Western Slopes Grassy Woodlands

The proposed open cut mining would remove a large quantum of grassy woodlands relative to the locality, with considerable spatial disjunctions occurring between residual vegetation cover as a consequence. Movement pathways will be lengthened by the open cut mining through the central parts of Murragamba, with traverse distances across the mined landscape being hostile to many fauna species, particularly threatened species.

Movement through the landscape would contract to residual vegetation located near the Triassic outcrop, where grassy woodlands are generally absent except for isolated places where basalt influences occur. Reduced foraging resources and/or increased competition for these resources, decreased vegetation cover and increased predation are predicted.

Western Slopes dry Sclerophyll Forest

Connectivity through vegetation classified as Western Slopes Dry Sclerophyll Forests would experience minimal disturbance, with the greatest impact on connectivity restricted to the lower footslopes where open cut mining will partly displace this vegetation cover. However, movement between habitats contained within this vegetation and offsite localities of similar character (e.g .movements between Goulburn River National Park and Munghorn Gap Nature Reserve) would be affected by mining impacts on Murragamba Sands Woodland.

Murragamba Sands Woodland

The Murragamba Sands Woodland is an isolated vegetation formation restricted locally to the lower Murragamba and Eastern Creeks. The vegetation shares similarities between Western Slopes Grassy Woodlands and Dry Sclerophyll Forests and as such could act as a movement pathway for threatened species that occupy or utilize habitats within either vegetation class.

The removal of this vegetation would have an impact on connectivity between Goulburn River National Park and Munghorn Gap Nature Reserve. Progressive mine site rehabilitation with the objective of creating self sustaining native vegetation cover is required to minimize these impacts of the long term, with targeted revegetation works throughout proximal unaffected lands also required to facilitate this objective.

11.1.6. How is the proposal likely to affect critical habitat?

No areas of mapped critical habitat as gazetted under the TSC Act occurs, overlaps, adjoins or is connected in any meaningful way to the impacts posed by the proposed development.

11.2. State Environmental Planning Policy No. 44 – Protection of Koala Habitat

At a landscape level only certain vegetation formations are considered to form potential koala habitat these being Grassy White Box Woodland and Shrubby White Box Woodland. Both of these vegetation formations will experience direct (2.95 ha – Grassy White Box Woodland) and indirect impacts (25.18 – Shrubby White Box Woodland; 79.15 ha – Grassy White Box Woodland) as a consequence of mining as well as no impacts (9.88 ha – Grassy White Box Woodland). Vegetation containing another preferred foraging species, Grey Gum (*E. punctata*), is not considered potential habitat as these vegetation formations do not contain on average densities of this species exceeding 15%.

Over the short term these impacts will serve to reduce the extent of potential habitat. However, in the absence of core hatbiat values, as defined by habitat containing known activity by the koala, it is considered that the impacts of mining would be restricted to potential habitat only.

Over the longterm both revegetation and rehabilitation works would seek to increase the overall quantum of vegetation cover containing the preferred foraging species White Box, thus reversing the magnitude of these impacts over time. The extent of other preferred foraging species such as Grey Gum (E. punctata) would remain intact throughout the period of mining, thus having no dicernable impact on local potential habitat for this species.

In the absence of known activity it is considered that the study area only constitutes potential koala habitat, which over the longterm would not be negatively impacted by mining. As no areas of core habitat ae to be impacted by mining it is considered that no management plans prepared under SEPP44 are required for the further consideration of this mining proposal.

11.3. EPBC Act

The list of Protected Matters relevant to the project (e.g. those forming or potentially forming important populations within habitats of the study area), as defined by a review of the Protected Matters Search (May, 2008) in conjuction with the interpretation of baselines studies, is identified as follows:

- **Large-eared Pied Bat;**
- Eastern Long-eared Bat;
- Regent Honeyeater;
- Swift Parrot;
- Brush-tailed Rock Wallaby;
- Spotted-tailed Quoll; and
- **White Box Yellow Box Blakely's Redgum Woodland and Derived Grasslands (WBYBBRW CEEC).**

Species or communities identified in bold have known occurrences within the study area and are considered important populations in the context of this assessment.

The 'Significant Impact Guidelines' (DEH, 2006) has been considered in the preparation of this referral for the above listed species and communities. The following is offered in response to an impact on an 'important population' for the above listed.

Lead to a long-term decrease in the size of an important population of a species

The productive landscapes of the study area support WBYBBRW and Derived Grasslands CEEC, particularly those within riparian areas, this representing the main ecological community supporting most of the above listed protected matters. Site and local surveys, combined with the literature, indicate that a loss of riparian vegetation thus connectivity will adversely affect the capacity of microchiropteran bats to move and forage through the landscape. The availability of rich nectar supplies associated with productive landscapes will also be locally adjusted thus impacting woodland birds. Top order predators such as the Spotted-tailed Quoll would experience reduced foraging resources and potentially increased completion with feral fauna such as the fox. Unmitigated the development will lead to a long term decrease in the size of important populations.

Reduce the area of occupancy of an important population

Mining over the short term would in effect reduce the area of occupancy of most important populations known or potentially occurring within the site (i.e. loss of riparian corridors, native vegetation cover and biodiversity hotspots). Proposed are long term initiatives designed to establish a maintain outcome for important local populations in response to the permanent impacts of mining. However the temporal implications of mining induced impacts could inevitably conflict with the minimum habitat needs of important local populations thereby potentially resulting in local extinctions prior to the influence of positive impact management responses. This is particularly the case for species residing within the permanent impact zone such as the Long-eared Pied Bat (i.e. occupies cave roosts).

Fragment an existing important population into two or more populations

Sequential mining over a 21 year period is expected to alter foraging and movement behaviours for mobile species (i.e. microchiropteran bats and birds). In this regard avoidance strategies have been used to integrate within the sequenced mining activities spatially important biodiversity hotspots designed to act as refuge habitat during and after the passing of mining activities. The long term role of such areas is designed to accelerate the re-establishment of ecological function (e.g. viable foraging areas, connectivity, core breeding zones). However, in the short term mining may still potentially sever local important populations.

Evidence from the baseline studies and those conducted as part of the monitoring program for the nearby Ulan coal mine indicates the existing fragmented valley floor landscape as having limited effect on habitat usage by microchiropteran bats such as the cave roosting species. Notwithstanding, it is expected that the effect of mining on the landscape will be substantial and would potentially have the capacity to sever populations particularly in light of cumulative habitat losses throughout the locality. Thus great emphasis will be placed on mitigation actions involving the revegetation and rehabilitation of lands to pre-empt and/or coincide with the impacts of sequenced mining works.

Adversely affect habitat critical to the survival of a species

Biodiversity hotspots identified within the study area represent key habitat areas critical to the survival of most listed species and/or communities subject to the impacts of this development (e.g. WBYBBRW and Derived Grasslands CEEC). These areas supply reliable and locally important resources such as trees with hollows, grassy landscapes, water resources, high value nectar, elevated insect populations with the decreased quantum and reliability of these resources potentially having substantial affect.

A selection of biodiversity hotspots are proposed to be permanently removed, whilst others will be retained with some of these indirectly impacted by longwall mining. Through the use of avoidance techniques, a spatially diverse network of biodiversity hotspots has been created for the purpose of acting as refuge habitat and source biodiversity for landscape recovery.

In the short term, the losses attributed to the mining activity are likely to adversely affect the availability and quality of habitat critical to important populations. Mitigation is required to minimise this disruption involving actions such as the enhancement of existing native vegetation, revegetation of excluded cleared lands, weed and feral animal management, fire management and strategic rehabilitation to reconnect biodiversity hotspots.

The successful implementation of impact management works is predicted to minimise the long term impacts through re-establishing similar ecological function (i.e. maintain outcome). Perceived improvements in ecological function are expected to be realised through increased native vegetation cover (i.e. areas of rehabilitation and revegetation), with the sustained retention of these values linked with stable ecological function founded on environmental gradients important to the locality (i.e. soil fertility and water resources).

Disrupt the breeding cycle of an important population

In the case of this development it is considered that a significant disruption of breeding cycles for important populations such as the Large-eared Pied Bat would eventuate over the short term through the loss of box gum woodlands. Sequenced mining will partly minimise the totality of these impacts through timed revegetation and rehabilitation works included targeted reinstatement/ introduction of specific habitat features (i.e. tree hollows). In this context it is considered that the development will not completely remove the local population but may seriously impinge on reproductive events and/or success.

While the extent of genetic transfer between important populations is not known, it is reasonable to assert that the scale of development is substantial particularly when compared with the expanse of retained known/ potential habitat over the short to medium term. Accordingly, it is considered that the proposed development has the potential to disrupt the breeding cycle of an important population.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed development will destroy foraging habitat for the cave roosting microchiropteran bat species and potential foraging/ breeding habitat for Regent Honeyeater, Swift Parrot Spotted-tailed Quoll. Ecological function supporting the formation of WBYBBRW and derived grasslands CEEC will be permanently destroyed (i.e. open cut mining), with some areas defined by this CEEC indirectly impacted by underground mining.

Short term impact management strategies are proposed such as revegetation works over lands controlled by MCMs, which are to be mined and unmined, in addition to the dedication of offsets to the conservation nreserve network. Medium to long term strategies include the rehabilitation of the mined landscape predominately with WBYBBRW and derived grasslands CEEC species in a manner designed to restore vegetation cover consistent with this CEEC. Revegetation works and other enhancement strategies will apply to indirectly impacted landscapes as well as revegetated landscapes (i.e. weed management).

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

There is a potential for the introduction of invasive species into habitat utilised by vulnerable species as a consequence of the proposed development. This potential is to be minimised by proactive measures such as vehicle wash downs, weed management and feral animal control.

Introduce disease that may cause the species to decline

No disease that may cause the species to decline is expected to be introduced into the habitat occupied/ utilised by threatened species as a consequence of the proposed development.

Interfere substantially with the recovery of the species

The cumulative impact of the proposed development is likely to interfere with the recovery of WBYBBRW and Derived Grasslands CEEC for the Sydney Basin Bioregion and local area. Local conservation outcomes are planned for this CEEC, however the net loss of WBYBBRW and Derived Grasslands CEEC from the area and more importantly the permanent loss of associated ecological function as a consequence of open cut mining cannot be reversed.

Remnants retained in the landscape will continue to act as important and potentially viable habitat areas for local biodiversity. However, the sensitivity of these remnants to stochastic events is increased, thus increasing the potential for localised extinctions arising from unplanned and/or unpredicted events.

11.3.1. Significance Analysis

The nature and magnitude of the development's impact has considered the following matters to determine whether a referral to the Department of Environment and Water Conservation is necessary.

Table 45: NES Matters

All on site and off site impacts	Permanent removal of WBYBBRW and derived grasslands. Large loss of intact native vegetation, including known and potential habitat for matters of NES. Offsite impact including temporal impacts on wildlife connectivity and cumulative impact on valley floor vegetation. High risk of adverse local impacts.
All direct and indirect impacts	Impacts include permanent direct impacts resulting from infrastructure placements and open cut mining. Indirect impacts include noise, dust, vibration and affects of subsidence.
The frequency and duration of the action	The proposed development is planned to be a single event spanning over 21 years and will be permanent.
The total impact which can be attributed to that action over the	High.

entire geographic area affected	
The sensitivity of the receiving environment	The sensitivity of the receiving environment is high. Areas of higher sensitivity will be permanently removed along with supporting ecological function. Native vegetation corridors will be temporarily compromised by site development.
The degree of confidence with which the impacts of the action are known and understood	A high degree of confidence is placed on this assessment.

In the absence of impact management it is concluded that there is a high risk for an adverse impact on matters of National Environmental Significance. However, when considering the impacts of the development in association with the impact management strategies defined within **Section 10** of this report it is considered that there will be long term sustainbable landscape recovery embodying ecological function thus restoring the habitat values lost during mining. The key to this prediction is the sequential revegetation/ rehabilition works conducted in step with habitat loss combined with immediate offsets for habitat loss.

12. CONCLUSIONS

12.1. Summary of Impacts of Proposal upon Key Assessment Criteria

12.1.1. Threatened Species, Populations, Ecological Communities and their habitats

Threatened Plants

One threatened flora species occurring as a natural population has been located within the study area, this being the endangered State listed *Pomaderris queenslandica*. One record was collected adjacent to the western margin of O/C 4 and U/G 2. Indirect impacts are likely but manageable, particularly given the predicted retention of the plant, its associated habitat and presence of additional unaffected known habitat nearby to the north adjacent the Goulburn River National Park, which is soon to be dedicated to this park as part of the approval for Stage 1.

A second threatened plant species known as Wallangarra White Gum (*Eucalyptus scoparia*) was identified centrally within the Murragamaba Valley and as such would be removed as a consequence of open cut mining. This species has been widely cultivated for roadside plantings since the 1970's with its natural habitat restricted to skeletal granite soils of the northern tablelands near the Queensland border at altitudes exceeding 800 m. Only one specimen of this species has been recorded at this stage with its proximity to the old school and historic regional road network potentially implying its occurrence as an planted population that is not within the context of viable habitat. The NSW Herbarium confirmed the identification and considered it to be a cultivated specimen.

No other threatened flora species are known to occur within the study area. Targeted searches for locally occurring threatened species such as Cannon's Stringybark (*Eucalyptus cannonii*), Ausfeld's Wattle (*Acacia ausfeildii*), Hoary Sunray (*Leucochrysum albicans var tricolor*), Painted Diuris (*Diuris tricolor*) and potentially occurring species such as the Tiger Orchid (*Cymbidium canaliculatum*)*, Swainsona recta* and *Ozothamnus tessellatus* failed to detect any known habitat/ populations within the impact area. Whilst it is recognised that potential habitat exists for these species within the study area, recent studies of the locality confirm the low likelihood of known habitat occurrences within the impact area (Kinhill, 1983; International Environmental Consultants, 2005; Resource Strategies, 2005; Cumberland Ecology, 2005).

Threatened Fauna

Numerous threatened woodland bird and microchiropteran bat species are known to occur within the study area, with the known habitat of the Hooded Robin, Brown Treecreeper, Diamond Firetail, Large-eared Pied Bat and Painted Honeyeater considered particularly vulnerable to the mining impacts. Mining would almost completely remove the habitat of the Hooded Robin, when considering the impacts in totality, with habitat loss suffered by the other species considered significant particularly when incorporating cumulative impacts. Impact management is required with substantial importance placed on early revegetation works of peripheral cleared unaffected lands, revegetation works of cleared lands that are to be proposed to be mined (buffering affect), mine sequencing (i.e. clearing works) and progressive mine site rehabilitation using specific methods to enhance habitat recovery.

Endangered Populations

No endangered populations or their habitats would be knowingly impacted by the proposed development.

White Box Yellow Box Blakely's Red Gum Woodland EEC

Stage 2 of the MCP will result in the removal of native vegetation including areas classified as White Box Yellow Box Blakely's Red Gum Woodland and Derived Grasslands EEC/ CEEC. Approximately 157 ha of this EEC/ CEEC are to be permanently removed by direct surface activities with approximately 88 ha to be indirectly impacted by underground mining leaving an unaffected residual of approximately 50 ha within the study area. It is proposed to offset the direct permanent loss of this EEC/ CEEC by dedicating like for like vegetation to the local conservation reserve network, with the quantum of this dedication to be determined by the consent authority and relevant government agencies (i.e. DECC). Other primary actions include revegetation works of cleared lands described as Secondary Grasslands and Shrubland under the control of MCMs (i.e. up to 174 Ha) and assisted recovery of at least 46 ha of Grassy White Box Woodlands on basalts in grassland or shrubland condition.

One particularly neglected but important area containing biodiversity assets are road corridors such as those of the Mid-Western Region local government area where this EEC/ CEEC is known to occur and is constantly under threat of degradation and/or unmitigated removal. Actions are proposed for this area including quantification of these assets, threats and management works.

A secondary objective is the rehabilitation of the inpit overburden dumps using long term sustainable mechanisms that promote the re-establishment of ecological function conducive to the occurrence of Box-Gum Woodland species. This combined with other revegetation works will result in estimated 1,700 ha of establishment native vegetation thus achieving over the long term a net increase of native vegetation cover by up to 800 ha. These works are aimed at addressing the overall local cumulative loss of valley floor habitats from mining and agricultural activities, with the intention of improving wildlife linkages throughout the landscape an expected positive outcome.

12.2. Cumulative Impacts

The proposed open cut mine represents the main component in the consideration of cumulative impacts. The action of open cut mining would result in the permanent loss of ecological function at the local level, which may be restored in part by the revegetation of peripheral cleared lands and use of specific rehabilitation methods to sustainably restore habitat values (i.e. addressing surface interception of groundwater resources in rehabilitated landscape). The scale of the impacts within the Murragamba valley when combined with other local coal mining works is substantial and must be considered significant in terms of woodland bird habitat loss.

Periperal landscapes retained post mining would be predominantly sink biodiversity areas with limited capacity to harbour threatened woodland bird species particularly given their requirements for fertile productive landscapes. Rehabilitaiton works seeking to sustainably integrate fertile landscapes with water resources would be required to increase the carrying capacity of these peripheral lands, with the successful mimicking of these environmental gradients throughout the rehabilitated landscape considered important in the longterm management of cumulative impacts.

12.3. Evaluation of Proposal against Key Thresholds

"*Whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts will maintain or improve biodiversity values*."

Land clearing for open cut mining and infrastructure will result in direct impacts on vegetation cover including disturbed landscapes and intact native vegetation. The more pronounced impacts are on woodlands and forest containing various species of Box and Ironbark throughout the valley floor (i.e. open cut operations), the resultant impact being permanent. This area is recognised as a high priority for avoidance.

The avoidance of selected vegetation remnants containing White Box, Yellow Box and Blakely's Red Gum Woodland and derived grasslands EEC/ CEEC has consequently resulted in the retention of some important biodiversity 'hotspots', these being important in accelerating the recovery of ecological function hence biodiversity. Revegetation works with plant species consistent with the valley landscape will be a priority action at the onset of mining activities, with the extent of these works to encompass all suitable lands under the control of MCMs (e.g. secondary grasslands and shrublands including those that are to be mined).

These actions will assist the restoration of wildlife corridors, particularly throughout the midslopes and lower elevations where Box Woodlands have historically been cleared for agricultural purposes. Given existing disturbance regimes, it is considered that the MCP represents an opportunity to improve local biodiversity values in the long term by re-establishing ecological function in currently disturbed landscapes through increasing native vegetation cover and removal of current land management practices.

Of particular importance is the sequential management of land clearing activities. Vegetation will be cleared progressively from the southern reaches or headwaters of Murragamba Creek (i.e. cleared lands adjacent to the Munghorn Nature Reserve), with ensuing mining operations moving north then east over a

21 year period. Progressive rehabilitation using native vegetation would subsequently follow the completion of in pit overburden and topsoil placements to reduce the temporal impacts of land clearing events. Detailed design for overburden placements would be investigated such as the consideration of heterogeneous layering in places and contouring to increase the likelihood of vegetation recovery and ecological succession. Peripheral biodiversity hotspots that are to be retained in the landscape together with peripheral revegetated lands would substantially aid the successful rehabilitation of mined areas.

Immediate actions including the dedication of 'like for like' vegetation formations, particularly those consistent with listed EECs/ CEECs, to the conservation reserve network will improve long term conservation security of native vegetation.

In the short term, biodiversity values will be detrimentally affected by the extent of land clearing works. Early revegetation works, combined with the avoidance and sequential mining strategies, will reduce the temporal effects of land clearing and maximise the speed of habitat restoration, with the medium to long term outlook (*i.e.* 25 years +) expected to deliver a maintain biodiversity outcome for the locality. This prediction has also considered the benefits of eliminating/managing disturbance regimes that are currently negatively impacting the existing environment.

Some individual fauna species may be lost and/or some local populations may be lost in the short to medium term. However, the sequentially revegetated landscape using specific rehabilitation techniques favouring the re-introduction of most fauna groups will in the long term provide sufficient areas for viable populations to occur. Under these terms it would be expected that the study area would be recolonised by 'lost' species in time, assuming habitat restoration remains connected with refuge populations.

"*Whether or not the proposal is likely to reduce the long-term viability of a local population of the species, population or ecological community*."

The extent of open cut mining impacts is restricted to lands where no known naturally occurring threatened flora species occur (i.e. suspected planted specimen of *Eucalyptus scoparia*). Extensive surveys have targeted all expected and predicted threatened flora species within the impact area, with no success. However, there are a number of threatened flora populations within the district and it is recognised that potential habitat for these species contained within the open cut void will be permanently lost. No attempt will be made to specifically recovery lost potential habitat due to the complexities associated with recreating natural ecological process, however effort to increase ecological complexity during the rehabilitation program may inadvertently have desirous effects.

The loss of White Box Yellow Box Blakely's Red Gum Woodland EEC/ CEEC will represent in the short term a loss of important vegetation cover and fauna habitat, particularly for threatened woodland birds. These impacts will be permanent, with effort to avoid, minimise and offset designed to establish an overall 'Maintain and Improve' outcome at the local and regional level respectively.

Mimicking environmental gradients/ factors that lead to sustainable ecological function consistent with existing conditions within the local area represents a realistic objective in light of the proposed impact management approach. Rehabilitation works would integrate the main environmental gradients into the modified landscape to increase the certainty of creating a sustainable functioning environment. Overburden placement will designed to maximise water infiltration and groundwater flows. Linkages between retained biodiversity hotspots and rehabilitated landscapes will be strengthened by proactive management works, thus maximising the benefit of these proximal excluded landscapes. Considerations such as nutrient cycling and flow will also feature in the design of overburden placements, which will include the integration of heterogeneous layering. Benefits to fauna populations would occur in the longer term as a consequence of habitat complexity returning in line with the predicted re-introduction of ecological function.

"*Whether or not the proposal is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction*."

The MCP is unlikely to result in the acceleration of local plant extinctions. Intensive targeted surveys failed to identify any threatened plant populations within the open cut and/or on top of the underground mining areas. Whilst potential habitat will be impacted, there is evidence to suggest that these habitats are of limited value for locally occurring threatened plants (Kinhill & Associates, 1983; International Environmental Consultants, 2005; Moolarben Biota, 2006; Cumberland Ecology, 2005).

The endangered *Pomaderris queenslandica* was detected at a location adjacent to the central western margin of O/C 4 and eastern margin of U/G 1. One specimen was observed with its position outside the direct impact zones of the open cut mine; however would be indirectly impacted by subsidence. A second specimen has been observed in similar habitat adjacent to Goulburn River National Park, with this location unaffected by the proposed mine development. It is predicted that the development will not accelerate the extinction of this or other threatened plants known to occur within the locality.

In relation to White Box Yellow Box Blakely’s Red Gum Woodland EEC/ CEEC, it is considered that the proposed short-term impact minimisation works through avoidance, dedication to the conservation reserve network and revegetation will secure the ongoing presence of this EEC/ CEEC within the Murragamba valley.

Progressive rehabilitation involving the mimicking of environmental gradients supportive of base ecological function is an objective equal importance. Processes aiding the establishment of structure and floristics consistent with White Box Yellow Box Blakely’s Red Gum Woodland EEC/ CEEC represents a focal goal with the success of this strategy leading to a localised improve outcome. For areas subject to rehabilitation this objective is reliant on the re-establishment of this base ecological function where the integration of water resources with soil fertility is paramount. Thus, should ecological function that currently support the occurrence of White Box Yellow Box Blakely’s Red Gum Woodland EEC/ CEEC within the Murragamba valley not be mimicked within rehabilitated landscapes, then the potential for the reduced re-establishment of White Box Yellow Box Blakely’s Red Gum Woodland EEC/ CEEC is a probable outcome.

The primary objective is to achieve at least a maintain outcome for the local area, with many ‘improve’ outcomes to be administered at a regional level. Numerous opportunities exist at this scale to minimise existing unacceptable levels of risk to intact native vegetation, particularly remnants classified as belonging to the White Box Yellow Box Blakely’s Red Gum Woodland EEC/ CEEC. Dedication to the conservations reserve network and proactive management represent the two focal methods for achieving the regional improve objective, with community education being a subset of these actions. It is anticipated that through a co-ordinated long-term impact management strategy of this design that indirect benefits will be attained through voluntary community involvement arising from increased community awareness.

“*Whether or not the proposal will adversely affect critical habitat*”

The proposed mine would not directly impact any areas declared as critical habitat as listed under the TSC Act, FM Act or EPBC Act

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Warrumbungles population from Part 2 of Schedule 1 (Endangered Populations) of the Act, and also omit reference to the Brush-tailed Rock-wallaby,*Petrogale penicillata* (Gray, 1825) from Schedule 2 (Vulnerable Species) of the Act. Listing of endangered species is provided for by Part 2 of the Act.

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APPENDIX 1

Details of Fauna Survey Methods

1 SURVEY METHODS, SEASONS AND EFFORT

Table 1.1 Targeted bird survey methods, seasons and effort.

Method	Season	Effort
Quantitative bird searches conducted at flora quadrat sites. Birds detected visually and aurally. Surveys timed for 20 minutes per 4 ha area, if new species found within last 10mins then survey continues, up to 1 hour.	summer ‘04 autumn ‘05 winter ‘05 early spring ‘05 late spring ‘05	6:50 person hours_8:35 person hours 28 surveys; 18:20 person hours 9 surveys; 14:10 person hours 3 surveys, 4:00 person hours 6 surveys; 12:50 person hours
Non-quantitative targeted bird surveys	winter ’05 . early spring ’05 . late spring ’05 .	Search at selected water body – 1 site, 0:10 hours Driving to known areas of Mistletoe in search of Painted Honeyeaters. Search at selected water body - 1 site, 0:10 hours
Call playback for the Powerful Owl, Masked Owl and Barking Owl. Method involved 3-5 minutes of call playback, with a brief silence of 3 mins between calls where multiple calls played, followed by 10-15 minutes of listening, then at least 10 mins spotlighting.	summer ‘04 autumn ’05 . winter ’05 . early spring ’05 late spring ‘05	2:30 hours of survey with 2 observers 23 surveys_8 consecutive nights at each of 2 sites 3 surveys, 1 of 6 consecutive nights and 2 of 8 consecutive nights 8 consecutive nights at 1 site; Masked Owl only - 1 night at each of 15 sites

Table 1.2 Targeted herpetological survey methods, seasons and effort.

Method	Season	Effort
Quantitative herpetological hand searches at each trapping site. Timed for 30 mins per 4 ha area.	summer ’04	1:20 person hours
	autumn ’05	4:45 person hours
	winter ’05	2 sites; 1 person hour
	early spring ’05	8 person hours
	Late spring ‘05	2 sites, 2:00 person hours
Pitfall trapping at 14 sites.	summer ‘04	12 bucket nights
Method - 30m of drift fence with 4 deep buckets (40cm and 25cm diameter) spaced at 10m intervals.	autumn ‘05	8 trapline nights (32 bucket nights)
	early spring ‘05 .	4 surveys, 20 trapline nights (80 bucket nights)
	late spring ‘05	7 sites, 54 trapline nights (216 bucket nights)
Opportunistic road frog surveys conducted at night after heavy rain. Method - driving a car along a specific route with 2 persons, identifying each frog observed, either through capture or aurally.	summer ‘04	1:45 survey hours with 2 observers
Call Playback – Green & Golden Bell Frog *Litoria aurea*	late spring ‘05	1 site 0:20 hours

Table 1.3 Targeted mammal survey methods, seasons and effort.

Method	Season	Effort
Trapping - Elliot Type A – 25 Elliot Type A traps were set in a grid pattern (as illustrated below) over an area of 1 ha at each trapping site. 20 traps set on the ground and 5 in trees. Baited with honey/rolled oats/peanut butter with vanilla	summer '04 autumn '05 Early spring '05	320 ground trap nights and 80 tree trap nights 547 trap nights 517 trap nights
Trapping – Elliot Type A – set in trees	Early spring '05	28 trap nights, targeting areas with flowering White Box
Trapping – Elliot Type B – 3 Elliot Type B traps were set at each trapping site, near areas of thicker groundcover to target bandicoots. Baited with honey/rolled oats/peanut butter with vanilla	summer '04 autumn '05 winter '05	51 trap nights 167 trap nights 220 trap nights (2 lines X 10 traps) set in areas with flowering White Box
Trapping – Elliot Type B – set in trees	Early spring '05 Late spring '05	3 sites, 72 trap nights, targeting areas with flowering White Box 3 sites, 126 trap nights
Trapping – Elliot Type E – 6 Elliot Type E traps were set at some trapping sites in flowering shrubs to target Pygmy Possums. Baited with honey/rolled oats/peanut butter with vanilla	summer '04	60 trap nights
Trapping – Cage Traps – 2 cage traps were set near each trapping site, near tracks or Quoll den habitat, to target carnivores. Baited with chicken necks	summer '04 autumn '05 Early spring '05	38 trap nights 32 trap nights 49 trap nights
Hair Tubes set in lines approx 2.3km long, with approx 30 tubes at 80m intervals. 12 regular tubes baited with honey/rolled oats/peanut butter,12 regular tubes baited with dry dog food ('Good O's'), 6 flexiglass tubes (refer to Murray 2005) baited with whole cans of sardines.	autumn '05 winter 0'5	370 tube nights 3 lines
Harp traps were set opportunistically along dirt tracks through forest or woodland for a variable number of nights (but at least 2 nights).	summer '04 autumn '05 Late spring '05	11 trap nights 16 trap nights 12 sites, 24 trap nights
Anabat II Bat Detectors Generally, 2 detectors were used at each spotlighting site – one was set stationary at the spotlight transect starting point, and the other was used as a roaming survey and taken along the spotlight transect	summer '04 autumn '05 Early spring '05 Late spring '05	6:35 hours at dusk 30:30 hours at dusk; 34:15 hours all night (3 nights) 5:55 hours – roaming only 114:31 hours

Table 1.4 Non-specific survey methods, seasons and effort.

Method	Season	Effort
Spotlighting surveys were conducted for approx 1 hour sessions with 2 persons and 2 spotlights.	summer ‘04 autumn ‘05 Early spring ‘05 Late spring ‘05	8:30 person hours 20:10 person hours 7 surveys, 18:10 person hours, targeting areas of flowering White Box 6 sites, 12:40 person hours
Dedicated scat searches, timed for 15 mins per 1 ha area.	autumn ‘05 winter ‘05 Early spring ‘05	1:45 person hours 19 surveys; 4:45 person hours 2 person hours
Opportunistic records of all species were maintained whilst travelling around the site, and whilst conducting other surveys. The majority of bird species records were obtained in this manner.	summer ‘04 autumn ‘05 winter ‘05	15 person hours 9 days 10 days (approx 1/3 of this time spent amongst flowering White Box)

2 SURVEYS WITHIN EACH VEGETATION FORMATION

Table 2.1 Details of fauna surveys within Secondary Grasslands and Shrublands.

Method	Season	Summary of Effort
Quantitative Bird	autumn '05	8 surveys
	winter '05	14 surveys
	Early spring '05	4 surveys
	Late spring '05	1 survey
Non-quantitative Bird	summer '04	1 survey at water body
	autumn '05	1 survey at water body
Call Playback 1 night	autumn '05	5 nights.
Call Playback 2 consecutive nights	Late spring '05	15 survey sets targeting Masked Owl Barking Owl
Call Playback 4 consecutive nights	autumn '05	4 survey sets.
	winter '05	2 survey sets.
Call Playback 8 consecutive nights	autumn '05	3 survey sets.
	winter	7 survey sets.
	Early spring '05	6 survey sets.
	Late spring '05	1 survey set.
Quantitative Herpetological	Late spring '05	1 survey
Pitfall Trapping	Early spring '05	30m trapline
Elliot Trapping	Early spring '05	Elliot Type A ground
Hair Tubes	autumn '05	short transect
	Early spring '05	3 survey sets/nights?,
Harp Trap	Late spring '05	2 sites
Anabat	autumn '05	8 survey sets/nights?,
Spotlighting	summer '04	1 survey night.
	autumn '05	5 survey nights.
	Early spring '05	3 survey nights.
	Late spring '05	1 survey night.
Scats, tracks, traces	winter '05	1 site

Table 2.2 Details of fauna surveys within Western Slopes Dry Sclerophyll Forests.

Method	Season	Summary of Effort
Quantitative Bird	summer ‘04	2 surveys
	autumn ‘05	4 survey
	winter ‘05	7 surveys
	Early spring ‘05	3 surveys
	Late spring ‘05	1 survey
Call Playback 1 night	summer ‘04	1 survey
	autumn ‘05	3 surveys
Quantitative Herpetological	summer ‘04	2 survey
	autumn ‘05	5 surveys
	Early spring ‘05	7 surveys
	Late spring ‘05	2 surveys
Pitfall Trapping	Early spring ‘05	2 30m traplines
	Late spring ‘05	2 30m trapline
Elliot Trapping	summer ‘04	4 surveys with Elliot B tree-mounted
	summer ‘04	4 surveys with Elliot A ground
	autumn ‘05	2 survey with Elliot A ground
	autumn ‘05	1 survey with Elliot B tree-mounted
	Early spring ‘05	1 survey with Elliot A ground
	Early spring ‘05	3 survey with Elliot B tree-mounted
	Late spring ‘05	2 surveys with Elliot B tree-mounted
Cage Traps	summer ‘04	4 surveys
	autumn ‘05	4 survey
	Early spring ‘05	4 survey
Harp Trap	summer ‘04	3 sites
	autumn ‘05	3 site
Anabat	summer ‘04	3 survey nights
	autumn ‘05	4 survey nights
	Early spring ‘05	2 survey night
	Late spring ‘05	1 survey night
Spotlighting	summer ‘04	1 survey night
	autumn ‘05	1 survey night
	Early spring ‘05	3 survey night
	Late spring ‘05	2 surveys nights
Scats, tracks, traces	summer ‘04	1 survey
	autumn ‘05	3 searches
	winter ‘05	1 survey
	Early spring ‘05	2 survey

Table 2.3 Details of fauna surveys within Western Slopes Grassy Woodlands.

Method	Season	Summary of Effort
Quantitative Bird	summer ‘04	2 surveys
	autumn ’05	5 surveys
	winter ‘05	31 surveys
	Early spring ‘05	5 surveys
	Late spring ‘05	1 survey
Non-quantitative Bird	Early spring ‘05	1 survey at water body
	Late spring ‘05	1 survey at water body
Call Playback 1 night	summer ‘04	2 survey
	autumn ‘05	3 survey
Call Playback 2 consecutive nights	Late spring ‘05	2 survey set targeting Masked Owl
Call Playback 8 consecutive nights	Early spring ‘05	1 survey sets
	Late spring ‘05	3 survey sets
Quantitative Herpetological	summer ‘04	2 surveys
	autumn ‘05	2 surveys
	winter ‘05	2 surveys
Pitfall Trapping	summer ‘04	1 30m traplines
	autumn ‘05	1 30m traplines
	Early spring ‘05	1 30m traplines
	Late spring ‘05	5 30m traplines
Elliot Trapping	summer ‘04	1 survey with Elliot B tree-mounted
	summer ‘04	1 survey with Elliot A ground
	autumn ‘05	5 surveys with Elliot B tree-mounted
	autumn ‘05	3 survey with Elliot A ground
	winter ‘05	2 surveys with Elliot B tree-mounted
	Early spring ‘05	1 survey with Elliot B tree-mounted
	Late spring ‘05	2 surrvey with Elliot B tree-mounted
Cage Traps	summer ‘04	1 survey
	autumn ‘05	4 survey
Hair Tubes	autumn ‘05	2 short transects
Harp Trap	summer ‘04	1 site
	autumn ‘05	4 sites
	Late spring ‘05	6sites
Anabat	summer ‘04	4 survey nights
	autumn ‘05	8 survey nights
	Late spring ‘05	5 survey nights
	Late spring ‘06	4 survey nights
	Spring ‘06	3 survey nights
Spotlighting	summer ‘04	2 survey night
	autumn ‘05	3 survey night
	Early spring ‘05	1 survey night
	Late spring ‘05	3 survey night
Scats, tracks, traces	autumn ‘05	1 search
	winter ’05	4 searches

3 WEATHER CONDITIONS

Date	Day	Evening
summer 2004		
Sun 5/12/04	Fine, approx 30°C	Cloudy, approx 20°C
Mon 6/12/04	Cloudy periods with light rain, approx 25°C	Cloudy, approx 20-25°C
Tues 7/12/04	Cloudy periods, approx 25°C, sunny periods up to approx 30°C	Thunderstorm approx 18°C
Wed 8/12/04	Heavy rain, approx 25°C, sunny periods up to 30°C	Thunderstorm with local lightening, approx 18°C
Thurs 9/12/04	Mostly fine, humid, 15-30°C	Mostly clear, 24°C
Fri 10/12/04	Morning shower and drizzle approx 18°C	20-25°C
Sat 11/12/04	Mostly fine 18-25°C	N/a
autumn 2005		
30/3/05-8/4/05	Weather conditions during the day were good for surveying, with temperatures mostly 20-25°C and an occasional day in the high 20's. Most days were still or with a light breeze.	Evenings were generally warm (15-20°C), dropping to around 15°C overnight, with the occasional cool night (13-17°C), dropping to 5-10°C. No rain except for a very few patches of fine drizzle. No moon during the nocturnal surveys.
winter 2005		
28/6/05	Overcast, light rain, 8-15°C, light to strong wind	Cloudy, moderate rainfall, 5-10°C, moderate to strong wind
29/6/05	Overcast, heavy rain, 10°C, moderate to strong wind	Cloudy, moderate to heavy rain, 5-10°C, moderate to strong wind
4/7/05	Fine, 10-17°C	Fine, temps down to 4°C
5/7/05	Some cloud (up to 30% cover), 10-17°C	Fine, temps down to 5°C
6/7/05	Fine, temps up to 18°C	Fine, temps down to 5°C
7/7/05	Overcast, light rain, temps up to 18°C	Cloudy, 13°C
8/7/05	Mostly cloudy (30-100% cover), 5-13°C	Overcast, 10°C, light breeze
9/7/05	Overcast, light to heavy showers, 5-10°C	Overcast, light showers, 5°C, strong wind
10/7/05	Cloudy (approx 70% cover), 10°C, cool moderate southerly wind	Overcast, 7°C, light wind

Date	Day	Evening
Early spring 2005		
5/9/05	Overcast, light rain, 20-25°C	Clearing, 5-10°C
6/9/05	Fine, 15-20°C	Fine, 7°C
7/9/05	Fine, 20°C	Fine, slight wind, 6°C
8/9/05	overnight slight frost, fine, 26°C, slight wind	-
9/9/05	overnight slight frost, fine, 25°C, slight wind	-
10/9/05	Cloudy (30-100% cover), light drizzle, 20°C, slight wind	Overcast, light rain, 17°C, strong wind
11/9/05	Overcast, light drizzle, 15°C, light to moderate windy gusts	Overcast, constant moderate drizzle
12/9/05	Cloudy (30-80% cover), 8-15°C, light showers, moderate windy gusts	Cloudy (30-100% cover), light to moderate rain, 8°C, gentle to strong wind
13/9/05	Cloudy (30-80% cover), 15°C, light to moderate wind	-
14/9/05	Cloudy (0-50% cover), 15°C, moderate windy gusts	5°C
15/9/05	Cloudy (0-50% cover), 17°C, moderate gusts, strong at times	-
16/9/05	Overcast, constant moderate to heavy rain, 11°C, light wind	Overcast, heavy rain, 5-10°C, moderate winds
17/9/05	Overcast, light showers, 10°C, moderate wind	-
Late spring 2005		
4/11/05-18/11/05	Weather conditions varied during this period, with some days reaching 30°C and other cooler days only 15°C. Heavy rain preceded the survey making the region very green. Some heavy rain also occurred during the surveys, which encouraged frogs to call.	Overnight temperatures varied from 10-15°C. Moon was out for some nights, but on most nights the moon was hidden by cloud

4 KEYING CHARACTERS FOR ANABAT CALLS

Table 4.1 Keying characters for Anabat calls of the bats of Moolarben.

Species	Calls on site?	Expected or Known Characteristic freq		Tail	IDing Notes	Pulse Shape	RA *	Trends/Notes
		Min	Max					
Tadarida australis	Yes	10	15			flat	4	
Saccolaimus flaviventris	No	17.5	22.5		harmonics	curved or flat	1	Only one call with nice curved pulses at 19-20, looks like S. flaviventris, although only 2 pulses recorded
Chalinolobus dwyeri	Yes	21.5	25.5	Up	Pulses alternate	Curved	2	Low pulse 22-24, high pulse 26-28
Chalinolobus gouldii	Yes	25	34	Down or none	Pulses alternate, low pulse sometimes flat in cruise mode	Curved	5	
Mormopterus sp4	Yes	24	30			flat	4	quite a range- from 24-30
Mormopterus sp2	No	28.5	31			flat	0	Calls around 30 could all be Mormopterus sp3 or sp4, and no Mormopterus sp2 were captured, so there is no proof of their presence
Scotorepens balstoni	Yes	28	34	Down or none or occasionally up	flat cruise pulse at 28	Curved	2	mostly at 32, no tail
Mormopterus sp3	Yes	31	36			flat	2	
Scoteanax rueppellii	No	32	36.5	mostly none, occ short down	knee>37, pre-characteristic drop >3	curved	0	No calls in range with large pre-characteristic section drop, suggesting calls in this range likely to be S. balstoni or S. orion
Scotorepens orion	Yes	34.5	37.5	mostly none, sometimes down	knee>38	curved	2	
Falsistrellus tasmaniensis	No	35.5	39	not up. none or down	often steep, pree-characteristic often long	curved	0	Calls in this range appeared to be the shape of S. orion
Scotorepens greyii	No	35	40	up, sometimes down or absent	sometimes flatter	curved	0	No calls in high 30's and most calls 35-37 likely to be S. orion
Vespadelus darlingtoni	No	40	44	absent or up	characteristic freq often long	curved	0	Some low Vespadelus calls could theoretically be this species but no V darlingtoni were captured, so have to call them V.vulturnus, since none were

Species	Calls on site?	Expected or Known Characteristic freq		Tail	IDing Notes	Pulse Shape	RA *	Trends/Notes
		Min	Max					
								below the known range of V. vulturnus from the western slopes.
Chalinolobus pictatus	Yes	42	44		pulses alternate	curved	1	Best call low pulse 39 high pulse 41, questionable calls 42-44 could be V. vulturnus
Vespadelus regulus	No	43.5	46	ussually up		curved	0	Some low Vespadelus calls could theoretically be this species but no V regulus were captured, so have to call them V.vulturnus, since none were below the known range of V. vulturnus from the western slopes.
Miniopterus schreibersii	Yes	43	48	down	characteristic section may be long, pulse shape and gap ussually variable	curved	1	Best call at 44, other questionable calls 46-48 could be C. morio
Vespadelus vulturnus	Yes	42.5	50	up		curved	5	mostly from 44-48
Chalinolobus morio	Yes	46.5	53	down	pulse shape (or sometimes frequency) alternates	curved	3	
Vespadelus troughtoni	No	49	53.5	up		curved	0	No vespadelus calls over 50
Rhinolophus megaphyllus	Yes	66	70			flat	1	
Nyctophilus sp	Yes	31-47	60-80			vertical	5	
Myotis macropus	No	35-40	70-80	Good calls have kink at 47-50, and sometimes at 35. Pulse interval <75, initial slope >400	near vertical	0		No calls with kink at 47-50 and none with initial slop >400 or pulse interval <75, so most all vertical calls seem to be Nyctophilus

Note: species are listed that have not been found on the site but are included because these were the characters used to distinguish these species from others that were found

RA *

Relative Abundance Score

0=Species appears not to occur at the site, or no convincing calls found

1= One or two confidently identified calls of this species

2= Species found rarely at a few sites

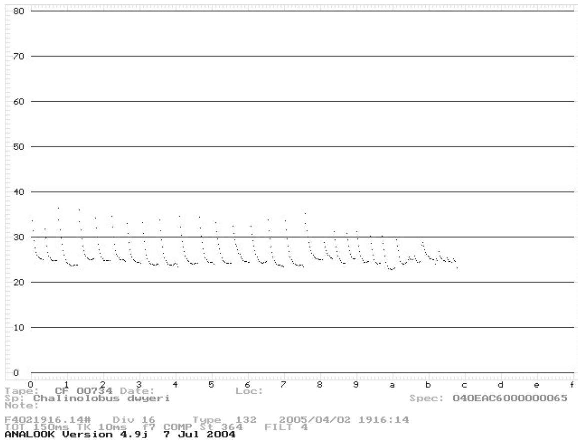
3= Species found occaioanlly at many locations

4= Species widespread and fairly common

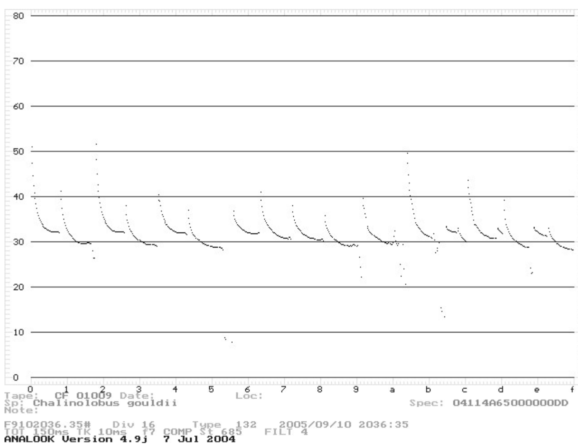
5= Species highly abundant and widepread, most anabat calls recorded during the project were one of these species

ANABAT FILES

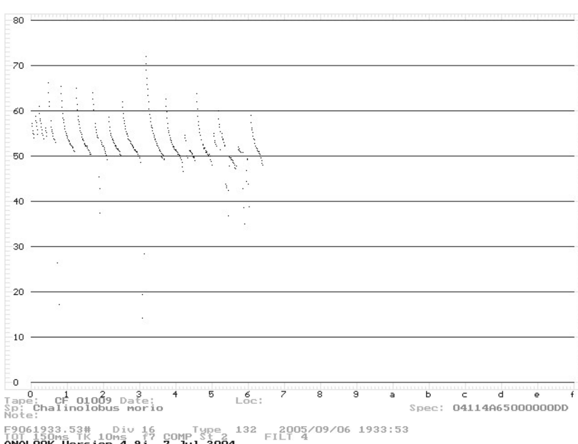
Chalinolobus dwyeri



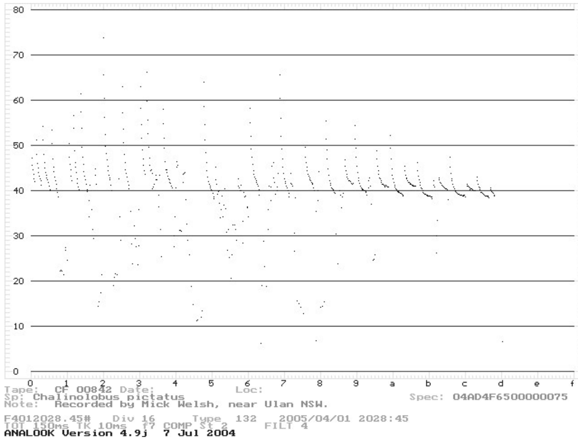
Chalinolobus gouldii



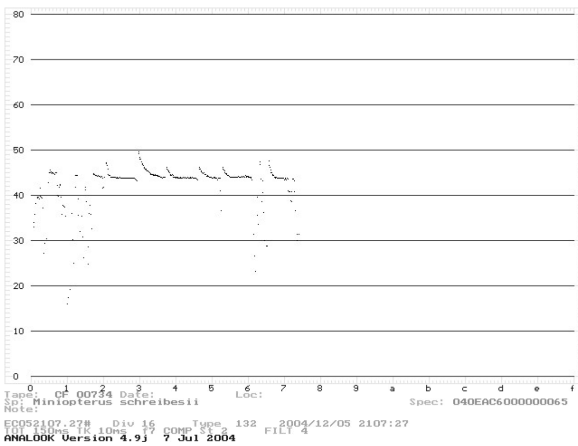
Chalinolobus morio



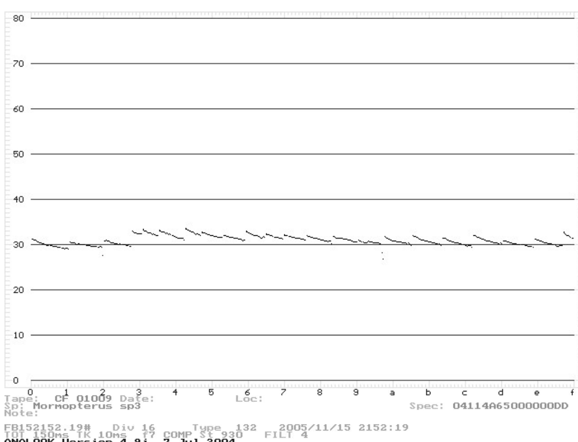
Chalinolobus pictatus

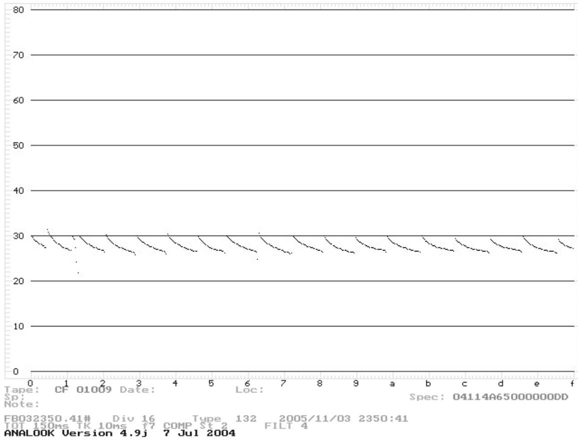


Miniopterus schreibersii

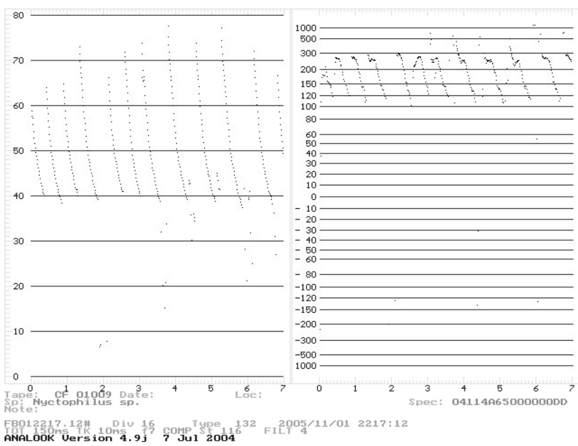


Mormopterus sp 3

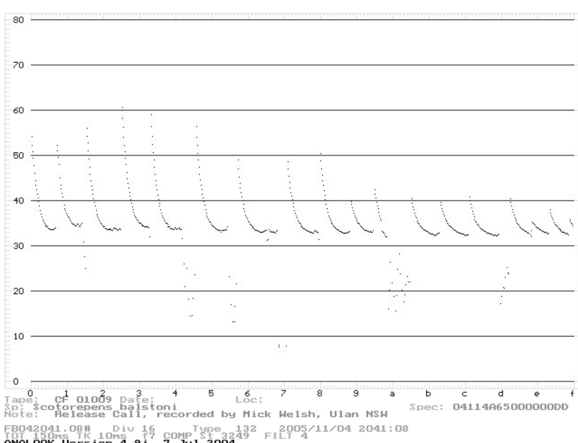




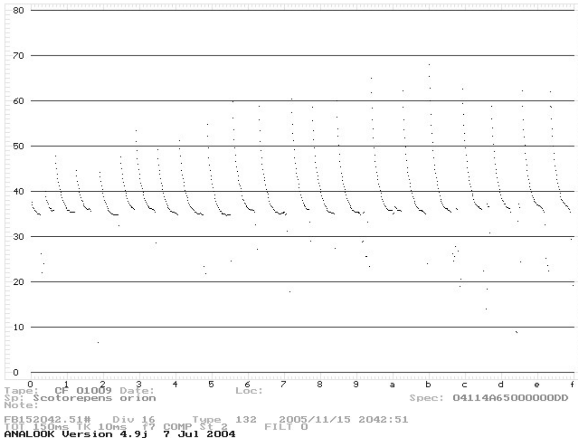
Nyctophilus sp



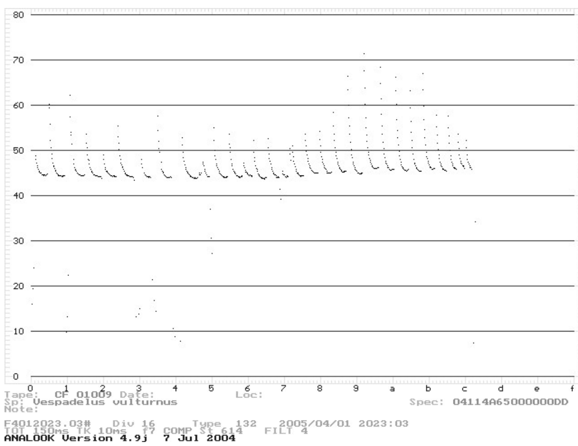
Scotorepens balstoni



Scotorepens orion



Vespadelus vulturnus



APPENDIX 2

Flora List of the Study Area

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
Acanthaceae	*Brunoniella pumilio*	*1(2)*						*1(2)*									*2*
Adiantaceae	*Cheilanthes distans*										*1(2)*						*1*
	Cheilanthes sieberi subsp. sieberi	*6(1.7)*		*16(1.9)*	*2(2)*	*1(2)*	*6(2)*	*13(1.6)*	*10(1.7)*	*17(1.9)*	*5(2)*	*5(2)*	*14(1.6)*	*7(2)*	*7(1.4)*		*13*
	Pellaea falcata							*1(1)*									*1*
Amaranthaceae	*Alternanthera denticulata*	*1(1)*															*1*
	Alternanthera sp. A							*1(2)*									*1*
	Alternanthera pungens		*1(1)*														*1*
Anthericaceae	*Caesia parviflora*								*1(1)*		*2(1.5)*		*1(2)*				*3*
	Dichopogon fimbriatus			*1(2)*				*3(1.7)*		*1(2)*		*1(1)*					*4*
	Laxmannia gracilis			*5(1.4)*		*3(1.7)*	*2(1.5)*			*10(1.6)*							*5*
	Thysanotus juncifolius							*1(1)*		*1(1)*							*2*
	Thysanotus patersonii			*2(1)*						*2(1)*							*2*
	Thysanotus tuberosus									*1(2)*							*1*
	Tricoryne elatior			*3(1.7)*		*1(2)*		*5(1.6)*	*2(1.5)*	*5(1)*			*1(1)*	*1(2)*			*7*
Apiaceae	*Actinotus helianthi*					*1(1)*											*1*
	Apium prostratum var. prostratum							*1(1)*									*1*
	Centella asiatica										*1(2)*						*1*
	Ciclospermum leptophyllum	*1(2)*						*1(1)*			*1(2)*		*2(1)*				*4*
	Daucus glochidiatus										*2(2)*	*1(2)*					*2*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
	Eryngium rostratum							*1(1)*									*1*
	Hydrocotyle laxiflora	*2(1.5)*		*6(1.8)*			*2(2)*	*13(1.8)*	*4(1.8)*	*9(2)*	*2(2)*	*4(2)*	*4(1.8)*	*9(1.6)*		*1(2)*	*11*
	Platysace ericoides			*2(1)*	*3(1.7)*					*1(1)*			*2(2)*				*4*
Asphodelaceae	*Bulbine bulbosa*												*1(2)*				*1*
Aspleniaceae	*Asplenium flabellifolium*							*1(2)*		*1(1)*							*2*
	Pleurosorus rutifolius										*1(1)*						*1*
Asteraceae	*Arctotheca calendula*	*4(2)*	*1(2)*					*2(1.5)*	*1(1)*								*4*
	Brachyscome multifida				*1(1)*					*1(2)*							*2*
	Bracteantha viscosa									*1(2)*							*1*
	Calocephalus citreus							*8(1.4)*									*1*
	Calotis cuneifolia	*4(1.8)*		*15(1.9)*	*5(1.4)*		*4(1.8)*	*10(1.7)*	*13(1.8)*	*12(1.3)*		*3(1.3)*		*2(1.5)*			*9*
	Calotis lappulacea	*2(1.5)*	*1(1)*	*4(1.3)*			*1(1)*	*7(1.6)*	*4(2)*	*2(1)*	*2(1)*	*1(2)*	*1(1)*	*1(1)*			*11*
	Cassinia aculeata			*1(2)*	*2(1.5)*				*1(1)*								*3*
	Cassinia arcuata	*8(2.1)*		*13(1.8)*	*4(1.3)*	*4(1.3)*	*11(1.9)*	*19(1.9)*	*15(2.6)*	*19(2.3)*	*3(1)*	*3(3)*	*13(2)*	*9(2.3)*	*3(1)*		*13*
Asteraceae	*Cassinia cunninghamiana*				*4(1.8)*	*2(1.5)*	*1(1)*	*2(1)*		*4(2)*		*1(2)*					*6*
	Cassinia quinquefaria			*4(2.5)*	*4(2)*	*2(2.5)*	*1(2)*	*5(1.6)*	*2(1)*	*2(1)*	*1(2)*	*4(2)*	*1(2)*				*10*
	Catharmus lanatus	*4(1.8)*	*1(2)*				*1(1)*	*3(1.7)*			*3(2)*		*1(1)*				*6*
	Chrysocephalum apiculatum			*1(1)*		*3(1.7)*		*4(2)*		*10(2)*				*2(1)*	*2(1.5)*		*6*
	Cirsium vulgare		*1(2)*			*1(1)*		*4(1.3)*				*1(1)*	*1(1)*				*5*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
	Conyza albida							*1(1)*									*1*
	Conyza bonariensis	*1(1)*								*1(1)*			*4(1)*	*2(2)*			*4*
	Cotula australis	*2(2)*								*1(1)*			*3(1)*				*3*
	Cotula coronopifolia							*1(1)*									*1*
	Cymbonotus lawsonianus	*1(2)*						*2(2)*	*1(1)*	*1(1)*	*1(1)*	*2(1)*					*6*
	Euchiton gymnocephalus	*2(2)*						*3(1.7)*					*2(2)*				*3*
	Euchiton involucratum			*1(1)*				*2(2)*				*1(1)*	*4(1.5)*		*1(1)*		*5*
	Euchiton sphaericus							*2(1.5)*									*1*
	Gamochaeta americanum	*3(2)*						*1(2)*					*1(2)*				*3*
	Glossogyne tannensis					*1(1)*											*1*
	Hedyponois glabra							*1(1)*									*1*
	Hypochaeris glabrata	*1(2)*		*3(1.7)*				*2(1.5)*	*1(1)*				*2(2)*	*3(1.7)*			*6*
	Hypochaeris radicata	*6(2)*	*1(2)*	*4(2)*		*1(1)*	*1(1)*	*8(2.1)*		*7(1.7)*	*1(2)*	*1(2)*	*6(1.7)*	*3(2)*	*2(1.5)*	*1(2)*	*13*
	Lactuca seriola							*1(1)*									*1*
	Microseris lanceolata												*1(2)*				*1*
	Minuria leptophylla										*1(1)*						*1*
	Olearia microphylla					*1(1)*											*1*
	Ozothamnus diosmifolius					*2(1)*											*1*
	Podolepis jaceoides							*1(3)*									*1*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
	Podolepis neglecta									*1(2)*		*1(1)*	*2(1.5)*				*3*
	Richardia stellaris	*1(1)*						*1(1)*									*2*
	Senecio diaschides												*1(1)*				*1*
	Senecio hispidulus			*1(1)*	*1(1)*												*2*
	Senecio prenanthoides			*1(2)*													*1*
	Senecio quadridentatus							*1(2)*							*1(1)*		*2*
	Sigesbeckia orientalis subsp. orientalis										*2(1)*						*1*
	Sochus oleraceus							*1(1)*			*1(1)*						*2*
	Solenogyne bellioides			*2(1.5)*				*5(1.8)*	*1(2)*	*1(1)*		*1(1)*	*2(1)*				*6*
Asteraceae	*Solenogyne dominii*	*1(1)*						*1(2)*									*2*
	Taraxacum officinale	*2(2.5)*					*1(1)*	*2(1.5)*		*1(2)*	*1(2)*	*1(1)*	*1(1)*	*1(2)*			*8*
	Tolpis umbellata	*3(2)*						*3(1.3)*	*1(2)*								*3*
	Triptilodiscus pygmaeus	*3(1.7)*		*2(1.5)*				*2(1.5)*						*1(2)*			*4*
	Vittadinia cuneata							*3(1.7)*	*1(1)*		*2(1.5)*		*1(1)*				*4*
	Vittadinia dissecta	*1(1)*						*1(2)*				*1(1)*					*3*
	Vittadinia muelleri							*3(1.3)*		*2(2)*	*1(1)*			*1(1)*			*4*
	Vittadinia pustulata			*1(1)*						*1(1)*	*1(1)*	*1(2)*					*4*
	Vittadinia sulcata									*1(1)*							*1*
	Vittadinia unknown											*1(1)*					*1*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
Blechnaceae	*Doodia aspera*										*1(2)*						*1*
Boraginaceae	*Cynoglossum australe*			*1(1)*				*2(1.5)*									*2*
	Echium plantagineum	*2(1.5)*						*2(1.5)*			*1(1)*						*3*
Brassicaceae	*Lepidium africanum*		*1(2)*					*2(1.5)*									*2*
	Lepidium bonariensis							*1(2)*									*1*
	Sisymbrium erysimoides										*1(1)*						*1*
	Sisymbrium irio										*1(2)*						*1*
Cactacea	*Opuntia stricta*			*3(1.3)*				*1(1)*	*1(1)*		*1(1)*	*1(1)*					*5*
Campanulaceae	*Wahlenbergia communis*	*1(1)*		*7(1.6)*		*1(2)*		*8(1.5)*	*2(1.5)*	*6(1.7)*	*4(1.8)*	*2(2)*	*4(1.3)*	*2(1.5)*			*10*
	Wahlenbergia gracilis	*4(1.5)*						*1(2)*	*1(2)*	*1(2)*			*1(2)*	*2(2)*	*1(1)*		*7*
	Wahlenbergia luteola				*1(1)*						*2(2)*	*1(2)*					*3*
	Wahlenbergia stricta							*1(2)*									*1*
	Wahlenbergia unknown					*1(1)*											*1*
Caryophyllaceae	*Cerastium glomeratum*	*2(1)*															*1*
	Petrorhagia nanteuilii	*3(1.7)*						*3(1.7)*			*4(1.8)*	*2(0.5)*	*1(1)*	*1(1)*			*7*
	Silene gallica	*3(1.7)*						*2(1.5)*			*2(2)*	*2(2)*					*4*
	Spergularia marina	*3(1.7)*						*2(1)*									*2*
	Stellaria pungens			*1(2)*	*1(2)*			*1(3)*		*1(2)*	*1(1)*						*5*
	Stellaria sp. D	*6(1.7)*						*5(1.8)*			*2(1.5)*	*1(2)*					*4*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
	Cerastium glomeratum	*2(1)*															*1*
	Petrorhagia nanteuilii	*3(1.7)*						*3(1.7)*			*4(1.8)*	*2(0.5)*	*1(1)*	*1(1)*			*7*
	Silene gallica	*3(1.7)*						*2(1.5)*			*2(2)*	*2(2)*					*4*
	Spergularia marina	*3(1.7)*						*2(1)*									*2*
Casuarinaceae	*Allocasuarina gymnanthera*	*1(2)*		*2(1)*	*4(1.8)*	*7(1.7)*	*1(1)*	*1(1)*		*3(2)*			*3(1.3)*		*4(1.5)*		*9*
	Allocasuarina luehmannii			*3(1.7)*			*4(2.3)*			*3(1.3)*			*2(1.5)*				*4*
	Allocasuarina verticillata								*1(1)*								*1*
Chenopodiaceae	*Einadia nutans*			*2(1.5)*	*1(1)*		*1(2)*					*1(2)*					*4*
	Einadia polygonoides			*3(1.7)*			*1(2)*	*2(2)*	*6(1.2)*	*1(1)*							*5*
	Einadia trigonos			*1(2)*	*2(1.5)*		*2(1.5)*	*5(1.6)*	*1(2)*		*2(1)*	*2(1)*					*7*
	Enchylaena tomentosa								*1(2)*								*1*
Clusiaceae	*Hypericum gramineum*	*2(1.5)*		*4(1.5)*	*1(2)*		*2(2)*	*5(1.4)*	*2(2)*	*10(1.8)*	*1(1)*	*2(1)*	*8(1.8)*	*2(1.5)*		*1(1)*	*12*
	Hypericum perforatum	*2(1.5)*	*1(1)*					*2(1)*			*3(2)*			*1(1)*			*5*
Colchicaceae	*Wurmbea biglandulosa*									*1(2)*							*1*
Convolvulaceae	*Convovulus erubescens*							*1(1)*			*2(1.5)*	*1(2)*		*1(1)*			*4*
	Dichondra repens	*1(2)*		*6(1.7)*	*1(1)*		*3(2)*	*13(1.7)*	*5(1.8)*	*3(2)*	*5(2)*	*4(2)*	*2(2)*				*10*
Crassulaceae	*Crassula sieberiana*				*1(1)*			*2(1)*			*1(2)*			*1(2)*			*4*
Cupressaceae	*Callitris endlicheri*			*10(2)*	*10(2.1)*	*13(2.9)*	*8(1.6)*	*4(1.5)*	*5(1.8)*	*9(1.4)*	*1(2)*	*5(1.4)*	*8(2)*	*3(1.3)*	*8(3.9)*		*12*
Cyperaceae	*Carex appressa*	*5(1.6)*						*5(1.4)*					*3(1.7)*			*1(1)*	*4*

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
	Carex inversa			1(1)				3(1.7)			1(2)						3
	Cyperus fulvus												1(2)			1(2)	2
	Cyperus gracilis										1(2)						1
	Cyperus lucidus												2(2)				1
	Cyperus sanguinolentus												2(2)				1
	Eleocharis gracilis															1(2)	1
	Fimbristylis dichotoma			2(1.5)				3(1)		1(1)		1(1)	1(2)				5
	Gahnia aspera	2(1.5)		8(1.9)	3(1.3)	3(1.3)	8(1.4)	9(1.4)	13(1.8)	8(1.4)		4(1.8)	4(1.5)	1(1)			11
	Isolepis inundatus												3(1.7)				1
	Lepidosperma laterale			6(1.5)	10(2.2)	9(1.4)	2(1)		2(1.5)	7(1.6)		1(1)	4(1)	1(2)	3(1.3)		10
	Luzula meridionalis	1(1)				3(1.7)				1(2)	1(2)					1(2)	5
	Scheonus apogon															1(1)	1
	Schoenus ericetorum					1(1)		1(2)	1(2)					2(2)	1(2)		5
	Schoenus moorei															1(3)	1
Dennstaedtiaceae	*Pteridium esculentum*							1(1)									1
Dilleniaceae	*Hibbertia acicularis*					3(1.3)				1(1)	1(2)	1(1)					4
	Hibbertia circumdans	1(1)		1(2)	3(1.3)	2(2)		1(1)	1(1)	3(1.7)			1(1)	1(2)			9
	Hibbertia linearis									1(1)							1
Dilleniaceae	*Hibbertia obtusifolia*				4(1.3)	2(1)	4(1.5)	2(1.5)		9(1.6)			5(1.6)	9(1.8)			7

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
	Hibbertia riparia					1(1)				1(2)			4(1.5)	1(1)			4
Droseraceae	*Drosera auriculata*									3(2)			3(2)	1(2)	1(2)		4
	Drosera burmannii															1(2)	1
Epacridaceae	*Acrotriche rigida*	1(1)		12(2)	13(1.9)	9(1.7)	12(2)	6(1.3)	7(1.4)	7(1.3)	3(1)	4(1.3)	7(2.4)	2(1)	4(1.3)		13
	Astroloma humifusum	1(1)		12(1.8)	6(1.7)	2(1)	8(2)	6(1.5)	10(1.6)	18(1.9)	3(1)	2(1.5)	11(1.6)	6(2)	6(2)		13
	Brachyloma daphnoides	1(2)				6(1.7)		1(2)		6(1.5)	1(1)		7(1.4)	9(1.4)	5(2)		8
	Leucopogon biflora													1(2)	1(1)		2
	Leucopogon microphyllus					2(1.5)											1
	Leucopogon muticus			9(1.2)	12(1.8)	11(2.5)	2(1.5)	2(1)		5(1.8)			4(1.8)	2(1)	7(2)		9
	Leucopogon setiger					1(2)							1(1)		2(1.5)		3
	Leucopogon virgatus				2(1)	3(1.7)							3(1.3)		3(2)		4
	Lissanthe strigosa	2(1.5)		8(1.5)	4(2.3)	2(2)	12(1.8)	6(1.3)	6(1.3)	15(1.9)		2(2)	3(1.7)	2(1)			11
	Melichrus erubescens			1(1)	2(1)	5(1.4)	2(1)						1(1)		2(2)		6
	Melichrus urceolatus			1(1)			1(2)	2(2)	1(2)	7(1.9)			3(1)	4(1.5)	3(1.7)		8
	Monotoca scoparia	1(2)				1(1)				3(1.3)			2(1.5)		1(2)		5
	Styphelia triflora	1(2)		3(1)	5(1)	5(1)	6(1)	3(1)	1(1)	10(1.6)		1(1)	10(1.3)	5(1.2)	3(1)		12
Eriocaulaceae	*Eriocaulon scariosum*															1(2)	1
Euphorbiaceae	*Chamaesyce drummondii*	1(2)		2(1)				2(1)									3
	Phyllanthus occidentalis	1(2)		8(1.5)	12(1.8)	9(1.9)	1(1)			1(2)			3(1)				7

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
	Poranthera corymbosa				*5(1.8)*	*1(1)*							*1(2)*				*3*
	Poranthera microphylla			*3(1.7)*				*4(1.5)*		*4(1.8)*		*1(2)*		*1(2)*	*1(1)*		*6*
	Pseudanthus divaricatissimus					*1(2)*											*1*
Fabaceae_Faboideae	*Aotus subglauca var. filiformis*			*1(1)*						*1(1)*			*3(1.7)*	*2(1.5)*			*4*
	Bossiaea buxifolia			*1(1)*				*2(1.5)*		*9(1.4)*	*1(2)*	*1(2)*	*3(1)*	*2(1.5)*			*7*
	Bossiaea obcordata	*1(2)*			*2(1)*	*2(1.5)*							*2(1.5)*	*1(2)*	*1(2)*		*6*
	Bossiaea rhombifolia subsp. concolor			*1(2)*									*1(1)*	*4(1.5)*	*2(1.5)*		*4*
	Daviesia acicularis									*3(2)*			*1(1)*	*1(2)*			*3*
	Daviesia genistifolia	*2(1.5)*					*2(1.5)*	*4(1)*		*6(1.7)*	*1(2)*	*1(2)*					*6*
	Daviesia ulicifolia			*1(1)*	*3(1)*	*4(1.3)*	*1(2)*							*1(1)*			*5*
	Desmodium brachypodum			*1(2)*							*1(1)*	*1(1)*	*1(1)*				*4*
	Desmodium variens	*1(2)*					*1(1)*	*4(1.8)*	*3(1.3)*	*1(2)*	*4(2)*		*1(2)*				*7*
	Dillwynia elegans					*2(1)*		*3(1.3)*		*2(1)*			*4(1.3)*				*4*
Fabaceae_Faboideae	*Glycine canescens*							*1(2)*				*1(2)*					*2*
	Glycine clandestina	*2(1)*		*7(1.3)*			*3(1.3)*	*4(1.3)*	*5(1.2)*	*11(1.6)*	*2(1)*		*4(1.3)*	*2(1.5)*			*9*
	Glycine tabacina	*1(1)*		*3(2)*	*1(2)*			*9(1.9)*	*4(1.8)*	*4(2)*	*3(1.7)*	*5(1.8)*		*5(1.4)*	*1(1)*		*10*
	Gompholobium huegelii	*1(1)*		*1(2)*	*1(1)*	*4(1)*							*1(2)*				*5*
	Hardenbergia violacea			*2(1.5)*		*1(1)*				*5(1.2)*		*1(1)*					*4*
	Hovea heterophylla					*1(1)*		*1(1)*		*6(1.3)*							*3*

	Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
Hovea lanceolata									*1(1)*							*1*
Hovea linearis													*1(1)*			*1*
Indigofera adesmiifolia						*1(2)*			*2(2)*	*2(2)*	*2(2)*					*4*
Indigofera australis			*1(1)*	*1(2)*							*1(1)*					*3*
Jacksonia scoparia					*1(1)*											*1*
Kennedia rubicundra							*1(1)*			*1(1)*						*2*
Medicago arabica	*1(3)*															*1*
Medicago laccunata	*1(2)*															*1*
Medicago polymorpha	*1(2)*															*1*
Oxylobium pulteneae					*2(1)*							*1(1)*	*1(2)*			*3*
Podolobium ilicifolium			*2(1.5)*	*7(1.7)*	*5(1.4)*	*1(1)*			*1(1)*		*1(1)*					*6*
Pultenaea foliolosa						*1(1)*		*1(2)*					*1(1)*			*3*
Pultenaea microphylla			*2(1)*	*6(1.7)*	*2(1)*	*8(1.5)*	*1(1)*	*2(1)*	*8(1.8)*	*1(1)*		*2(1)*				*9*
Pultenaea spinosa			*1(1)*	*1(2)*												*2*
Swainsona galegifolia							*1(2)*			*4(1.5)*						*2*
Swainsona reticulata												*1(2)*				*1*
Templetonia stenophylla									*2(2)*		*1(1)*					*2*
Trifolium arvense	*4(1.8)*	*1(3)*					*8(1.5)*		*1(1)*	*5(1.8)*	*1(2)*	*1(1)*	*2(1)*			*8*
Trifolium subterraneum	*3(2)*															*1*

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
	Unknown unknown					2(1.5)	1(1)										2
	Zornia dyctiocarpa							1(1)					1(1)	1(2)			3
Fabaceae_Mimosoideae	*Acacia acinacea*						3(2)										1
	Acacia brownii			1(1)	2(1)	1(1)				2(1)			3(1)		2(1)		6
	Acacia decora			3(1.7)				3(1.7)	3(1.7)	5(1.8)		3(1.3)		2(1)			6
	Acacia difformis					1(1)	2(1.5)		2(1)								3
	Acacia doratoxylon				1(2)					1(1)							2
	Acacia gladiiformis	1(2)				7(1.1)				1(2)			1(2)	1(2)	2(1.5)		6
Fabaceae_Mimosoideae	*Acacia gunnii*	1(1)															1
	Acacia hakeoides						3(1.7)	1(1)	4(1.3)	2(2)							4
	Acacia implexa			3(1)	1(2)		3(1.7)	5(1.6)	4(1.3)	2(1)		4(1)	2(1.5)	2(2)			9
	Acacia lanigera									1(1)							1
	Acacia leucolobia	1(2)		1(1)	4(1.3)	5(1.4)	1(1)		1(1)	5(1.8)		1(1)	3(1.7)		5(1.4)		10
	Acacia linearifolia	1(2)		13(2.5)	5(2.6)	4(2)	3(1.3)	4(2)	5(1.6)	1(2)	1(2)	2(1)		2(2)	2(1)		12
	Acacia penninervis						1(1)					1(2)					2
	Acacia polybotrya									1(1)				1(1)			2
	Acacia sertiformis					1(1)				1(2)			1(1)				3
	Acacia spectablis					1(1)	1(2)	1(1)	1(1)	4(1.3)			4(1.8)	3(1.7)	1(1)		8
	Acacia subulata													1(1)			1

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
	Acacia triptera														*1(1)*		*1*
	Acacia verniciflua	*1(2)*		*4(1.8)*		*1(1)*	*3(1.7)*	*1(2)*		*2(2)*		*3(1.3)*					*7*
	Neptunia gracilis							*1(1)*									*1*
Gentianaceae	*Centaurium tenuiflorum*			*1(1)*				*2(1)*		*1(1)*							*3*
	Sebaea ovata												*1(1)*				*1*
Geraniaceae	*Erodium crinitum*	*1(3)*						*1(1)*									*2*
	Geranium retrorsum									*1(1)*							*1*
	Geranium solanderi	*1(2)*		*1(2)*				*7(1.9)*			*6(1.8)*	*1(1)*		*1(1)*			*6*
Goodeniaceae	*Dampiera lanceolata var. lanceolata*					*1(1)*											*1*
	Goodenia hederacea	*1(2)*		*9(1.8)*	*10(1.9)*	*9(1.6)*	*7(1.4)*	*2(2)*	*3(2)*	*17(1.9)*		*2(1.5)*	*7(1.9)*	*2(1.5)*	*3(1.7)*		*12*
	Goodenia heterophylla				*2(1.5)*												*1*
	Goodenia macbarronii					*1(1)*		*2(2.5)*	*2(2.5)*	*1(2)*			*7(2)*			*1(2)*	*6*
	Goodenia pinnatifida							*2(1.5)*				*1(2)*					*2*
Haloragaceae	*Gonocarpus elatus*			*2(2.5)*	*3(2)*								*1(1)*		*1(2)*		*4*
	Gonocarpus tetragynus				*1(2)*		*2(1)*			*10(1.5)*	*1(1)*	*1(2)*	*1(1)*		*1(2)*		*7*
	Haloragis heterophylla	*5(1.6)*						*4(1.3)*	*1(2)*	*1(2)*			*5(1.6)*	*1(1)*		*1(2)*	*7*
	Myriophyllum gracile var. lineare															*2(2)*	*1*
Iridaceae	*Patersonia sericea*	*1(3)*			*2(2)*	*4(1.3)*				*7(1.4)*			*3(2)*	*5(2)*	*2(1.5)*		*7*
	Sisrynichum sp. A							*1(1)*									*1*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
Juncaceae	*Juncus articulatus*															*1(1)*	*1*
	Juncus filicaulis					*1(2)*	*1(1)*	*1(1)*		*2(1.5)*			*4(1.3)*				*5*
	Juncus homalocaulis	*1(1)*					*1(1)*	*7(1.7)*		*1(1)*	*1(2)*	*1(1)*	*1(1)*				*7*
Juncaceae	*Juncus planifolius*							*1(2)*	*2(1)*				*1(2)*			*3(2)*	*4*
	Juncus subsecundus	*2(1.5)*					*2(1.5)*	*3(2)*	*1(2)*	*1(1)*							*5*
	Juncus usitatus	*2(1.5)*															*1*
	Luzula meridionalis	*1(1)*				*3(1.7)*				*1(2)*	*1(2)*					*1(2)*	*5*
Lamiaceae	*Ajuga australis*						*1(2)*	*1(1)*			*2(1.5)*						*3*
	Marrubium vulgare								*2(1)*								*1*
	Mentha diemenica							*2(1.5)*			*2(1.5)*	*1(1)*					*3*
	Prostanthera howelliae					*1(2)*											*1*
Lauraceae	*Cassytha glabrella*					*2(2)*	*1(1)*			*1(2)*			*3(1)*	*1(1)*			*5*
	Cassytha pubescens									*1(2)*							*1*
Lentibulariaceae	*Utricularia dichotoma*															*2(2)*	*1*
Linaceae	*Linum marginale*							*1(1)*		*1(2)*	*2(1.5)*						*3*
Lobeliaceae	*Isotoma axillaris*			*1(1)*	*1(1)*			*1(1)*					*1(1)*				*4*
	Isotoma fluviatilis								*1(4)*				*1(2)*			*1(1)*	*3*
Lomandraceae	*Lomandra confertifolia*	*3(2)*		*3(2)*	*5(1.8)*	*2(2)*	*6(1.7)*	*6(1.8)*	*2(1)*	*6(1.8)*	*1(1)*		*5(1.8)*	*5(1.6)*	*2(1.5)*		*12*
	Lomandra filiformis subsp. coriacea			*3(1.7)*	*1(2)*	*2(1.5)*	*2(1.5)*	*3(1.3)*		*6(1.7)*	*2(1)*	*2(2)*	*3(1.3)*	*1(2)*	*3(1.3)*		*12*

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
	Lomandra filiformis subsp. filiformis	*1(2)*			*5(1.8)*	*9(1.6)*	*8(1.9)*	*9(2)*		*4(1.8)*		*1(2)*	*8(1.8)*	*7(1.6)*	*2(1.5)*		*10*
	Lomandra glauca	*1(2)*			*4(1.5)*	*6(1.7)*	*3(2)*			*6(1.2)*			*2(2)*	*1(1)*			*7*
	Lomandra leucocephala												*1(1)*	*2(1)*			*2*
	Lomandra longifolia				*1(2)*								*1(2)*				*2*
	Lomandra multiflora subsp. multiflora	*3(1.7)*		*4(1.3)*	*3(1.3)*	*6(1.2)*	*9(1.2)*	*15(1.4)*	*4(1)*	*14(1.6)*	*3(1.3)*	*2(1.5)*	*12(1.6)*	*7(1.6)*			*12*
Loranthaceae	*Amyema miquelii*			*2(1.5)*		*2(1.5)*	*3(2.7)*	*6(2)*		*6(1.5)*		*1(1)*	*4(1.8)*	*1(1)*			*8*
	Amyema miraculosum sp. boormanii							*1(1)*									*1*
	Amyema quandang var. quandang	*1(2)*		*8(1.9)*	*1(1)*	*2(2)*	*2(1)*	*2(1)*	*7(1.7)*	*1(2)*				*1(3)*	*1(1)*		*10*
Malvaceae	*Sida corrugata*							*2(1.5)*	*1(2)*			*2(1.5)*					*3*
	Sida cunninghamii			*1(1)*				*2(1)*									*2*
Myoporaceae	*Eremophila debilis*								*1(1)*								*1*
Myrtaceae	*Angophora floribunda*	*1(1)*		*3(1.7)*	*1(1)*	*1(2)*	*1(2)*	*9(2.1)*	*4(1.3)*	*8(2.6)*	*1(1)*	*1(2)*	*13(1.8)*	*10(3.5)*	*5(1.8)*		*13*
	Babingtonia cunninghamii	*1(2)*		*1(1)*		*2(2.5)*	*1(2)*	*1(1)*	*1(1)*	*5(1.4)*			*11(2.3)*	*1(1)*	*4(2)*		*10*
	Babingtonia densifolia					*5(1.8)*									*1(3)*		*2*
	Calytrix tetragona	*1(1)*				*7(1.7)*				*3(2)*			*2(1.5)*	*4(2.3)*	*4(2)*		*6*
	Eucalyptus agglomerata				*2(2)*	*2(2.5)*							*1(1)*				*3*
	Eucalyptus albens			*4(2.3)*			*1(1)*	*1(3)*		*3(1.7)*	*2(1)*	*7(3.1)*					*6*
	Eucalyptus blakelyi					*1(3)*		*11(2.5)*	*5(2.2)*	*10(2.6)*			*13(2.3)*	*3(1)*			*6*
	Eucalyptus cannonii							*1(1)*									*1*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
Myrtaceae	*Eucalyptus crebra*	*1(1)*		*8(2)*	*6(1.3)*	*4(1.3)*	*10(2.4)*	*3(1)*	*10(1.9)*	*8(2.4)*		*3(1.3)*	*9(2.1)*		*4(1.8)*		*11*
	Eucalyptus dawsonii				*1(1)*		*7(2.3)*		*1(4)*	*1(2)*				*1(1)*			*5*
	Eucalyptus dealbata														*1(2)*		*1*
	Eucalyptus dwyeri				*1(2)*	*5(1.6)*											*2*
	Eucalyptus fibrosa			*6(2.5)*	*11(3.2)*	*11(2.5)*	*5(2.4)*						*4(3)*				*5*
	Eucalyptus macrorhyncha			*2(2.5)*	*3(2)*		*1(1)*			*7(2)*			*1(1)*	*1(1)*			*6*
	Eucalyptus macrorhyncha X	*1(2)*		*1(1)*				*1(2)*		*1(2)*							*4*
	Eucalyptus melliodora			*2(1.5)*				*12(2.5)*	*1(1)*	*1(1)*			*1(1)*	*1(1)*			*6*
	Eucalyptus moluccana	*1(1)*		*1(1)*			*3(1)*	*1(1)*	*12(2.8)*	*7(3)*			*1(1)*				*7*
	Eucalyptus punctata	*1(3)*		*3(2.7)*	*14(1.8)*	*3(2.3)*			*1(2)*	*1(1)*			*5(2)*				*7*
	Eucalyptus rossii					*2(1.5)*							*2(3)*	*2(2)*	*2(1.5)*		*4*
	Eucalyptus sideroxylon				*2(3)*		*5(2.4)*		*2(2.5)*	*6(1.2)*			*1(2)*	*1(1)*			*6*
	Eucalyptus sparsifolia			*1(1)*	*6(2.5)*	*2(3.5)*											*3*
	Kunzea Mt Kapitar	*1(3)*		*2(1)*						*1(1)*					*1(2)*		*4*
	Kunzea parvifolia			*1(4)*		*1(2)*				*1(1)*			*4(1.8)*	*1(1)*	*1(2)*		*6*
	Leptospermum continentale												*1(2)*				*1*
	Leptospermum parvifolium					*1(1)*				*1(1)*				*1(2)*			*3*
	Leptospermum polygalifolium					*1(3)*				*1(1)*			*4(3)*	*2(2)*			*4*
	Melaleuca thymifolia					*2(3)*		*1(1)*							*1(1)*		*3*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
Orchidaceae	*Acianthus fornicatus*				*3(2)*	*1(2)*											*2*
	Caladenia caerulea	*1(1)*			*1(1)*	*3(1.3)*				*2(1.5)*							*4*
	Caladenia fuscata			*1(2)*		*1(1)*	*1(1)*			*4(1.3)*							*4*
	Caladenia gracilis					*1(1)*				*2(1)*							*2*
	Diuris goonooensis				*1(2)*	*2(1)*				*4(1.3)*				*1(2)*			*4*
	Diuris sulphurea									*1(1)*							*1*
	Eriochilus cucullatus									*1(1)*							*1*
	Glossodia major			*1(1)*	*3(2)*	*1(2)*	*1(2)*	*1(1)*		*5(1.6)*			*2(1.5)*				*7*
	Microtis parviflora			*1(2)*			*1(1)*	*1(1)*		*1(1)*							*4*
	Pterostylis bicolor									*1(1)*	*1(1)*						*2*
	Pterostylis nutans	*1(1)*															*1*
	Thelymitra pauciflora						*1(1)*		*1(1)*	*3(1.3)*					*1(2)*		*4*
Oxalidaceae	*Oxalis chnoodes*										*1(2)*						*1*
	Oxalis exilis				*1(1)*		*1(1)*			*2(1.5)*	*1(2)*		*1(2)*				*5*
	Oxalis perennans	*5(1.6)*		*11(1.7)*			*1(2)*	*10(1.4)*	*4(1.8)*	*1(2)*	*1(1)*	*2(1.5)*	*3(1.3)*	*4(1.5)*			*10*
Philydraceae	*Philydrum lanuginosum*															*2(1.5)*	*1*
Phormiaceae	*Dianella caerulea*						*1(1)*	*4(1)*			*1(2)*		*1(1)*				*4*
	Dianella longifolia					*1(1)*		*1(1)*					*1(1)*	*2(1)*			*4*
	Dianella revoluta	*1(2)*		*4(1.8)*	*1(1)*	*3(1.3)*	*3(1.3)*	*8(1.4)*	*2(1.5)*	*13(1.7)*			*3(1.7)*	*6(1.8)*	*2(1.5)*		*11*

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
Pittosporaceae	*Billardiera scandens*			*1(1)*	*2(1)*												*2*
	Bursaria spinosa			*3(1.7)*	*2(1.5)*	*1(1)*	*4(1.3)*	*4(1)*		*7(1.4)*	*3(1.3)*	*2(1)*		*1(2)*	*1(1)*		*10*
Pittosporaceae	*Cheiranthera cyanea*					*1(1)*				*1(1)*							*2*
Plantaginaceae	*Plantago debilis*								*1(2)*				*1(2)*				*2*
	Plantago gaudichaudii							*2(2)*			*2(2)*		*1(2)*	*1(1)*			*4*
	Plantago hispidulus											*1(1)*					*1*
	Plantago lanceolata	*3(1.7)*						*3(1.7)*			*1(2)*						*3*
	Plantago varia			*1(1)*				*5(1.4)*		*1(2)*		*3(2)*					*4*
Poaceae	*Aira elegantissima*	*6(2)*						*3(2)*		*3(1.3)*	*1(2)*		*1(1)*	*1(1)*	*1(1)*		*8*
	Aristida calycina						*1(2)*										*1*
	Aristida ramosa	*9(2.8)*		*10(2)*	*2(2)*	*5(1.8)*	*6(2)*	*16(2.7)*	*15(2.1)*	*17(2.1)*	*5(2.4)*	*6(2.2)*	*19(2)*	*12(2.8)*	*5(1.4)*		*13*
	Aristida warburgii							*1(1)*									*1*
	Arundinella nepalensis			*1(1)*		*2(3.5)*	*1(1)*	*3(1.3)*	*4(1.8)*	*8(2.1)*				*4(1.8)*		*1(1)*	*8*
	Austrodanthonia bipartita	*3(1.7)*		*4(2)*	*1(2)*	*1(2)*	*1(2)*	*7(1.6)*		*4(2.3)*	*1(2)*	*1(2)*	*2(2)*		*2(2)*		*12*
	Austrodanthonia caespitosa							*1(2)*				*1(2)*					*2*
	Austrodanthonia eriantha			*1(2)*													*1*
	Austrodanthonia pilosa						*1(2)*				*3(2)*						*2*
	Austrodanthonia racemosa			*1(2)*	*2(2.5)*		*1(2)*	*8(2)*	*4(2)*	*1(3)*	*2(2)*	*2(2)*	*3(2)*				*9*
	Austrodanthonia richardsonii							*1(3)*		*1(2)*							*2*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
Poaceae	*Austrodanthonia setacea*			*1(2)*					*1(1)*		*3(1.7)*			*1(2)*			*4*
	Austrodanthonia tenuior												*1(1)*				*1*
	Austrodanthonia unknown	*2(2.5)*		*3(2)*		*1(1)*		*4(2)*	*4(1.5)*	*2(1.5)*		*2(2)*		*1(1)*	*1(2)*		*9*
	Austrostipa densiflora			*6(2)*		*2(1.5)*	*1(2)*	*1(2)*		*3(2)*		*1(2)*	*1(1)*		*1(2)*		*8*
	Austrostipa scabra	*3(2)*		*7(1.7)*	*3(1.7)*	*1(2)*	*6(2)*	*9(2.1)*	*14(2.2)*	*6(2)*	*2(2)*	*5(1.8)*	*4(1.8)*	*4(2)*	*2(2)*		*13*
	Austrostipa unknown																*0*
	Bothriochloa decipiens							*2(1.5)*				*1(1)*					*2*
	Bothriochloa macra	*3(2.3)*					*1(2)*	*1(2)*	*2(1.5)*		*3(2.7)*						*5*
	Briza minor	*5(2)*						*3(2)*			*1(2)*		*3(1.3)*			*1(2)*	*5*
	Bromus hordeaceus	*1(4)*	*1(4)*														*2*
	Chloris truncata	*1(1)*						*1(2)*		*2(1.5)*	*1(1)*						*4*
	Chloris ventricosa											*1(2)*					*1*
	Cymbopogon refractus								*1(1)*	*3(1)*	*1(1)*		*1(2)*				*4*
	Cynodon dactylon	*3(2)*								*1(1)*				*1(2)*		*1(2)*	*4*
	Dactyloctenium australe	*2(1.5)*															*1*
	Dichelacne micrantha			*7(1.7)*	*2(1.5)*	*2(2)*	*7(1.3)*	*6(2)*	*2(1.5)*	*7(1.9)*	*3(1.7)*	*3(2)*		*3(1.7)*	*1(2)*		*11*
	Dichelacne rara									*1(2)*							*1*
	Digitaria breviglumis			*1(2)*					*1(1)*								*2*
	Digitaria brownii								*1(1)*								*1*

	Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
Digitaria divaricatissima			*1(2)*													*1*
Digitaria violascens								*2(2)*				*1(2)*	*1(1)*			*3*
Echinopogon caespitosus			*2(2)*		*2(1)*	*2(1.5)*	*6(1.8)*	*3(1)*	*6(1.8)*		*1(1)*	*7(1.6)*	*7(1.7)*			*9*
Echinopogon cheelii							*1(1)*			*1(1)*						*2*
Echinopogon ovata													*1(1)*			*1*
Eleusine indica	*1(2)*															*1*
Elymus scaber	*1(2)*	*1(2)*					*3(1.3)*			*3(1.7)*	*1(1)*					*5*
Enneapogon gracilis								*1(2)*								*1*
Entolasia marginata			*1(2)*													*1*
Entolasia stricta						*1(1)*		*1(1)*								*2*
Eragrostis brownii	*1(2)*						*1(2)*			*1(1)*					*1(2)*	*4*
Eragrostis leptostachya	*2(2)*						*1(1)*	*1(1)*	*2(1.5)*			*1(2)*	*1(1)*			*6*
Eragrostis unknown												*1(2)*				*1*
Eriochloa pseudoacrotricha												*1(1)*				*1*
Eulalia aurea			*2(1.5)*		*1(1)*		*2(1)*									*3*
Hordeum hystrix	*1(2)*															*1*
Hordeum leporinum	*1(5)*									*1(1)*						*2*
Imperata cylindrica												*1(4)*	*7(2.3)*			*2*
Joycea pallida			*3(1.7)*	*1(1)*	*2(1)*	*6(1.7)*	*1(2)*	*2(2)*	*4(1.8)*		*1(2)*					*8*

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
	Lolium rigidum	*1(2)*	*1(3)*					*2(1.5)*		*2(1)*		*1(1)*					*5*
	Melinus repens	*1(2)*															*1*
Poaceae	*Microlaena stipoides*			*8(2.8)*	*1(1)*			*10(1.9)*	*10(2)*	*8(1.6)*	*3(2)*	*1(2)*	*2(1.5)*	*7(2.1)*	*1(1)*		*10*
	Panicum decompositum			*1(1)*													*1*
	Panicum effusum	*2(2)*						*3(1.7)*		*1(1)*	*2(2)*				*1(1)*		*5*
	Panicum simile									*1(2)*							*1*
	Paspalum dilatatum	*4(2.5)*						*1(2)*	*1(2)*								*3*
	Phragmites australis							*1(1)*									*1*
	Poa labillardieri			*1(2)*				*1(2)*		*1(2)*		*1(2)*					*4*
	Poa meionectes									*1(2)*							*1*
	Poa sieberiana			*1(2)*		*1(1)*		*3(2.7)*	*1(1)*	*3(2.3)*	*5(2.4)*	*1(2)*	*1(2)*		*1(1)*		*9*
	Sarga leioclada										*3(1.3)*						*1*
	Setaria gracilis	*1(2)*															*1*
	Sporobolus creber	*7(2)*						*4(1.5)*				*1(2)*					*3*
	Tetrarrhena juncea				*4(2)*	*2(2.5)*	*2(1)*										*3*
	Themeda australis	*1(1)*		*2(2)*			*1(1)*	*11(1.9)*		*7(2.1)*	*3(3)*		*5(1.6)*		*1(1)*		*8*
	Themeda avenacea					*1(3)*											*1*
	Vulpia bromoides										*1(1)*				*1(2)*		*2*
	Vulpia myuros	*6(2)*						*3(1.7)*			*2(1.5)*						*3*

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
Polygonaceae	*Acetosella vulgaris*	2(1.5)	1(1)	1(2)				2(1.5)					1(1)	1(2)			6
	Rumex brownii	2(1.5)	1(2)	1(2)			1(1)	6(1.3)	1(2)	1(1)	4(1.8)	1(1)	1(1)	2(2)			11
	Rumex conglomeratus	1(2)															1
	Rumex crispis							1(2)									1
Primulaceae	*Anagallis arvensis*	3(2)		1(1)				3(1)	1(2)	1(1)	1(2)	2(1.5)					7
Proteaceae	*Banksia marginata*			1(1)				1(1)						6(2)	1(1)		4
	Grevillea ramosissima				1(1)	1(1)				1(1)				1(1)	2(1.5)		5
	Grevillea sericea	1(2)			4(1.5)	6(1.7)	1(1)			4(1.3)		1(1)	9(1.4)				7
	Grevillea triternata	1(1)		2(1.5)	2(1.5)	2(1)				2(1)			1(1)	1(2)			7
	Hakea dactyloides					2(1)											1
	Isopogon dawsonii			1(1)													1
	Isopogon petiolaris												1(1)				1
	Persoonia curvifolia	1(1)		1(1)		1(1)				1(1)			2(1.5)				5
	Persoonia linearis	1(2)		10(1.6)	12(1.8)	9(1.6)	2(1.5)	3(1)	1(1)	6(1.7)		1(2)	7(1.4)	3(1)	2(1)		12
	Persoonia myrtiloides sp. cunninghamii									1(1)							1
Ranunculaceae	*Clematis glycinoides*							2(1)			1(1)	2(1.5)					3
Ranunculaceae	*Ranunculus inundatus*	1(2)						1(2)									2
Rhaminaceae	*Cryptandra amara var. floribunda*			2(1)	1(2)	4(1.5)	1(2)	1(1)		2(1.5)							6
	Cryptandra spinescens					1(1)				2(2)							2

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
	Pomaderris elliptica var. elliptica				1(1)												1
Rosaceae	*Acaena ovina*							1(2)		1(1)	3(2)	1(1)					4
	Rosa rubiginosa							1(1)			1(1)						2
	Rubus discolor							1(3)									1
	Rubus parvifolius							1(1)									1
Rubiaceae	*Asperula conferta*	2(1)		1(1)				10(2)	2(1.5)	3(1.7)	2(1)	2(1.5)		1(2)			8
	Gallium gaudichaudii			1(2)								1(1)					2
	Gallium migrans			2(1)			1(1)	1(2)		3(1.3)	2(2)	1(1)		1(1)			7
	Gallium propinquum			2(1.5)													1
	Opercularia diphylla			3(1)	4(1)			1(1)		3(1.7)							4
	Opercularia hispida			1(1)		1(1)	1(1)			3(1)							4
	Pomax umbellata			9(1.7)	8(1.6)	9(2)	2(1)		1(1)	4(2)			8(1.8)		3(1.7)		8
Rutaceae	*Correa reflexa*			1(2)	3(1.3)												2
	Phebalium glandulosum sp. angustifoliu			2(1)	1(2)												2
	Phebalium squamulosum			3(1.7)	7(1.7)	2(2.5)	2(1)	1(2)		2(2)							6
	Philotheca salsolifolia				1(2)					1(1)							2
Santalaceae	*Choretrum pauciflorum*							1(2)		1(1)							2
	Exocarpos cupressiformis			2(1.5)	1(1)	1(1)			3(1.3)	2(2)		1(1)					6
	Exocarpos strictus				3(1.3)		3(1.3)	7(1.3)	4(1.5)	4(1.5)			1(1)	2(1.5)			7

		Secondary Grasslands and Shrublands	*Crop/ Plantation*	*Footslope Box - Gum - Ironbark*	*Broad-leaved Ironbark Grey Gum Forest*	*Ridgetop Broad-leaved Ironbark - Black Cypress Pine*	*Lowland Ironbark Forest*	*Blakely's Redgum - Yellow Box - Apple Woodland*	*Grey Box - Narrow-leaved Ironbark Forest*	*Lowland Box - Redgum*	*Grassy White Box Woodland*	*Shrubby White Box Forest*	*Blakely's Redgum - Rough-barked Apple Woodland*	*Rough-barked Apple - Banksia Woodland*	*Hardcap Scribbly Gum - Ironbark Woodland*	*Cyperoid Herbland*	*Occurrence*
	Santalum lanceolatum						*1(2)*				*1(2)*						*2*
Sapindaceae	*Dodonaea boroniifolia*				*1(1)*		*1(1)*										*2*
	Dodonaea sinuolata						*2(1.5)*			*1(2)*							*2*
	Dodonaea triangularis			*3(2.3)*	*2(1.5)*												*2*
	Dodonaea viscosa			*7(1.4)*	*5(1.8)*	*1(1)*	*3(1)*	*1(1)*	*1(2)*	*1(1)*		*1(1)*	*2(1.5)*				*9*
Scrophulariaceae	*Gratiola pedunculata*	*1(1)*											*2(1.5)*				*2*
	Linaria pelisseriana	*1(1)*															*1*
	Parentucellia latifolia	*4(1.5)*						*2(1.5)*									*2*
	Veronica plebia			*6(1.5)*	*1(1)*			*6(1.7)*	*4(1.5)*	*3(1.7)*	*4(1.8)*	*2(1)*	*2(1)*	*2(1)*			*9*
Solanaceae	*Solanum brownii*			*1(2)*				*2(1)*			*1(1)*	*1(1)*					*4*
	Solanum campanulatum			*2(1)*			*1(1)*		*1(1)*			*1(1)*		*1(1)*			*5*
Solanaceae	*Solanum cinereum*	*1(1)*				*1(1)*			*3(1)*			*1(2)*					*4*
Stackhousiaceae	*Stackhousia monogyna*							*2(1.5)*			*1(2)*						*2*
	Stackhousia viminea			*4(1.3)*			*1(2)*	*3(2)*	*5(1.8)*	*9(1.6)*		*1(1)*	*4(1.3)*	*1(1)*	*1(2)*		*9*
Sterculiaceae	*Brachychiton populneus*			*1(1)*					*2(1.5)*		*2(1.5)*	*1(1)*					*4*
Stylidiaceae	*Stylidium eglandulosum*									*1(1)*							*1*
Thymelaeaceae	*Pimelea curviflora subsp. sericea*							*2(2)*		*1(2)*	*5(1.4)*						*3*
	Pimelea linifolia			*1(1)*		*2(1.5)*									*1(1)*		*3*
Typhaceae	*Typha domingensis*							*1(1)*									*1*

		Secondary Grasslands and Shrublands	Crop/ Plantation	Footslope Box - Gum - Ironbark	Broad-leaved Ironbark Grey Gum Forest	Ridgetop Broad-leaved Ironbark - Black Cypress Pine	Lowland Ironbark Forest	Blakely's Redgum - Yellow Box - Apple Woodland	Grey Box - Narrow-leaved Ironbark Forest	Lowland Box - Redgum	Grassy White Box Woodland	Shrubby White Box Forest	Blakely's Redgum - Rough-barked Apple Woodland	Rough-barked Apple - Banksia Woodland	Hardcap Scribbly Gum - Ironbark Woodland	Cyperoid Herbland	Occurrence
Urticaceae	*Urtica incisa*							*1(1)*									*1*
Verbenaceae	*Verbena bonariensis*							*1(2)*									*1*
Violaceae	*Hymenanthera dentata*							*1(1)*									*1*
Xanthorrhoeaceae	*Xanthorrhoea johnsonii*							*1(1)*			*2(2.5)*		*1(2)*				*3*
Xyridaceae	*Xyris complanta*															*1(1)*	*1*
Zamiaceae	*Macrozamia secunda*			*2(2)*	*8(1.4)*	*4(1.3)*	*1(1)*			*3(1.3)*		*1(2)*	*1(1)*		*1(1)*		*8*
	Species Richness	*134*	*14*	*149*	*102*	*128*	*111*	*217*	*105*	*194*	*117*	*113*	*158*	*115*	*73*	*25*	

Key: X(Y)

X = number of observations within systematic surveys for that vegetation formation

Y = average cover abundance for that vegetation formation

APPENDIX 3

Fauna List of EL6288

KEY

Status

*	Introduced species
M	Migratory species listed under the Commonwealth EPBC Act
E (TSC)	Endangered species listed on the NSW TSC Act
V (TSC)	Vulnerable species listed on the NSW TSC Act
E (EPBC)	Endangered species listed on the Commonwealth EPBC Act
V (EPBC)	Vulnerable species listed on the Commonwealth EPBC Act

Season/Survey Period

S	summer '04
A	autumn '05
W	winter '05 first part of survey
LW	winter '05 second part of survey, after break due to wet weather
ES	Early spring '05
LS	Late spring '05

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
	MAMMALS							
	Tachyglossidae							
	Short-beaked Echidna	*Tachyglossus aculeatus*	S	A	W		ES	LS
	Dasyuridae							
	Yellow-footed Antechinus	*Antechinus flavipes*	S	A			ES	LS
	Common Dunnart	*Sminthopsis murina*					ES	
	Vombatidae							
	Common Wombat	*Vombatus ursinus*	S	A	W		ES	LS
	Petauridae							
	Sugar Glider	*Petaurus breviceps*	S	A			ES	LS
	Squirrel Glider	*Petaurus norfolcensis*					ES	
	Pseudocheiridae							
	Common Ringtail Possum	*Pseudocheirus peregrinus*	S	A	W		ES	LS
	Acrobatidae							
	Feathertail Glider	*Acrobates pygmaeus*					ES	LS
	Phalangeridae							
	Common Brushtail Possum	*Trichosurus vulpecula*	S	A	W		ES	LS
	Macropodidae							

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
	Eastern Grey Kangaroo	*Macropus giganteus*	S	A	W	LW	ES	LS
	Common Wallaroo	*Macropus robustus*	S	A	W	LW	ES	LS
	Red-necked Wallaby	*Macropus rufogriseus*	S	A	W	LW	ES	LS
	Swamp Wallaby	*Wallabia bicolor*	S	A			ES	LS
	Pteropodidae							
	Little Red Flying-fox	*Pteropus scapulatus*		S?				
	Emballonuridae							
V (TSC)	Yellow-bellied Sheath-tail Bat	*Saccolaimus flaviventris*		S?				
	Vespertilioidae							
V (TSC & EPBC)	Large-eared Pied Bat	*Chalinolobus dwyeri*						LS
V (TSC)	Little Pied Bat	*Chalinolobus picatus*						LS
	Gould's Wattled Bat	*Chalinolobus gouldii*	S					LS
	Chocolate Wattled Bat	*Chalinolobus morio*		A				LS
V (TSC)	Common Bent-wing Bat	*Miniopterus schreibersii*	S?					
	Lesser Long-eared Bat	*Nyctophilus geoffroyi*	S	A				LS
	Gould's Long-eared Bat	*Nyctophilus gouldi*		A				LS
V (TSC & EPBC)	Eastern Long-eared Bat	*Nyctophilus timoriensis*		A				
	Eastern Broad-nosed Bat	*Scotorepens orion*	S					LS
	Inland Broad-nosed Bat	*Scotorepens balstoni*	S					LS
	Little Forest Bat	*Vespadelus vulturnus*	S	A				LS
	Molossidae							
	Inland Freetail Bat	*Mormopterus sp. 3*						LS
	Southern Freetail Bat	*Mormopterus sp. 4 (planiceps)*	S					LS
	White-striped Freetail Bat	*Tadarida australis*	S	A			ES	LS
	Muridae							
	House Mouse	*Mus musculus*		A			ES	LS
	Canidae							
	Dog (Feral)	*Canis familiaris*		A			ES	
*	Fox	*Vulpes vulpes*	S	A	W		ES	LS
	Felidae							
*	Feral Cat	*Felis catus*		A			ES	LS
	Leporidae							
*	Rabbit	*Oryctolagus cuniculus*	S	A	W	LW	ES	LS
*	Brown Hare	*Lepus capensis*	S					
	Suidae							
*	Pig	*Sus scrofa*	S	A	W		ES	LS
	Bovidae							
*	Goat	*Capra hircus*		A	W			
	Cervidae							
*	Fallow Deer	*Dama dama*			W			
BIRDS								
	Megapodiidae							
	Dromaiidae							
	Emu	*Dromaius novaehollandiae*	S	A	W	LW	ES	LS
	Phasianidae							
	Stubble Quail	*Coturnix pectoralis*		A				
	Brown Quail	*Coturnix ypsilophora*		A			ES	
	Turnicidae							
	Painted Button-quail	*Turnix varia*					ES	
	Pelecanidae							
	Australian Pelican	*Pelecanus conspicillatus*	S		W			LS

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
	Anhingidae							
	Darter	*Anhinga melanogaster*			W		ES	LS
	Phalacrocoracidae							
	Pied Cormorant	*Phalacrocorax varius*	S	A				
	Little Pied Cormorant	*Phalacrocorax melanoleucos*	S	A			ES	
	Great Cormorant	*Phalacrocorax carbo*		A			ES	
	Little Black Cormorant	*Phalacrocorax sulcirostris*	S					
	Podicipedidae							
	Australasian Grebe	*Tachybaptus novaehollandiae*	S	A	W		ES	
	Anatidae							
	Black Swan	*Cygnus atratus*		A			ES	LS
	Pacific Black Duck	*Anas superciliosa*	S	A	W		ES	LS
	Grey Teal	*Anas gracilis*		A			ES	
	Hardhead	*Aythya australis*	S				ES	LS
	Australian Wood Duck	*Chenonetta jubata*	S	A	W	LW	ES	LS
	Rallidae							
	Dusky Moorhen	*Gallinula tenebrosa*					ES	
	Purple Swamphen	*Porphyrio porphyrio*						
	Eurasian Coot	*Fulica atra*	S	A	W		ES	LS
	Ardeidae							
	Cattle Egret	*Ardea ibis*						LS
	White-necked Heron	*Ardea pacifica*		A			ES	LS
	White-faced Heron	*Egretta novaehollandiae*	S	A	W		ES	LS
	Threskiornidae							
	Straw-necked Ibis	*Threskiornis spinicollis*		A				
	Charadriidae							
	Masked Lapwing	*Vanellus miles*	S	A	W	LW	ES	LS
	Recurvirostridae							
	Black-fronted Dotterel	*Elseyornis melanops*	S		W		ES	LS
	Black-winged Stilt	*Himantopus himantopus*						
	Accipitridae							
	Black-shouldered Kite	*Elanus axillaris*		A	W		ES	LS
V (TSC)	Square-tailed Kite	*Lophoictinia isura*			W			
	Whistling Kite	*Haliastur sphenurus*				LW	ES	LS
	Wedge-tailed Eagle	*Aquila audax*	S	A		LW	ES	LS
	Little Eagle	*Hieraaetus morphnoides*						
	Brown Goshawk	*Accipiter fasciatus*			W		ES	LS
	Collared Sparrowhawk	*Accipiter cirrhocephalus*						LS
	Spotted Harrier	*Circus assimilis*		A				
	Falconidae							
	Peregrine Falcon	*Falco peregrinus*	S	A				LS
	Australian Hobby	*Falco longipennis*	S	A	W			
	Falconidae cont							
	Brown Falcon	*Falco berigora*	S	A			ES	LS
	Nankeen Kestrel	*Falco cenchroides*	S	A	W	LW	ES	LS
	Columbidae							
	Peaceful Dove	*Geopelia striata*	S			LW	ES	LS
	Bar-shouldered Dove	*Geopelia humeralis*					ES	
	Common Bronzewing	*Phaps chalcoptera*	S	A	W	LW	ES	LS
	Brush Bronzewing	*Phaps elegans*						
	Crested Pigeon	*Ocyphaps lophotes*	S	A	W	LW	ES	LS
	Wonga Pigeon	*Leucosarcia melanoleuca*	S					

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
	Cacatuidae							
V (TSC)	Glossy Black-Cockatoo	*Calyptorhynchus lathami*	S	A	W	LW	ES	LS
	Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*	S	A	W	LW		
V (TSC)	Gang-Gang Cockatoo	*Callocephalon fimbriatum*						
	Galah	*Eolophus roseicpilla*	S	A	W	LW	ES	LS
	Little Corella	*Cacatua sanguinea*						
	Sulphur-crested Cockatoo	*Cacatua galerita*	S	A	W	LW	ES	LS
	Psittacidae							
	Musk Lorikeet	*Glossopsitta concinna*	S			LW	ES	
	Little Lorikeet	*Glossopsitta pusilla*	S			LW	ES	
	Australian King Parrot	*Alisterus scapularis*	S	A	W	LW	ES	LS
	Crimson Rosella	*Platycercus elegans*						
	Eastern Rosella	*Platycercus eximius*	S	A	W	LW	ES	LS
	Red-rumped Parrot	*Psephotus haematonotus*	S	A	W	LW	ES	LS
	Cuculidae							
	Pallid Cuckoo	*Cuculus pallidus*	S				ES	LS
	Brush Cuckoo	*Cuculus variolosus*				LW	ES	LS
	Fan-tailed Cuckoo	*Cuculus flabelliformis*	S	A		LW	ES	LS
	Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*						LS
	Common Koel	*Eudynamys scopopacea*						LS
	Channel-billed Cuckoo	*Scthrops novaehollandiae*	S					LS
	Centropodidae							
	Strigidae							
V (TSC)	Powerful Owl	*Ninox strenua*		A	W *		ES	
	Southern Boobook	*Ninox novaeseelandiae*	S	A	W		ES	LS
	Tytonidae							
	Barn Owl	*Tyto alba*	S	A				
	Podargidae							
	Tawny Frogmouth	*Podargus strigoides*		A	W		ES	LS
	Caprimulgidae							
	White-throated Nightjar	*Eurostopodus mysticalis*						LS
	Aegothelidae		S					
	Australian Owlet-nightjar	*Aegotheles cristatus*		A	W		ES	LS
	Apodidae							
M	White-throated Needletail	*Hirundapus caudacutus*	S					
	Alcedinidae							
	Laughing Kookaburra	*Dacelo naxaeguineae*	S	A	W	LW	ES	LS
	Sacred Kingfisher	*Todiramphus sanctus*	S					LS
	Meropidae							
M	Rainbow Bee-eater	*Merops ornatus*	S					LS
	Coraciidae							
	Dollarbird	*Eurystomus orientalis*	S					LS
	Menuridae							
	Superb Lyrebird	*Menura novaehollandiae*	S	A	W	LW	ES	
	Neosittidae							
	Varied Sittella	*Daphoenositta chrysoptera*	S	A	W		ES	
	Climacteridae							
	White-throated Treecreeper	*Cormobates leucophaeus*	S	A	W	LW	ES	LS
V (TSC)	Brown Treecreeper	*Climacteris picumnus*	S	A	W	LW	ES	LS
	Maluridae							
	Superb Fairy-wren	*Malurus cyaneus*	S	A	W	LW	ES	LS
	Variegated Fairy-wren	*Malurus lamberti*	S				ES	LS

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
	Red-backed Fairy-wren	*Malurus melanocephalus*	S?					
	Pardalotidae							
	Spotted Pardalote	*Pardalotus punctatus*	S	A	W	LW	ES	LS
	Striated Pardalote	*Pardalotus striatus*	S	A	W	LW	ES	LS
	Rockwarbler	*Origma solitaria*	S	A	W	LW	ES	LS
	White-browed Scrubwren	*Sericornis frontalis*	S	A	W	LW	ES	LS
	Chestnut-rumped Heathwren	*Hylacola pyrrhopygia*				LW	ES	
V (TSC)	Speckled Warbler	*Chthinicola sagittata*	S	A	W	LW	ES	LS
	Weebill	*Smicrornis brevirostris*	S	A	W	LW	ES	LS
	White-throated Gerygone	*Gerygone olivacea*			W		ES	LS
	Western Gerygone	*Gerygone fusca*	S	A			ES	LS
	Brown Thornbill	*Acanthiza pusilla*	S	A	W	LW	ES	LS
	Yellow Thornbill	*Acanthiza nana*		A	W		ES	
	Striated Thornbill	*Acanthiza lineata*		A	W	LW	ES	LS
	Buff-rumped Thornbill	*Acanthiza reguloides*	S	A	W	LW	ES	
	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	S	A	W	LW	ES	LS
	Southern Whiteface	*Apehelocephala leucopsis*	S	A	W		ES	LS
	Meliphagidae							
	Red Wattlebird	*Anthochaera carunculata*	S	A	W	LW	ES	LS
	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	S		W	LW	ES	LS
	Striped Honeyeater	*Plectorhyncha lanceolata*			W	LW		LS
	Noisy Friarbird	*Philemon corniculatus*	S	A	W	LW	ES	LS
	Little Friarbird	*Philemon citreogularis*						LS
	Blue-faced Honeyeater	*Entomyzon cyanotis*	S	A	W			LS
	Noisy Miner	*Manorina melanocephala*	S	A	W	LW	ES	LS
	Yellow-faced Honeyeater	*Lichenostomus chrysops*	S	A	W	LW	ES	LS
	White-eared Honeyeater	*Lichenostomus leucotis*	S	A	W	LW	ES	
	Yellow-tufted Honeyeater	*Lichenostomus melanops*	S	A	W	LW	ES	LS
	Singing Honeyeater	*Lichenostonus virescens*						
	Fuscous Honeyeater	*Lichenostomus fuscus*	S	A	W	LW	ES	LS
	White-plumed Honeyeater	*Lichenostomus pencillatus*	S	A	W	LW	ES	LS
	Meliphagidae cont							
V (TSC)	Black-chinned Honeyeater	*Melithreptus gularis*	S?		W	LW	ES	
	Brown-headed Honeyeater	*Melithreptus brevirostris*	S?	A	W	LW	ES	
	White-naped Honeyeater	*Melithreptus lunatus*		A	W	LW		LS
	Brown Honeyeater	*Lichmera indistincta*		A				
	New Holland Honeyeater	*Phylidonryis novaehollandiae*				LW	ES	
V (TSC)	Painted Honeyeater	*Grantiella picta*						LS
	Eastern Spinebill	*Acanthorhynchus tenuirostris*	S	A	W	LW	ES	
	Scarlet Honeyeater	*Myzomela sanguinolenta*	S					
	White-fronted Chat	*Epthianura albifrons*					ES	
	Orthonychidae							
	Eastern Whipbird	*Psophodes olivaceus*					ES	
	Cinclosomatidae							
	Spotted Quail-thrush	*Cinclosoma punctatum*		A	W	LW	ES	LS
	Pomatostomidae							
V (TSC)	Grey-crowned Babbler	*Pomatostomus temporalis*	S	A		LW		
	White-browed Babbler	*Pomatostomus superciliosus*	S	A	W	LW	ES	LS
	Petroicidae							
	Red-capped Robin	*Petroica goodenovii*		A	W	LW	ES	
	Scarlet Robin	*Petroica multicolor*			W	LW		
V (TSC)	Hooded Robin	*Melanodryas cucullata*	S	A	W	LW	ES	LS

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
					**			
	Eastern Yellow Robin	*Eopsaltria australis*	S	A	W	LW	ES	LS
	Jacky Winter	*Microeca fascinans*		A	W	LW	ES	LS
	Pachycephalidae							
	Crested Shrike-tit	*Falcunculus frontatus*	S	A	W	LW		
	Grey Shrike-thrush	*Colluricincla harmonica*	S	A	W	LW	ES	LS
	Golden Whistler	*Pachycephala pectoralis*	S	A	W	LW	ES	
V (TSC)	Gilbert's Whistler	*Pachycephala inornata*	S					
	Rufous Whistler	*Pachycephala rufiventris*	S	A	W		ES	LS
	Dicruridae							
	Grey Fantail	*Rhipidura fuliginosa*	S	A	W		ES	LS
M	Rufous Fantail	*Rhipidura rufifrons*		A				
	Willie Wagtail	*Rhipidura leucophrys*	S	A	W	LW	ES	LS
M	Satin Flycatcher	*Myiagra cyanoleuca*		A				
	Restless Flycatcher	*Myiagra inquieta*	S	A	W	LW	ES	LS
	Magpie Lark	*Grallina cyanoleuca*		A	W	LW	ES	LS
	Oriolidae							
	Olive-backed Oriole	*Oriolus sagittatus*		A		LW	ES	LS
	Ptilonorhynchidae							
	Campephagidae							
	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	S	A		LW	ES	LS
	White-bellied Cuckoo-shrike	*Coracina papuensis*			W	LW	ES	LS
	Cicadabird	*Coracina tenuirostris*						LS
	White-winged Triller	*Lalage sueurii*	S					LS
	Varied Triller	*Lalage leucomela*	S					
	Artamidae							
	Masked Woodswallow	*Artamus personatus*	S					
	White-browed Woodswallow	*Artamus superciliosus*	S					
	Black-faced Woodswallow	*Artamus cinereus*	S					
	Dusky Woodswallow	*Artamus cyanopterus*	S	A		LW	ES	LS
	Grey Butcherbird	*Cracticus torquatus*	S	A	W	LW	ES	LS
	Pied Butcherbird	*Cracticus nigrogularis*	S	A	W	LW	ES	LS
	Australian Magpie	*Gymnorhina tibicen*	S	A	W	LW	ES	LS
	Pied Currawong	*Strepera graculina*	S	A	W	LW	ES	LS
	Corvidae							
	Australian Raven	*Corvus coronoides*	S	A	W	LW	ES	LS
	Corcoracidae							
	White-winged Chough	*Corcorax melanorhamphos*	S	A	W	LW	ES	LS
	Hirundinidae							
	White-backed Swallow	*Cheramoeca leucosternus*	S	A			ES	
	Welcome Swallow	*Hirundo neoxena*	S	A	W	LW	ES	LS
	Tree Martin	*Hirundo nigricans*	S					LS
	Fairy Martin	*Hirundo ariel*	S				ES	LS
	Motacillidae							
	Richard's Pipit	*Anthus naovaeseelandiae*	S		W	LW	ES	LS
	Sylviidae							
	Rufous Songlark	*Cincloramphus mathewsi*	S		W			LS
	Brown Songlark	*Cincloramphus cruralis*	S					
	Clamorous Reed-warbler	*Acrocephalus stentoreus*						LS
	Passeridae							
*	House Sparrow	*Passer domesticus*	S	A	W			
	Ploceidae							

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
	Double-barred Finch	*Taeniopygia bichenovii*		A	W	LW	ES	LS
	Red-browed Finch	*Neochmia temporalis*	S	A		LW	ES	LS
V (TSC)	Diamond Firetail	*Stagonopleura guttata*	S	A	W	LW	ES	LS
	Dicaeidae							
	Mistletoebird	*Dicaeum hirundinaceum*	S		W	LW	ES	LS
	Zosteropidae							
	Silvereye	*Zosterops lateralis*			W		ES	LS
	Muscicapidae							
	Bassian (Ground) Thrush	*Zoothera lunulata*	S	A				
*	Common Blackbird	*Turdus merula*	S					
	Sturnidae							
*	Common Starling	*Sturnus vulgaris*	S	A	W	LW	ES	LS
REPTILES								
	Chelidae							
	Eastern Long-necked Turtle	*Chelodina longicollis*	S	A			ES	LS
	Gekkonidae							
	Wood Gecko	*Diplodactylus vittatus*		A			ES	LS
	Lesueur's Velvet Gecko	*Oedura lesueurii*		A			ES	LS
	Southern Leaf-tailed Gecko	*Phyllurus platurus*		A				
	Thick-tailed Gecko	*Underwoodisaurus milii*		A			ES	
	Pygopodidae							
	Burton's Snake-lizard	*Lialis burtonis*	S					
	Common Scaly-foot	*Pygopus lepidopodus*	S					
	Agamidae							
	Nobbi	*Amphibolurus nobbi*	S	A	W	LW	ES	
	Eastern Bearded Dragon	*Pogona barbata*	S				ES	LS
	Mountain Dragon	*Tympanocryptis diemensis*		A				LS
	Varanidae							
	Lace Monitor	*Varanus varius*	S	A			ES	LS
	Scincidae							
	Two-clawed Worm Skink	*Anomalopus leukartii*	S	A	W		ES	LS
	Littrer Skink	*Carlia foliorum*						LS
	Southern Rainbow Skink	*Carlia tetradactyla*	S					LS
	Striped Skink	*Ctenotus robustus*						
	Copper-tailed Skink	*Ctenotus taeniolatus*	S	A	W		ES	
	Cunningham's Skink	*Egernia cunninghami*	S					
	White's Skink	*Egernia whitii*		A			ES	LS
	Yellow-bellied Skink	*Eulamprus tenuis*	S					LS
	Grass Skink	*Lampropholis delicata*		A				
	South-eastern Slider	*Lerista bouganvilli*		A			ES	LS
	Boulenger's Skink	*Morethia boulengeri*	S	A	W	LW	ES	LS
	Eastern Blue-tongued Lizard	*Tiliqua scincoides*	S					
	Shingle-back	*Trachydosaurus rugosus*	S					LS
	Typhlopidae							
	Blind Snake	*Ramphotyphlops nigrescens*					ES	LS
	Blind Snake	*Ramphotyphlops proximus*						LS
	Elapidae							
	Yellow-faced Whip Snake	*Demansia psammophis*			W			LS
	Red-naped Snake	*Furina diadema*			W		ES	
	Red-bellied Black Snake	*Pseudechis porphyriacus*	S	A			ES	
	Eastern Brown Snake	*Pseudonaja textilis*						LS

Status	Common Name	Scientific Name	S	A	W	LW	ES	LS
	Dwyer's Black-headed Snake	*Suta dwyeri*		A			ES	
	Bandy Bandy	*Vermicella annulata*						LS*
AMPHIBIANS								
	Myobatrachidae							
	Common Eastern Froglet	*Crinia signifera*		A	W	LW	ES	LS
	Eastern Banjo Frog	*Limnodynastes dumerilii dumerilii*	S	A			ES	LS
	Ornate Burrowing Frog	*Limnodynastes ornatus*	S					
	Myobatrachidae cont							
	Striped Marsh Frog	*Limnodynastes peronii*	S		W			
	Spotted Grass Frog	*Limnodynastes tasmaniensis*	S				ES	LS
	Northern Banjo Frog	*Limnodynastes terraereginae*	S				ES	LS
	Painted Burrowing Frog	*Neobatrachus sudelli*		A	W		ES	LS
	Brown Toadlet	*Pseudophryne bibronii*	S	A		LW	ES	LS
	Smooth Toadlet	*Uperoleia laevigata*	S	A			ES	LS
	Tyler's Toadlet	*Uperoleia tyleri*	S					
	Hylidae							
	Green Tree Frog	*Litoria caerulea*	S					LS
	Eastern Dwarf Tree Frog	*Litoria fallax*	S				ES	LS
	Broad-palmed Frog	*Litoria latopalmata*	S					LS
	Leseur's Tree Frog	*Litoria lesueuri*						LS
	Peron's Tree Frog	*Litoria peronii*	S	A			ES	LS
	Bleating Tree Frog	*Litoria dentata*						
	Verreaux's Tree Frog	*Litoria verreauxii*			W		ES	LS
FISH								
	Short-finned Eel	*Anguilla australis*					ES	

APPENDIX 4

Aquatic Ecology and field water quality sampling results

Appendix Table 5.1

Modified Riparian, Channel and Environment (RCE) Inventory.

Descriptor			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Category		
	Category		WCX0	WCX1	WC1	MGX1	MGX2	MG1	MG2*	WC2	EC Spring	ECX0	ECX1	ECX1.5	ECC1	ECX1.75	ECX2	WC3	WC4	Median	Mean	SE
		Value																				
1	Land-use pattern beyond immediate riparian zone																			3	2.6	0.1
	Undisturbed native vegetation	4	4																			
	Mixed native vegetation and pasture/exotics	3			3		3	3	2	3				3	3	3	3	3				
	Mainly pasture, crops or pine plantation	2		2		2					2	2	2						2			
	Urban, some vegetation	1																				
	Industrial, little vegetation	0																				
2	Width of riparian strip-of woody vegetation																			3	3	0.2
	More than 30 m	4	4							4				4	4	4	4					
	Between 5 and 30 m	3		3	3		3	3	3									3	3			
	Less than 5 m	2									1	2	2									
	No woody vegetation	1				1																
	No Vegetation	0																				
3	Completeness of riparian strip of woody vegetation																			2	1.9	0.3
	Riparian strip without breaks in vegetation	4	4													4	4					
	Breaks at intervals of more than 50 m	3								3					3							
	Breaks at intervals of 10-50 m	2					2	2						2				2				
	Breaks at intervals of less than 10 m	1		1	1				1		1	1	1						1			
	No riparian strip at all	0				0																
4	Vegetation of riparian zone within 10 m of channel																			3	3	0.1
	Native tree and shrub species	4	4																			
	Mixed native and exotic trees and shrubs	3		3	3		3	3	3	3	3	3	3	3	3	3	3	3	3			
	Exotic trees and shrubs	2				2																
	Exotic grasses/weeds	1																				
	No vegetation at all	0																				
5	Stream bank structure																			3	2.5	0.2
	Banks fully stabilized by trees, shrubs, concrete	4																				
	Banks firm but held mainly by grass and herbs	3			3	3	3	3				3		3	3	3	3	3	3			
	Banks loose, partly held by sparse grass, rubble	2	2							2	2		2									
	Banks unstable, mainly loose sand or soil	1		1																		
	Banks actively eroding	0							0													
6	Bank undercutting																			3	2.7	0.2
	None, or restricted by tree roots or man-made	4	4			4																
	Only on curves and at constrictions	3			3		3			3	3	3	3		3			3	3			
	Frequent along all parts of stream	2		2				2						2		2	2					
	Severe; bank collapses common	1							1													
	Total bank collapse	0																				
7	Channel form																			3	3	0.3
	Deep; width:depth ratio less than 8:1	4	4		4			4	4	4				4		4	4					
	Medium; width:depth ratio 8:1 to 15:1	3													3			3	3			
	Shallow; width:depth ratio greater than 15:1	2				2	2				2	2	2									
	Artificial; concrete or excavated channel< 8:1	1																				
	Artificial; concrete or excavated channel > 8:1	0		0																		
8	Riffle/pool sequence																			2	1.5	0.2
	Frequent alternation of riffles and pools	4																				
	Long pools with infrequent short riffles	3																				
	Natural channel without riffle/pool sequence	2	2		2		2	2		2		2	2	2	2	2	2	2	2			
	Artificial channel; some riffle/pool sequence	1																				
	Artificial channel; no riffle/pool sequence	0		0		0			0		0											
9	Retention devices in stream																			1	1.5	0.2
	Many large boulders and/or debris dams	4		4																		
	Rocks/logs present; limited damming effect	3			3																	
	Rocks/logs present but unstable; no damming	2	2											2		2						
	Stream or channel with few or no rocks/logs	1				1	1	1	1	1	1	1	1		1		1	1	1			
	Artificial channel; no retention devices	0																				
10	Channel sediment accumulations																			2	2.1	0.2
	Little or no accumulation of loose sediments	4									4											
	Some gravel bars but little sand or silt	3		3																		
	Bars of sand and silt common	2	2		2	2	2	2	2			2	2	2	2	2	2	2				
	Braiding by loose sediment	1								1									1			
	Complete in-filled muddy channel	0																				
11	Stream bottom																			1	1.2	0.2
	Mainly clean stones with obvious interstices	4																				
	Mainly stones with some cover of algae/silt	3									3											
	Bottom heavily silted but stable	2		2	2				2	2				2				2				
	Bottom mainly loose and mobile sandy sediment	1	1				1					1	1		1							
	Bottom mainly loose and mobile muddy sediment	0				0		0								0	0		0			
12	Stream detritus																			2	1.6	0.3
	Mainly unsilted wood, bark, leaves	4	4																			
	Some wood, leaves, etc. with much fine detritus	3			3									3								
	Mainly fine detritus mixed with sediment	2		2			1	2		2	2				2			2	2			
	Little or no organic detritus, mainly sandy	1										1	1			1						
	No organic detritus, mainly mud	0				0			0								0					
13	Aquatic vegetation																			3	3.1	0.2
	Little or no macrophyte or algal growth	4	4				4	4	4					4		4	4					
	Substantial algal growth; few macrophytes	3			3						3	3	3		3							
	Substantial macrophyte growth; little algal growth	2				2				2								2	2			
	Substantial macrophyte and algal growth	1		1																		
	Total cover of macrophytes plus algae	0																				
			WCX0	WCX1	WC1	MGX1	MGX2	MG1	MG2*	WC2	EC Spring	ECX0	ECX1	ECX1.5	ECC1	ECX1.75	ECX2	WC3	WC4			
	RCE Score		41	24	35	19	30	31	23	32	27	26	25	36	33	34	32	31	26			
	RCE %age		78.8	46.2	67.3	36.5	57.7	59.6	44.2	61.5	51.9	50	48.1	69.2	63.5	65.4	61.5	59.6	50			

*MG2 represents the more permanent site sampled on the downstream side of the crossroad

Appendix Table 5.2 Field Comments – Spring 2007 Aquatic Ecology Sites		
Date	Site	Comments
29/10/07	MG2	Creek section sampled above and below road crossing. Upstream channel with isolated pools between 4 and 10m length x 2m max width, max depth 0.7m, and average depth 0.2m. Water turbid with no flow. Pool substrate soft clayey with detritus (leaves, bark and sticks) in pool basin. Some emergent sedges (*Eleocharis spp*) around pool perimeter. Banjo frog *Lymnodynastes dumerilii* Pool on downstream side of road culvert same pool as sampled on previous survey occasions. Max length 5m x 4m width, maximum depth 1.5m. Water turbid with no flow. Substrate soft clayey with small amounts of detritus. Very little habitat available. Cumbungi (*Typha orientalis*) died back since previous samples. Yabbie *Cherax destructor* retained in traps from sample. Some surface water downstream in similar holes to that sampled at downstream end on site, but shallower.
29/10/07	MGX1	In line dam sampled. Pool length approx 15m x 13m max width, depth to ~1.8m, average depth 1m. Water moderately turbid with no flow in or out. Substrate soft and muddy. Cumbungi, Eleocharis spp and Floating Pondweed (*Potamageton sulcatus*) were present around pool edges, plus Charophytes were noted. Filamentous green algae present in small amounts.
29/10/07	13	Pool length approx 12m x 4m max width, depth to 1m. Water turbid with no flow. Substrate soft and clayey with some larger gravel. A couple of logs present with moderate amounts of detritus in pool basin. Charophytes present in moderate amounts.
30/10/07	ECX1	Large dam sampled (eastern most). Pool length approx 25m x 20m width, max depth ~3m (?).Water turbid with no flow. Substrate soft clayey overlying sandy gravel. Water buttons (*Cotula coronopifolia*) present in channel upstream and downstream of site. Filamentous green algae present in small amounts. Adult yabbies retained in traps.
30/10/07	EXC0	In line dam sampled just below soak. Pool length approx 20m x 20m max width, max depth ~2m. Water slightly turbid with no flow, however spring fed soak immediately upstream in channel. Substrate soft muddy clay, with some coarser fragments. Water buttons present in channel upstream of site. Cumbungi, Eleocharis spp and Floating Pondweed common, plus Blunt Pondweed (*Potamogeton ochreatus*) present in small amounts. Filamentous green algae present in small amounts.

30/10/07	ECSpring	Spring fed waterhole sampled below outlet pipes via carved wooden aquifers. Pool length 5m x 5m width, max depth 0.8m. Water very clear with trickling flow in and out of man-made pool. Substrate sandy mud. Eleocharis spp and Floating Pondweed common, plus unidentified Watermilfoil (*Myriophyllum spp*) around edges. Filamentous green algae present in moderate amounts. Common eastern toadlet *Crinia signifera* heard calling from soak immediately downstream of pool area.
30/10/07	ECX1.5	Site sampled around 200-400m downstream from pump. Two pools sampled, separated by sediment bed. Combined pool length 20m x 2.5m max width, max depth 0.4m. Water turbid with no flow. Substrate mainly sandy gravel with some deposits of soft clay. Abundant erosion holes along creek section, with some claystone rock bars present in channel. Undercut banks in site. Detritus present in pool basin. Eleocharis spp present around upper edge of downstream pool. Eastern Long Necked Turtle observed in upstream pool.
30/10/07	ECC1	In line dam just below spring fed soak (tributary to Eastern Creek). Pool length 15m x 9m width, max depth 0.9m. Water tanin stained with no flow in or out. Substrate soft and muddy. Eleocharis spp and Cumbungi the main emergent plants. Filamentous green algae present in small amounts. Frog spawn present within edge habitat at five locations around pool perimeter. Eastern Long Necked Turtle observed in site.
31/10/07	ECX1.75	Creek section sampled at and just below ECC1 confluence with Eastern Creek (three pools). Combined pool length 25m x 4m max width, max depth 0.8m (average depth 0.2m). Water cloudy at upstream (pool 1) and downstream (pool 3) pool, and slightly stained in middle spring fed pool (pool 2). Channel section in between pools 1 and 3 all soaked with Watermilfoil, Water Buttons and Paspalum spp. Watermilfoil and Eleocharis spp only emergent plants in pool areas (in pool 2). Pools 1 and 3 with no plants. Substrate sandy with some finer clayey deposits. Undercut banks present at both pools 1 and 3. Charophytes present in all pools. Dead yabbie in pool 1.
31/10/07	ECX1.8 & 1.85	Creek section sampled downstream from ECX1.75 Pool 3, (below confluence with Creek ECC1) and adjacent to riparian bank seep from western bank.

31/10/07	WC4	Sampled just above road crossing. Pool length continuous through creeks section, max width 10m, max depth 1m (average depth 0.4m). Water turbid brown with trickle flow. Some orange staining on substrate. Substrate muddy with abundant Cumbungi roots. Cumbungi noted to have died back since previous sample occasions, with more open water. Cumbungi still present, with Eleocharis spp and grasses submerged around edge areas. Gambusia observed in site.

Appendix Table 5.3 Moolarben Water Quality Results											
Spring 04, Autumn 05, Spring 05, Summer 06, Autumn 06, Spring 07											
Creek				Depth	Temp	Cond	DO	DO	Acidity	ORP	Turb
	Site	Date	Time	m	°C	μs/cm	%Sat	mg/L	pH units	mv	NTU
Wilpinjong Creek											
	WCX1	16/01/06	13:58	0.1	26.97	515	120.1	9.6	9.24	219	51.6
	WCX1	16/01/06	13:59	0.4	26.64	524	118.8	9.5	9.20	222	51.6
	WCX1	16/01/06	13:59	0.6	26.33	530	107.0	8.6	9.08	228	53.5
	WC1	27/09/05	8:21	0.3	15.14	898	62.0	6.2	7.14	247	20.3
	WC2	15/12/04	10:34	0.1	18.21	953	11.9	1.1	6.64	152	30.2
	WC2	27/09/05	10:03	0.1	16.12	738	51.2	5.0	7.29	135	38.1
	WC2	08/06/06	8:53	0.6	6.29	1470	53.3	6.6	5.74	134	3.6
	WC4	27/09/05	11:13	0.1	16.85	1143	57.9	5.6	7.02	325	3.2
	WC4	28/09/05	10:34	0.1	16.95	1173	58.0	5.6	7.24	315	3.8
	WC4	17/01/06	16:08	0.1	23.61	635	13.5	1.1	7.61	240	87.2
	WC4	31/10/07	11:59	0.1	22.99	1206	107.3	9.2	5.94	295	164.5
	WC4 hole	31/10/07	12:01	0.1	24.39	1178	82.1	6.8	6.78	295	22.2
Murragamba Creek											
	MGX1	29/10/07	11:58	0.1	23.68	724	57.6	4.9	7.45	295	42.5
	RB	29/10/07	15:01	0.2	21.83	53	31.0	2.7	6.84	295	508.4
	MGX2	29/10/07	15:22	0.2	22.34	84	43.7	3.8	7.33	295	243.2
	OB	29/10/07	16:26	0.1	27.83	417	114.2	9.0	8.91	295	437.0
	MG0	17/01/06	14:50	0.2	25.09	452	3.3	0.3	7.26	82	50.7
	MG1	28/09/05	9:06	0.1	14.58	192	56.5	5.8	7.47	274	277.9
	MG1	17/01/06	14:47	0.2	23.50	491	3.0	0.3	7.32		543.2
	MG2	15/12/04	9:05	0.2	19.09	362	49.6	4.6	6.92	467	115.9
	MG2	18/05/05	13:30	0.2	12.55	582	53.1	5.6	7.60	588	23.1
	MG2	22/09/05	11:09	0.4	11.84	548	71.0	7.7	7.18	390	266.6
	MG2	08/06/06	9:54	0.1	6.20	409	39.5	4.9	6.77	380	95.2
	MG2	08/06/06	9:55	0.4	6.10	410	39.2	4.9	6.77	380	113.0
	MG2	29/10/07	10:25	0.1	17.46	208	51.1	4.9	6.95	295	492.9
	MG2	29/10/07	10:27	0.1	18.49	303	30.9	2.9	6.59	295	421.0
*	Yards Pool	29/10/07	12:57	0.1	22.92	174	81.1	7.0	8.09	295	66.4
*	ELE	29/10/07	14:29	0.1	24.12	149	122.0	10.2	8.25	295	62.9
*	Dam1	29/10/07	16:53	0.1	26.11	230	106.8	8.6	7.73	295	11.9
*	Dam2	29/10/07	16:59	0.1	23.59	95	95.4	8.1	8.35	295	23.5
*	Dam3	29/10/07	17:05	0.1	22.90	96	98.8	8.5	8.76	295	22.4
Eastern Creek											
	EXC0Spring	30/10/07	11:37	0.1	26.11	1131	123.0	9.9	6.75	295	37.5
	EXC0	30/10/07	11:36	0.2	22.59	1592	68.5	5.9	7.32	295	21.6
	SnakePool	30/10/07	9:42	0.1	19.48	425	92.2	8.5	7.25	295	105.8
	SnakePool	30/10/07	9:44	0.1	19.56	298	82.9	7.6	7.03	296	25.8
	In-LineDam	30/10/07	9:48	0.2	22.57	1412	88.6	7.6	7.31	295	356.0
	RemnantCreek	30/10/07	9:50	0.2	19.63	2297	78.9	7.2	6.91	496	600.0
	Ectaninpool	30/10/07	14:59	0.1	21.64	614	42.8	3.8	6.64	295	142.0
	ECX1.5 u/s	30/10/07	15:37	0.2	16.51	518	17.6	1.7	6.95	295	505.2
	ECX1.5 d/s	30/10/07	15:39	0.2	18.29	839	9.0	0.8	6.56	295	147.5
	ECX1.75 -1	31/10/07	10:54	0.1	15.00	975	43.2	4.4	5.78	295	190.3
	ECX1.75 soak	31/10/07	11:24	0.2	19.92	486	88.2	8.0	7.02	295	29.4
	ECX1.75 -2	31/10/07	11:00	0.1	16.93	756	52.2	5.0	6.87	295	71.7
	ECX1.75 -3	31/10/07	11:03	0.1	15.53	430	9.7	1.0	6.73	295	399.8
	EC1.8	31/10/07	11:52	0.1	18.77	1152	33.9	3.2	4.70	294	41.7
	EC1.8	31/10/07	11:53	0.1	16.44	1183	36.0	3.5	4.76	294	49.1
	EC1.85	31/10/07	11:56	0.1	25.56	2300	59.7	4.8	3.21	294	4.0
	EC1.85	31/10/07	11:57	0.1	25.78	2296	59.2	4.8	3.20	294	2.3
	ECX2	27/09/05	9:56	0.1	15.80	325	87.1	8.6	7.27	261	67.9
	ECX2	17/01/06	17:08	0.1	24.87	663	26.7	2.2	4.43	676	97.1
	ECX2	08/06/06	9:00	0.1	6.04	300	40.6	5.1	5.91	308	94.3

*	ECSpring	30/10/07	12:37	0.3	16.33	133	49.7	4.9	6.25	295	2.0
*	ECX1	30/10/07	9:37	0.2	20.81	785	93.6	8.4	7.87	295	63.1
*	ECC1 u/s	30/10/07	17:19	0.1	24.54	110	56.0	4.7	6.50	295	65.6
*	ECC1 d/s	31/10/07	10:58	0.1	16.72	1663	55.1	5.3	6.76	295	87.8
*	ECC1	30/10/07	17:04	0.1	26.01	381	52.4	4.2	6.80	295	91.4
*	Pump(d/s)	30/10/07	14:56	0.2	20.33	453	29.0	2.6	6.84	295	230.3
*	ECC1hole	30/10/07	17:17	0.1	20.73	234	9.6	0.9	6.89	295	554.3
	Minimum			0.05	6.04	53	3.0	0.3	3.20	82.00	2.0
	Maximum			0.60	27.83	2300	123.0	10.2	9.24	676.00	600.0
	Mean			0.16	19.71	702	59.9	5.4	6.93	300.63	145.4
	SE of Mean			0.02	0.71	73	4.3	0.4	0.16	12.06	22.4
	Median			0.10	20.13	521	55.6	5.1	6.95	295.00	67.2
Note: * Represents those sites off the main creek channel											

Appendix Table 5.4 Aquatic Biota Taxonomy - Moolarben Combined Aquatic Species Survey Results											
Spring 04, Autumn 05, Spring 05, Summer 2006, Autumn 06, Spring 07									Occurrence in		
								Tax	main catchments		
INVERTEBRATE AQUATIC FAUNA					Sub-	Genus/	Common	No	Goulburn	Wilpinjong	Common to
Phylum	Class	Order	Sub-Order	Family	Family	species	Name		River	Creek	Both
Arthropoda	Insecta	Coleoptera		Dytiscidae			Diving Beetles	1	1		1
Arthropoda	Insecta	Coleoptera		Elmidae			Riffle Beetles	2	1	1	1
Arthropoda	Insecta	Coleoptera		Gyrinidae			Whirligig Beetles	3	1		
Arthropoda	Insecta	Coleoptera		Haliplidae			Crawling Water Beetles	4	1	1	1
Arthropoda	Insecta	Coleoptera		Hydraenidae			Minute Rove Beetles	5	1	1	1
Arthropoda	Insecta	Coleoptera		Hydrochidae			Scavenger Water Beetles	6	1	1	1
Arthropoda	Insecta	Coleoptera		Hydrophilidae			Scavenger Water Beetles	7	1	1	1
Arthropoda	Insecta	Coleoptera		Scirtidae			Marsh Beetles	8	1	1	1
Arthropoda	Insecta	Diptera		Ceratopogonidae			Biting Midges	9	1	1	1
Arthropoda	Insecta	Diptera		Chaoboridae			Phantom Midges	10		1	
Arthropoda	Insecta	Diptera		Chironomidae	Chironominae		Bloodworms	11	1	1	1
Arthropoda	Insecta	Diptera		Chironomidae	Orthocladiinae		Bloodworms	12	1	1	1
Arthropoda	Insecta	Diptera		Chironomidae	Tanypodinae		Bloodworms	13	1	1	1
Arthropoda	Insecta	Diptera		Culicidae			Mosquitoes	14	1	1	1
Arthropoda	Insecta	Diptera		Ephydridae?			Ephydrid fly larvae	15		1	
Arthropoda	Insecta	Diptera		Dixidae			Meniscus Midges	16	1		
Arthropoda	Insecta	Diptera		Psychodidae			Moth Flies	17	1		
Arthropoda	Insecta	Diptera		Simuliidae			Black Flies	18	1		
Arthropoda	Insecta	Diptera		Stratiomyidae			Soldier Flies	19	1	1	1
Arthropoda	Insecta	Diptera		Tabanidae			March Flies	20	1	1	1
Arthropoda	Insecta	Diptera		Tipulidae			Crane Flies	21	1	1	1
Arthropoda	Insecta	Ephemoptera		Baetidae			Mayflies	22	1	1	1
Arthropoda	Insecta	Ephemoptera		Caenidae			Mayflies	23	1	1	1
Arthropoda	Insecta	Ephemoptera		Leptophlebiidae			Mayflies	24	1		
Arthropoda	Insecta	Hemiptera		Aphididae			Aphids	25	1		
Arthropoda	Insecta	Hemiptera		Coroxidae			Lesser Water Boatmen	26	1	1	1
Arthropoda	Insecta	Hemiptera		Mesoveliidae			Water Treaders	27		1	
Arthropoda	Insecta	Hemiptera		Gerridae			Water Striders	28	1		
Arthropoda	Insecta	Hemiptera		Hydrometridae			Water Measurers	29	1	1	1
Arthropoda	Insecta	Hemiptera		Naucoridae			Creeping Water Bugs	30	1		
Arthropoda	Insecta	Hemiptera		Nepidae			Water Scorpions/ Needle Bugs	31	1	1	1
Arthropoda	Insecta	Hemiptera		Hydrometridae			Water Measurers	32	1		
Arthropoda	Insecta	Hemiptera		Notonectidae			Backswimmers	33	1	1	1
Arthropoda	Insecta	Hemiptera		Pleidae			Pygmy Backswimmers	34	1	1	1
Arthropoda	Insecta	Hemiptera		Veliidae			Small Water Striders	35	1	1	1
Arthropoda	Insecta	Lepidoptera		Pyralidae			Moths	36	1	1	1
Arthropoda	Insecta	Odonata	Epiproctophora	Aeshnidae			Dragonflies	37	1	1	1
Arthropoda	Insecta	Odonata	Epiproctophora	Cordulephyidae			Dragonflies	38	1		
Arthropoda	Insecta	Odonata	Epiproctophora	Gomphidae			Dragonflies	39	1	1	1
Arthropoda	Insecta	Odonata	Epiproctophora	Hemicorduliidae			Dragonflies	40	1	1	1
Arthropoda	Insecta	Odonata	Epiproctophora	Libellulidae			Dragonflies	41	1	1	1
Arthropoda	Insecta	Odonata	Epiproctophora	Synthemistidae			Dragonflies	42	1	1	1
Arthropoda	Insecta	Odonata	Epiproctophora	Telephlebiidae			Dragonflies	43	1		
Arthropoda	Insecta	Odonata	Zygoptera	Coenagrionidae			Damselflies	44	1	1	1
Arthropoda	Insecta	Odonata	Zygoptera	Lestidae			Damselflies	45	1	1	1
Arthropoda	Insecta	Odonata	Zygoptera	Megapodagrionidae			Damselflies	46	1		
Arthropoda	Insecta	Odonata	Zygoptera	Synlestidae			Damselflies	47	1		
Arthropoda	Insecta	Plecoptera		Gripopterygidae			Stone Flies	48	1		
Arthropoda	Insecta	Trichoptera		Calamoceratidae			Caddis Flies	49	1		
Arthropoda	Insecta	Trichoptera		Ecnomidae			Caddis Flies	50	1	1	1
Arthropoda	Insecta	Trichoptera		Hydropsychidae			Caddis Flies	51	1		
Arthropoda	Insecta	Trichoptera		Hydroptilidae			Caddis Flies	52	1	1	1
Arthropoda	Insecta	Trichoptera		Leptoceridae			Caddis Flies	53	1	1	1
Arthropoda	Insecta	Trichoptera		Philorheithridae			Caddis Flies	54	1		
Arthropoda	Arachnida	Acarina	Hydracarina				Freshwater Mites	55	1	1	1
Arthropoda	Collembola						Springtails	56	1	1	1
Arthropoda	Crustacea	Diplostraca	Cladocera				Water Fleas	57	1	1	1
Arthropoda	Crustacea	Calanoida		Centropagidae			Copepods	58	1	1	1
Arthropoda	Crustacea	Cyclopoida		Cyclopidae			Copepods	59	1	1	1
Arthropoda	Crustacea	Decapoda		Atyidae			Freshwater Shrimp	60	1	1	1
Arthropoda	Crustacea	Decapoda		Palaemonidae			Freshwater Prawns	61	1		
Arthropoda	Crustacea	Decapoda		Parastacidae		*Cherax destructor*	Yabbies	62		1	
Arthropoda	Ostracoda						Seed Shrimps	63	1	1	1
Annelida	Hirudinea			Glossiphoniidae			Leeches	64	1	1	1
Annelida	Hirudinea			Richardsoniadidae			Leeches	65	1		
Annelida	Oligochaeta						Freshwater Worms	66	1	1	1
Mollusca	Bivalvia			Sphaeriidae			Pea Shells	67	1	1	1
Mollusca	Gastropoda			Ancylidae			Freshwater Limpets	68	1	1	1
Mollusca	Gastropoda			Lymnaeidae			Freshwater Snails	69	1	1	1
Mollusca	Gastropoda			Physidae		*Physa acuta*	Freshwater Snails	70	1	1	1
Mollusca	Gastropoda			Planorbidae			Freshwater Snails	71	1		
Nematomorpha							Horsehair Worms	72		1	
Platyhelmint	Turbellaria	Tricladida		Dugesiidae			Flatworms	73	1	1	1
							Total Number of Invertebrate Taxa		68	53	48
VERTEBRATE AQUATIC FAUNA											
Phylum	Class	Family	Sub-Family			Genus/ species	Common Name				
Chordata	Amphibia						Tadpoles		1	1	1
Chordata	Amphibia	Hylidae				*Litoria fallax/phyllochroa*	Green Frogs			1	
Chordata	Amphibia	Myobatrachidae					Common Eastern Froglet			1	
Chordata	Amphibia	Myobatrachidae				*Lymnodynastes dumerilii grayi*	Eastern Banjo Frog			1	
Chordata	Osteichthye	Anguillidae				*Anguilla reinhardtii*	Freshwater Eel		1	1	1
Chordata	Osteichthye	Eleotridae					Gudgeon		1		
Chordata	Osteichthye	Eleotridae				*Gobiomorphus coxii*	Cox's Gudgeon		1		
Chordata	Osteichthye	Poeciliidae				*Gambusia holbrooki*	Eastern Gambusia		1	1	1
Chordata	Osteichthye	Retropinnidae				*Retropinna semoni*	Australian Smelt		1		
Reptilia		Chelidae				*Chelodina longicollis*	Long-Necked Turtle		1	1	1
							Number of Vertebrate Taxa		7	7	4
AQUATIC PLANTS											
						Spirodela spp	Duck Weed		1		
						Marsilea mutica	Nardoo		1		
						Typha spp	Cumbungi		1	1	1
						Persicaria (mainly P. decipens)	Slender Knotweed		1		
						Phragmites australis	Common Reed		1		
						Myriophyllum spp	Watermilfoil			1	
						Potamogeton spp	Pondweed		1	1	1
						Potamogeton ochreatus	Pondweed		1	1	1
						Potamogeton sulcatus	Pondweed		1	1	1
						Chara spp	Charophytes		1	1	1
						Azolla pinnata	Ferny Azolla		1		
							Number of Aquatic Plants		10	6	5

Appendix Table 5.5 Moolarben EA2 Combined Aquatic Species Survey Results - Spring 04, Autumn 05, Spring 05, Summer 06, Autumn 06, and Spring 07

Class	Sub-Order Family	Sub-Family	Genus/species	Common Name	Sp04 15/12/04 MG2	Sp04 15/12/04 WC2	Au 05 18/05/05 MG2	Sp 05 22/09/05 MG2	Sp 05 27/09/05 ECX2	Sp 05 27/09/05 WC1	Sp 05 28/09/05 MG1	Sp 05 28/09/05 WC4	Su 06 16/01/06 WCX1	Su 06 17/01/06 ECX2	Su 06 17/01/06 MG1	Su 06 17/01/06 WC4	Au 06 ###### MG2	Au 06 ###### ECX2	Sp 07 ###### MG2	Sp 07 ###### MGX1	Sp 07 ###### MGX2	Sp 07 ###### ECX1-dam	Sp 07 ###### ECX0	Sp 07 ###### ECSpring	Sp 07 ###### ECX1.5	Sp 07 ###### ECC1	Sp 07 ###### ECX1.75	Sp 07 ###### WC4	Sp 2004 N=2	Au 2005 N=1	Sp 2005 N=5	Su 2006 N=4	Au ### N=2	Sp 2007 N=10	Total Survey N=24	Total Survey %	Combined Taxa No.	Combined SIG Score
Insecta	Dytiscidae			Diving Beetles	1		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	3	2	10	22	92	1	2
Insecta	Elmidae			Riffle Beetles																						1								1	1	4	2	8
Insecta	Haliplidae			Crawling Water Beetles								1																			1				1	4	3	2
Insecta	Hydraenidae			Minute Rove Beetles	1				1	1											1					1	1	1	1		2			4	7	29	4	5
Insecta	Hydrochidae			Scavenger Water Beetles						1				1												1					1	1		1	3	13	5	4
Insecta	Hydrophilidae			Scavenger Water Beetles	1	1				1	1			1	1	1				1	1			1	1		1	1	2		2	3		6	13	54	6	4
Insecta	Scirtidae			Marsh Beetles		1			1					1	1			1							1				1		1	2	1	1	6	25	7	6
Insecta	Ceratopogonidae			Biting Midges			1		1	1	1		1		1					1		1		1		1				1	3	2		4	10	42	8	2
Insecta	Chaoboridae			Phantom Midges		1			1																				1		1				2	8	9	5
Insecta	Chironomidae	Chironominae		Bloodworms	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	2	1	5	3	2	9	22	92	10	3
Insecta	Chironomidae	Orthocladiinae		Bloodworms						1																		1			1			1	2	8	11	3
Insecta	Chironomidae	Tanypodinae		Bloodworms				1	1	1	1		1		1				1	1	1	1	1	1		1	1				4	2		8	14	58	12	3
Insecta	Culicidae			Mosquitoes	1			1		1					1	1			1	1	1				1		1	1	1		2	2		6	11	46	13	6
Insecta	Ephydridae?			Ephydrid fly larvae															1															1	1	4	14	2
Insecta	Stratiomyidae			Soldier Flies																1														1	1	4	15	3
Insecta	Tabanidae			March Flies												1																1			1	4	16	3
Insecta	Tipulidae			Crane Flies				1																				1			1			1	2	8	17	5
Insecta	Baetidae			Mayflies	1	1		1			1	1	1						1	1		1	1						2		3	1		4	10	42	18	7
Insecta	Caenidae			Mayflies															1															1	1	4	19	5
Insecta	Coroxidae			Lesser Water Boatmen	1	1	1	1		1	1		1		1				1	1	1	1	1	1	1	1	1	1	2	1	3	2		10	18	75	20	3
Insecta	Mesoveliidae			Water Treaders																				1										1	1	4	21	2
Insecta	Hydrometridae			Water Measurers				1							1	1															1	2			3	13	22	3
Insecta	Nepidae			Water Scorpions/ Needle Bugs										1								1										1		1	2	8	23	3
Insecta	Notonectidae			Backswimmers	1	1				1			1	1	1			1	1	1	1	1	1	1		1	1	1	2		1	3	1	9	16	67	24	6
Insecta	Pleidae			Pygmy Backswimmers	1						1																		1		1				2	8	25	2
Insecta	Veliidae			Small Water Striders	1	1					1				1	1			1		1			1	1	1	1	1	2		1	2		7	12	50	26	6
Insecta	Pyralidae			Moths							1					1															1	1			2	8	27	6
Insecta	Aeshnidae			Dragonflies		1	1	1		1		1			1	1			1	1		1	1	1			1	1	1	1	3	2		7	14	58	28	7
Insecta	Gomphidae			Dragonflies				1																							1				1	4	29	6
Insecta	Hemicorduliidae			Dragonflies	1		1	1	1	1	1			1	1				1	1		1		1				1	1	1	4	2		5	13	54	30	4
Insecta	Libellulidae			Dragonflies			1								1								1							1		1		1	3	13	31	4
Insecta	Synthemistidae			Dragonflies							1																				1				1	4	32	5
Insecta	Coenagrionidae			Damselflies			1	1		1	1	1	1		1					1				1				1		1	4	2		3	10	42	33	2
Insecta	Lestidae			Damselflies		1			1	1		1			1				1	1	1	1	1			1	1		1		3	1		7	12	50	34	1
Insecta	Ecnomidae			Caddis Flies			1																							1					1	4	35	5
Insecta	Hydroptilidae			Caddis Flies								1			1																1	1			2	8	36	4
Insecta	Leptoceridae			Caddis Flies			1		1				1	1	1	1		1		1	1	1	1		1	1	1	1		1	1	4	1	8	15	63	37	7
Arachnida	Hydracarina			Freshwater Mites	1				1		1				1	1			1	1	1	1	1	1		1	1	1	1		2	2		9	14	58	38	6
Collembola				Springtails				1																							1				1	4	39	1
Crustacea	Cladocera			Water Fleas	1	1	1	1	1	1	1	1									1		1				1	1	2	1	5			4	12	50	40	*
Crustacea	Centropagidae			Copepods						1													1								1			1	2	8	41	*
Crustacea	Cyclopidae			Copepods	1	1		1	1		1					1			1		1			1		1	1		2		3	1		5	11	46	42	*
Crustacea	Atyidae			Freshwater Shrimp			1	1				1	1				1											1		1	2	1	1	1	6	25	43	6
Crustacea	Parastacidae		*Cherax destructor*	Yabbies	1						1								1			1							1		1			2	4	17	44	4
Ostracoda				Seed Shrimps	1	1		1	1	1	1	1			1	1			1	1	1	1	1	1		1	1	1	2		5	2		9	18	75	45	*
Hirudinea	Glossiphoniidae			Leeches											1					1			1									1		2	3	13	46	3
Oligochaeta				Freshwater Worms		1	1	1	1		1	1	1		1	1				1	1			1		1		1	1	1	4	3		5	14	58	47	2
Bivalvia	Sphaeriidae			Pea Shells		1									1												1		1			1		1	3	13	48	5
Gastropoda	Ancylidae			Freshwater Limpets					1																						1				1	4	49	7
Gastropoda	Lymnaeidae			Freshwater Snails					1	1	1	1				1												1			4	1		1	6	25	50	4
Gastropoda	Physidae			Freshwater Snails		1	1	1			1	1			1	1	1		1		1		1					1	1	1	3	2	1	4	12	50	51	1
Nematomorpha				Horsehair Worms																1	1													2	2	8	52	0
Turbellaria	Dugesiidae			Flatworms		1	1	1	1		1	1		1	1	1				1	1			1					1	1	4	3		3	12	50	53	3
Amphibia				Tadpoles	1					1	1	1							1	1	1	1	1	1			1		1		3			7	11	46		
Amphibia	Hylidae		*Litoria fallax/phyllochroa*	Green Frogs								1																			1				1	4		
Amphibia	Myobatrachidae			Common Eastern Froglet																				1										1	1	4		
Amphibia	Myobatrachidae		*...nodynastes dumerilii grayi*	...astern Banjo Frog				1											1												1			1	2	8		
Osteichthyes	Anguillidae		*Anguilla reinhardtii*	Freshwater Eel									1																			1			1	4		
Osteichthyes	Poeciliidae		*Gambusia holbrooki*	Eastern Gambusia		1	1	1	1			1	1	1			1	1										1	1	1	3	2	2	1	10	42		
Reptilia	Chelidae		*Chelodina longicollis*	...ong-Necked Turtle									1												1	1						1		2	3	13		
			Typha spp	Cumbungi		1	1	1	1	1		1		1		1	1	1	1	1			1			1		1	1	1	4	2	2	5	15	63		
			Myriophyllum spp	Watermilfoil																							1							1	1	4		
			Potamogeton spp	Potamageton						1																					1				1	4		
			Potamogeton ochreatus	Potamageton									1										1									1		1	2	8		
			Potamogeton sulcatus	Potamageton									1							1			1	1								1		3	4	17		
			Chara spp	Charophytes			1	1			1		1		1					1	1						1			1	2	2		3	8	33		
				Total Number of Invertebrate taxa	16	17	15	20	18	19	22	15	10	10	25	16	4	5	18	21	19	15	16	17	7	16	17	21	24	15	41	33	7	41				
						16.5	15					18.8				15.25		4.5										16.7										

Appendix Table 5.6 Macroinvertebrate Fauna and Site SIGNAL Score Calculations

Class	Sub-Order	Family	Sub-Family	Genus/specie	Common Name	Sp04	Sp04	Au 05	Sp 05	Sp 05	Sp 05	Sp 05	Sp 05	Su 06	Su 06	Su 06	Su 06	Au 06	Au 06	Sp 07	Sp 07	Sp 07	Sp 07	Sp 07	Sp 07	Sp 07	Sp 07	Sp 07	Sp 07	Individual SIGNAL Scores**		
						15/12/04	15/12/04	18/05/05	22/09/05	27/09/05	27/09/05	28/09/05	28/09/05	16/01/06	17/01/06	17/01/06	17/01/06	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####	#####			
						MG2	WC2	MG2	MG2	ECX2	WC1	MG1	WC4	WCX1	ECX2	MG1	WC4	MG2	ECX2	MG2	MGX1	MGX2	ECX1-dam	ECX0	ECSpring	ECX1.5	ECC1	ECX1.75	WC4	HU97	SIG-2	Combined Score
Insecta		Dytiscidae			Diving Beetles	2		2	2	2	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Insecta		Elmidae			Riffle Beetles																						8			8	7	8
Insecta		Haliplidae			Crawling Water Beetles								2																	*	2	2
Insecta		Hydraenidae			Minute Rove Beetles	5				5	5											5					5	5	5	5	3	5
Insecta		Hydrochidae			Scavenger Water Beetles						4				4												4			4	4	4
Insecta		Hydrophilidae			Scavenger Water Beetles	4	4				4	4			4	4	4				4	4			4	4		4	4	4	2	4
Insecta		Scirtidae			Marsh Beetles		6			6					6	6			6							6				6	6	6
Insecta		Ceratopogonidae			Biting Midges			2		2	2	2		2		2					2		2		2		2			*	2	2
Insecta		Chaoboridae			Phantom Midges		5			5																				5	4	5
Insecta		Chironomidae	Chironominae		Bloodworms	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3		3	3	3	3	3	3
Insecta		Chironomidae	Orthocladiinae		Bloodworms						3																		3	3	4	3
Insecta		Chironomidae	Tanypodinae		Bloodworms				3	3	3	3		3		3				3	3	3	3	3	3		3	3		3	4	3
Insecta		Culicidae			Mosquitoes	6			6		6					6	6			6	6	6				6		6	6	6	1	6
Insecta		Ephydridae?			Ephydrid fly larvae															2										*	2	2
Insecta		Stratiomyidae			Soldier Flies																3									3	2	3
Insecta		Tabanidae			March Flies												3													*	3	3
Insecta		Tipulidae			Crane Flies				5																				5	5	5	5
Insecta		Baetidae			Mayflies	7	7		7			7	7	7						7	7		7	7						7	5	7
Insecta		Caenidae			Mayflies															5										5	4	5
Insecta		Coroxidae			Lesser Water Boatmen	3	3	3	3		3	3		3		3				3	3	3	3	3	3	3	3	3	3	3	2	3
Insecta		Mesoveliidae			Water Treaders																				2					2	2	2
Insecta		Hydrometridae			Water Measurers				3							3	3													*	3	3
Insecta		Nepidae			Water Scorpions/ Needle Bugs										3								3							*	3	3
Insecta		Notonectidae			Backswimmers	6	6				6			6	6	6			6	6	6	6	6	6	6		6	6	6	6	1	6
Insecta		Pleidae			Pygmy Backswimmers	2						2																		*	2	2
Insecta		Veliidae			Small Water Striders	6	6					6				6	6			6		6			6	6	6	6	6	6	3	6
Insecta		Pyralidae			Moths							6					6													6	3	6
Insecta		Aeshnidae			Dragonflies		7	7	7		7		7			7	7			7	7		7	7	7			7	7	7	4	7
Insecta		Gomphidae			Dragonflies				6																					6	5	6
Insecta		Hemicorduliidae			Dragonflies	4		4	4	4	4	4			4	4				4	4		4		4				4	4	5	4
Insecta		Libellulidae			Dragonflies			4								4								4						4	4	4
Insecta		Synthemistidae			Dragonflies							5																		*	5	5
Insecta		Coenagrionidae			Damselflies			2	2		2	2	2	2		2					2				2				2	2	2	2
Insecta		Lestidae			Damselflies		1			1	1		1			1				1	1	1	1	1			1	1		*	1	1
Insecta		Ecnomidae			Caddis Flies			5																						5	4	5
Insecta		Hydroptilidae			Caddis Flies								4			4														4	4	4
Insecta		Leptoceridae			Caddis Flies			7		7				7	7	7	7		7		7	7	7	7		7	7	7	7	7	6	7
Arachnida	Hydracarina				Freshwater Mites	6				6		6				6	6			6	6	6	6	6	6		6	6	6	*	6	6
Collembola					Springtails				1																					*	1	1
Crustacea	Cladocera				Water Fleas	*	*	*	*	*	*	*	*									*		*				*	*	*	*	*
Crustacea		Centropagidae			Copepods						*													*						*	*	*
Crustacea		Cyclopidae			Copepods	*	*		*	*		*					*			*		*			*		*	*		*	*	*
Crustacea		Atyidae			Freshwater Shrimp			6	6				6	6				6											6	6	3	6
Crustacea		Parastacidae		*Cherax destructor*	Yabbies	4						4								4			4							*	4	4
Ostracoda					Seed Shrimps	*	*		*	*	*	*	*			*	*			*	*	*	*	*	*		*	*	*	*	*	*
Hirudinea		Glossiphoniidae			Leeches											3					3			3						3	1	3
Oligochaeta					Freshwater Worms		2	2	2	2		2	2	2		2	2				2	2			2		2		2	*	2	2
Bivalvia		Sphaeriidae			Pea Shells		5									5												5		5	5	5
Gastropoda		Ancylidae			Freshwater Limpets					7																				7	4	7
Gastropoda		Lymnaeidae			Freshwater Snails					4	4	4	4				4												4	4	1	4
Gastropoda		Physidae			Freshwater Snails		1	1	1			1	1			1	1	1		1		1		1					1	1	1	1
Nematomorpha					Horsehair Worms																6	6									6	0
Turbellaria		Dugesiidae			Flatworms		3	3	3	3		3	3		3	3	3				3	3			3					3	2	3
					Number of Taxa	16	17	15	20	18	19	22	15	10	10	25	16	4	5	18	21	19	15	16	17	7	16	17	21			
					Site Combined SIGNAL Score	4.5	4.2	3.6	3.8	4.0	3.7	3.6	3.4	4.1	4.2	3.9	4.3	3.0	4.8	4.1	4.0	4.0	4.1	4.1	3.7	4.9	4.1	4.6	4.3			4.00
Notes:	* represents those taxa for which SIGNAL scores					Sp04	Sp05	Su06	Au06	Sp07																						0.04
	do not apply, or are not available				Mean	4.33	3.70	4.07	4.00	4.16																						
					SE	0.36	0.21	0.24	0.75	0.16																						

APPENDIX 5

Preliminary Statistical Analysis of Florisitc Data

Preliminary Analysis

The ordination plot is presented below in **Figure A6.1** together with statistically significant vectors that describe the general data trend.

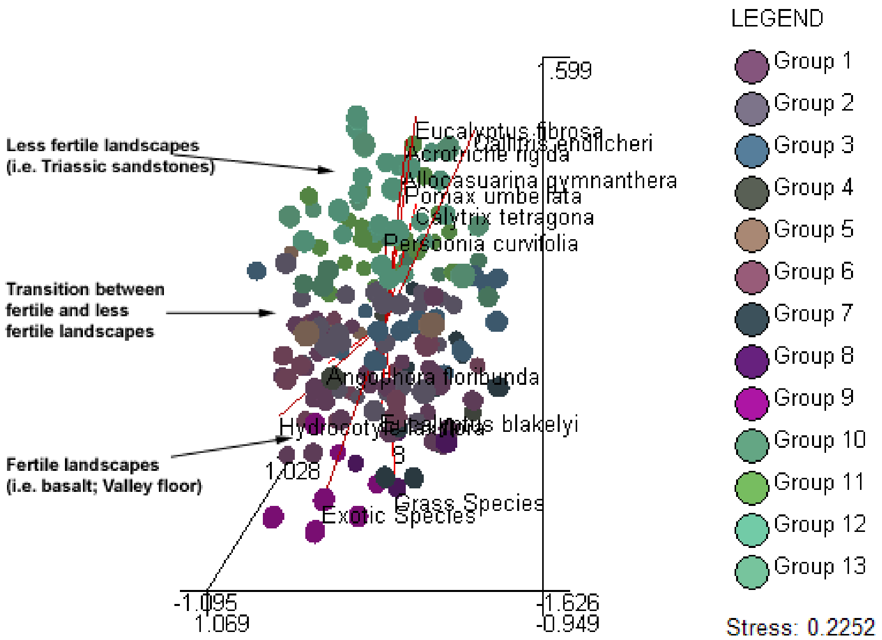


Figure A6.1: 3D Ordination Plot of Quadrat Data derived from an agglomerative hierarchical clustering analysis

In the above analysis groups 8 and 9 represent grasslands on basalt and valley floor landscapes respectively with ordinated similarities likely to be the primarily driven by a combination of factors such as elevated soil fertility and anthropogenic influences. It is also possible to consider the above similarities between groups 8 and 9 are a function of plant dispersal regimes (i.e. group 9 quadrats occur downslope of group 8 quadrats) and localised hydrological regimes. Here is a case where at least three perhaps four environmental gradients are each contributing to the formation of local plant associations.

Quadrat groups proximal to 8 and 9 represent vegetation generally characterised by Box and/or Redgum vegetation types on the Permian geological formation. Groups 12 and 13 represent vegetation on Triassic geological formations (i.e. sandstones and conglomerates). This vegetation is generally shrubby and dominated by Ironbark and/or Scribbly gum as opposed to the more grassy/ herbaceous characteristics of groups 8 and 9. Groups located centrally within the ordination plot generally represent the transition between Permian and Triassic geological formations where tree canopy dominants and understorey constituents vary in accord with natural and anthropogenic environmental gradients (e.g. transition between grassy and shrubby environment; increased plant diversity).

Outlier Data

Certain environmental gradients can be broad and spatially well defined, such as geology and species, while other environmental gradients can be less well defined, potentially including transitional zones, temporally and/or spatially contrained natural disturbances.

The effects of anthropogenic land uses, such as agriculture, could potentially obscure natural environmental gradients by introducing one or more environmental gradients. These confounding effects are generally termed "Noise" and distinguishing between informative and non-informative (noise) data then excluding the 'noise' data can substantially improve the understanding of broad environmental gradients and their inter-relationships (e.g. consider the exclusion of ‘noisy’ outlier quadrats and/or variables).

'Noise' can also be attributed to "Outlier objects" and for this analysis, quadrats potentially contributing to noise) - as identified by the preliminary analysis - where reviewed (**Appendix 5**). In this study outlier quadrats generally represent survey sites with plant occurrences 'unique' to the study area and/or appreciably dissimilar cover abundance characteristics. For example quadrats 67, 96 and 119 are all associated with permanently wet creeklines and/or groundwater soaks with the vegetation response primarily being the localised occurrence of 'unique' species. Quadrats 124, 138 and 176 are situated within heavily disturbed conditions where routine grazing and cropping have had a pronounced effect on the response of exotic plant species. Quadrat 148 appears to be an anomaly with no obvious reason for its disjunct ordination obvious. Each of these outlier quadrats was removed for the non-hierarchical clustering analysis and will be separately discussed.

Refined Analysis

On removing the 'noisy' species and quadrats the analysis identified a statistically interpretable trend (i.e. ordination stress level of 0.1487). However, this analysis was restricted to 82 quadrats and 70 species, thus limiting its applicability to vegetation descriptions and mapping. The summary dendrogram (**Figure A6.2**) and ordination (**Figure A6.3**) is provided as follows.

Figure A6.2: Simplified Row Fusion Dendrogram for Flora Quadrats

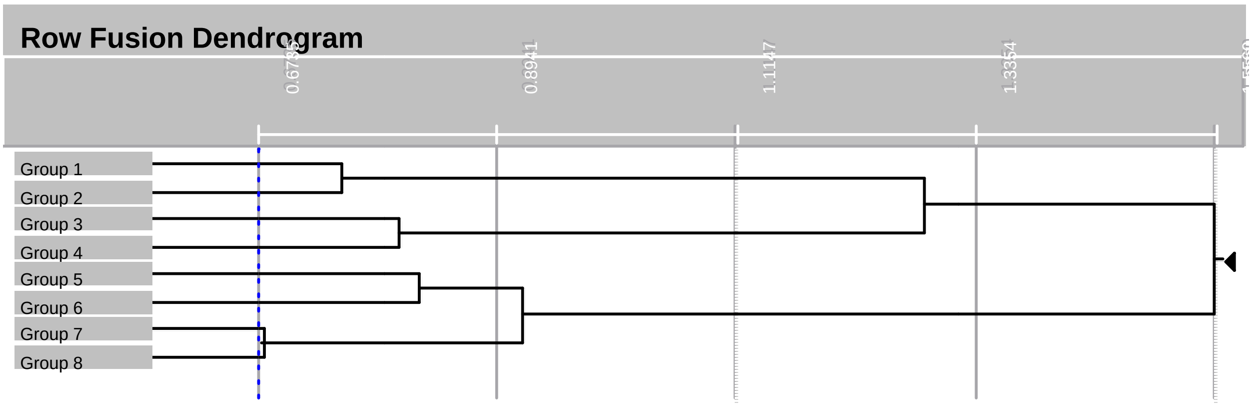
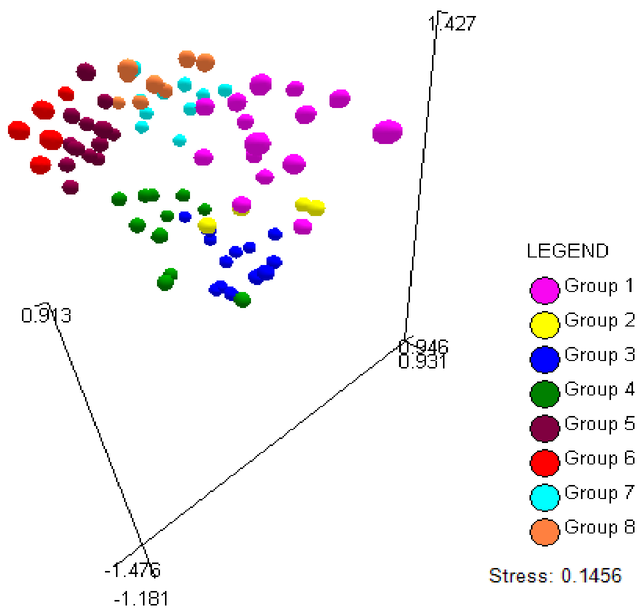


Figure A6.3



3D Ordination Plot of Flora Quadrat Data

Red spheres represent quadrats from grassy basalt cap vegetation types with blue coloured quadrats representing shrubby Broad-leaved Ironbark forests on Triassic sandstones. Groups 4 and 7-8 represent quadrats with transitional qualities that display a varying mix of grass/ herb species and shrubby species, thus implying a general environment gradient from left to right (i.e. soil fertility).

The primary split in the above dendrogram differentiates between quadrats allocated to Groups 1-4 from Groups 5-8, this generally representing the separation of valley floor vegetation (i.e. Permian based geologies) from midslope and ridgetop formations (i.e. Triassic based geologies). Species having the most pronounced influence on the analysis include the following:

Broad-leaved Ironbark (*E. fibrosa*) [KW: 54.2 and $r^2 = 0.75$]

Brachyloma daphnoides	[KW: 38.9 and r^2 = 0.49]
Sifton Bush (*Cassinia arcuata*)	[KW: 38.7 and r^2 = 0.46]
Spear Grass (*A. ramosa*)	[KW: 38.5 and r^2 = 0.63]
Blakely's Redgum (*E. blakelyi*)	[KW: 37.4 and r^2 = 0.38]
Beared Heath (*Leucopogon muticus*)	[KW: 36.2 and r^2 = 0.56]
Poison Fern (*Cheilanthes seiberi*)	[KW: 33.4 and r^2 = 0.47]
Pennywort (*Hydrocotyle laxiflora*)	[KW: 31.2 and r^2 = 0.39]
Surge (*Phyllanthus occidentalis*)	[KW: 30.5 and r^2 = 0.50]
Kidney Weed (*Dichondra repens*)	[KW: 30.3 and r^2 = 0.51]

These are likely to be strong indicator species for vegetation groups as they have high Kruskal Wallis and correlation (r^2) values, with the above species all ranked within the top 15 r^2 species. These species are generally more common within a group and less abundant or absent from others. **Figure A6.4** exhibits the ordination of the 70 species into their respective eight groups, with the trend from right to left generally representing transition from grassy to shrubby understorey composition (i.e. change in soil fertility). The colour scheme depicted in **Figure A6.4** is consistent with those in **Figure A6.3**.

The correlation vectors shown in **Figure A6.4** includes quadrat 22 (i.e. representing Scribbly gum open woodland), quadrat 74 (i.e. representing grassy White Box on basalt) and quadrat 94 (i.e. representing Blakely's Redgum on sandy soils). There is a notable disjunction between groups 1-3 and 4-8, with the likely reason for the separation likely to be attributed to soil fertility. Other factors also appear to be involved such as disturbance and soil moisture, as implied by the quadrat 94 vector.

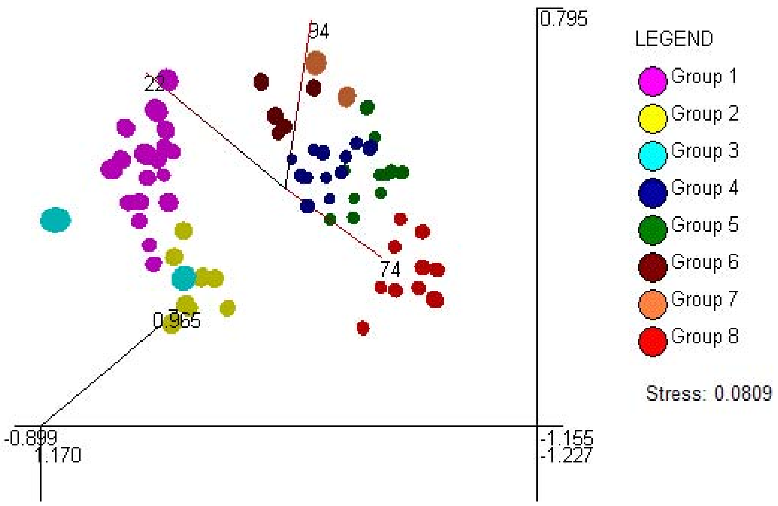


Figure A6.4

3D Ordination Plot of Species by Vegetation Group

APPENDIX 6

WBYBBRW EEC/ CEEC Species Count Data per Quadrat

Quadrat	Non-grass Species	Grass Species	Dominant tree	Non-Dominant Tree Species	Total WBYBBRW Species	Important Species	Exotic Species	shrub species
1	24	3	1	1	29	7	2	10
2	19	3	1	1	24	7	7	4
3	9	1	1	1	12	5	1	4
4	15	5	0	2	22	5	1	8
5	6	3	0	1	10	2	2	3
6	8	3	0	1	12	4	0	3
7	21	4	1	2	28	12	0	8
8	9	0	0	1	10	4	0	4
9	14	1	0	1	16	3	0	5
10	21	6	0	2	29	10	2	5
11	14	2	0	4	20	8	0	7
12	32	4	3	2	41	15	3	11
13	22	4	0	3	29	9	0	8
14	12	2	0	2	16	5	0	7
15	7	2	0	2	11	3	0	4
16	15	2	0	1	18	6	0	5
17	5	0	0	0	5	3	0	2
18	18	0	0	3	21	9	0	9
19	21	3	1	4	29	10	0	8
20	16	2	1	2	21	9	0	4
21	17	1	0	2	20	6	0	7
22	11	0	0	1	12	4	0	7
23	7	1	1	0	9	1	3	2
24	22	1	1	1	25	12	6	3
25	12	2	0	2	16	5	2	2
26	27	1	1	1	30	12	0	7
27	19	4	2	0	25	7	0	2
28	21	3	2	0	26	9	0	9
29	9	0	0	2	11	3	0	4
30	10	0	0	1	11	4	1	4
31	6	0	0	1	7	3	0	4
32	9	1	0	0	10	3	0	3
33	12	7	2	1	22	5	4	3
34	20	5	0	2	27	10	0	8
35	28	4	1	2	35	16	0	15
36	27	5	0	0	32	13	4	9
37	22	3	1	1	27	8	2	3
38	17	4	1	2	24	5	2	5
39	9	0	0	2	11	2	0	4
40	11	1	0	3	15	6	0	3
41	7	0	0	2	9	3	0	4
42	12	2	0	1	15	4	0	6
43	18	2	0	1	21	8	0	6
44	24	6	1	1	32	8	3	2
45	13	2	0	3	18	5	0	7
46	19	1	0	3	23	6	0	8
47	21	2	1	1	25	2	0	5
48	17	3	1	1	22	6	0	6
49	9	0	0	2	11	4	0	5
50	12	2	0	2	16	2	1	1
51	6	0	0	2	8	1	0	3
52	12	1	0	2	15	3	0	1
53	14	2	1	2	19	7	0	9
54	9	0	0	0	9	6	0	3

Quadrat	Non-grass Species	Grass Species	Dominant tree	Non-Dominant Tree Species	Total WBYBBRW Species	Important Species	Exotic Species	shrub species
55	9	0	1	1	11	5	0	6
56	11	2	0	1	14	5	0	10
57	14	2	0	1	17	5	0	7
58	12	3	1	1	17	7	0	3
59	5	5	0	2	12	3	0	1
60	0	2	0	1	3	0	0	0
61	5	2	1	3	11	2	0	3
62	9	8	0	2	19	5	0	4
63	5	1	1	1	8	0	0	3
64	9	5	0	3	17	4	0	3
65	9	3	0	3	15	3	0	5
66	16	4	0	3	23	9	0	5
67	1	0	0	0	1	0	1	1
68	27	6	1	0	34	14	1	5
69	10	0	0	1	11	4	0	4
70	6	1	0	1	8	2	0	5
71	7	0	0	1	8	2	0	3
72	9	0	0	2	11	2	0	5
73	5	1	0	1	7	2	0	2
74	15	8	0	2	25	4	3	2
75	8	0	0	1	9	2	0	3
76	8	0	1	1	10	3	0	3
77	12	1	0	1	14	6	0	7
78	6	2	0	1	9	5	0	2
79	16	2	1	1	20	5	0	4
80	14	1	1	3	19	5	0	9
81	17	1	0	0	18	8	0	6
82	14	1	1	1	17	6	0	3
83	9	2	0	2	13	3	0	2
84	14	1	0	3	18	5	0	6
85	10	1	0	2	13	6	0	7
86	13	1	1	2	17	4	1	2
87	10	0	0	0	10	3	0	7
88	6	0	0	2	8	1	0	2
89	9	0	0	2	11	4	0	1
90	18	1	0	2	21	10	0	8
91	17	1	1	3	22	9	0	8
92	4	0	0	1	5	1	0	1
93	11	0	0	0	11	3	0	8
94	5	0	1	1	7	0	1	1
95	20	1	2	1	24	8	3	3
96	5	0	2	1	8	0	5	0
97	18	0	1	1	20	10	0	8
98	10	2	1	1	14	4	1	3
99	18	1	1	1	21	10	1	8
100	12	1	0	1	14	6	0	6
101	7	0	0	1	8	1	0	3
102	17	1	0	3	21	9	0	6
103	20	0	1	2	23	5	1	7
104	8	1	0	1	10	3	0	6
105	12	1	0	3	16	8	0	6
106	17	0	1	3	21	7	1	4
107	8	0	0	1	9	3	0	2
108	9	0	0	1	10	4	0	7

Quadrat	Non-grass Species	Grass Species	Dominant tree	Non-Dominant Tree Species	Total WBYBBRW Species	Important Species	Exotic Species	shrub species
109	19	1	1	2	23	11	0	8
110	14	0	0	1	15	8	0	4
111	11	0	0	0	11	6	0	7
112	13	0	0	2	15	6	1	4
113	5	1	0	0	6	0	2	2
114	8	1	0	2	11	3	0	4
115	15	1	0	2	18	7	1	7
116	9	0	0	1	10	3	1	3
117	11	2	0	1	14	4	0	3
118	20	3	0	1	24	12	1	4
119	3	0	0	0	3	1	2	0
120	17	6	0	3	26	6	0	4
121	7	1	0	0	8	3	0	4
122	5	0	0	1	6	1	0	3
123	8	3	0	3	14	3	1	1
124	5	3	0	0	8	0	3	0
125	22	4	1	2	29	10	1	2
126	15	4	0	2	21	7	0	5
127	12	5	0	3	20	8	0	4
128	5	1	0	2	8	2	0	3
129	4	1	1	2	8	1	0	1
130	30	6	1	1	38	13	5	6
131	17	3	0	1	21	7	0	3
132	29	4	2	2	37	16	1	10
133	14	4	1	4	23	7	0	4
134	14	1	0	1	16	3	0	4
135	13	4	1	3	21	3	3	3
136	28	1	1	2	32	16	0	9
137	17	3	1	2	23	10	1	6
138	9	1	0	0	10	1	8	0
139	17	2	2	0	21	5	0	6
140	8	1	0	1	10	4	0	4
141	23	3	2	2	30	9	2	4
142	20	3	1	1	25	8	2	6
143	11	1	2	3	17	4	0	5
144	22	6	0	1	29	10	4	3
145	7	4	0	4	15	2	0	4
146	4	2	0	0	6	1	1	1
147	7	0	0	2	9	1	0	6
148	8	2	1	0	11	3	0	4
149	8	1	0	2	11	5	0	6
150	11	1	0	1	13	4	0	9
151	7	2	0	1	10	3	0	6
152	15	3	1	2	21	7	1	3
153	15	1	2	1	19	5	0	7
154	5	0	0	2	7	3	0	4
155	5	0	0	1	6	2	0	3
156	10	2	1	1	14	3	0	4
157	11	2	2	2	17	4	0	6
158	5	0	0	3	8	2	0	2
159	8	0	1	2	11	5	0	3
160	5	0	0	3	8	1	0	3
161	10	2	0	2	14	3	0	5
162	7	1	0	2	10	3	0	6

Quadrat	Non-grass Species	Grass Species	Dominant tree	Non-Dominant Tree Species	Total WBYBBRW Species	Important Species	Exotic Species	shrub species
163	7	1	0	2	10	2	0	3
164	10	1	0	2	13	2	0	3
165	10	3	1	2	16	4	0	4
166	5	0	0	1	6	2	0	3
167	5	1	0	2	8	2	0	2
168	5	3	3	1	12	1	0	2
169	5	2	0	2	9	1	0	3
170	9	1	1	1	12	2	0	3
171	7	0	0	0	7	2	0	5
172	2	2	0	1	5	2	0	1
173	20	4	1	0	25	6	5	4
174	18	6	0	0	24	4	9	2
175	17	3	0	0	20	5	10	2
176	7	0	0	0	7	1	8	0
177	16	4	0	0	20	2	11	1
178	10	2	0	0	12	2	11	1
179	27	2	0	0	29	7	15	1
180	30	2	0	2	34	9	3	8
181	17	2	0	3	22	7	0	8
182	15	0	0	1	16	4	0	5
183	6	0	0	2	8	1	0	4
184	27	1	0	0	28	13	2	8
185	10	0	0	1	11	4	0	4
186	14	3	0	2	19	5	2	3
187	14	1	0	1	16	2	6	1
188	23	2	0	1	26	6	2	8
189	25	4	1	0	30	9	6	8
190	17	1	1	3	22	7	0	5
191	8	0	0	2	10	4	0	5
192	11	2	1	4	18	3	0	3
193	10	2	0	3	15	6	0	5
194	12	1	0	0	13	1	9	1
195	17	4	0	1	22	7	3	4
196	27	7	0	1	35	8	9	1
197	15	1	0	1	17	7	0	6
198	7	1	0	0	8	2	0	3
199	5	1	1	1	8	1	0	1
200	14	2	1	3	20	3	0	4
201	23	4	1	0	28	8	3	4
202	9	1	1	1	12	4	0	2
203	17	2	0	2	21	7	0	9
204	9	1	1	1	12	3	0	6
205	11	1	1	2	15	3	0	6
206	15	0	1	1	17	6	0	4

APPENDIX 7

Threatened Biodiversity Habitat, Conservation Status and Recovery Effort Details

Threatened Species

Hoary Sunray (*Leucochrysum albicans var tricolor*) (E)

The Hoary Sunray *Leucochrysum albicans* var *tricolor* is an erect perennial woolly herb with woody rootstock growing to 45 cm high. Leaves linear to narrow-oblong, 2.5-10 cm long, 0.5-1.5 mm wide, crowded around base of stems and are woolly. Grows typically in grassy woodlands west of the Great Dividing Range south from Mudgee. Flowers spring to summer.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

None prepared as this species is listed and endangered only on the EPBC Act and priority action statements are exclusively prepared in response to TSC Act listings.

Relevant Priority Actions listed for this species

None prepared as this species is listed and endangered only on the EPBC Act and priority action statements are exclusively prepared in response to TSC Act listings.

White-flower Wax Plant (*Cynanchum elegans*) (E)

Climber or twiner with stems to ca 1 m long. Broad-ovate to ovate leaves with lamina, 1.5-5.5 cm long, 15-25 mm wide, apex short-acuminate, base truncate to scarcely cordate, mostly glabrous, 2 basal glands present; petiole 5-25 mm long. Few white flowers are borne in clusters or umbels on branched peduncles during summer. Grows in vine thickets, dry rainforest and scree slopes on fertile soils along the eastern fall of the Great Dividing Range.

Regional Conservation Status

The White Flowered Wax Plant is known to occur within 5 conservation reserves of the Hunter Central Rivers Catchment management Area including: Booti Booti National Park (2 records); Copeland Tops State Recreation Area (one record); Camels Hump Nature Reserve (one record) Woko National Park (4 records) and Wollemi National Park (one record). A total of 9 records have been collated from habitat contained within these reserves with the database analysis indicating Woko National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Determine and implement appropriate fire management practices.
- Consider off-site impacts in the assessment of nearby developments.
- Prevent inappropriate water run-off entering sites.
- Install fencing to exclude livestock and machinery, and control access where required.
- Protect areas of known and potential habitat from clearing and further fragmentation.

Restore degraded habitat using bush regeneration techniques (note that it is crucial that workers are able to distinguish the species from the exotic Moth Plant *Araujia sericifera*).

- Monitor the populations for changes.
- Monitor the health of known populations.
- Mark sites and potential habitat onto maps used for planning maintenance work.
- Map known sites and conduct searches of potential habitat for new sites.

Relevant Priority Actions for the locality

None relevant.

Ozothamnus tesselatus (V)

A dense shrub to 1 m high, branches woolly. Leaves spreading, oblong, 4--5 mm long, <1 mm wide, apex reflexed, base decurrent on stem for 4--5 mm, margins revolute; lamina discolorous, upper surface green and shining viscid, glandular-punctate, lower surface white-woolly. Heads in dense hemispherical corymbs; heads globose. Grows on tallus slopes within the Sandy Hollow to Merriwa district. Flowers in spring.

Regional Conservation Status

Ozothamnus tesselatus is known to occur within one conservation reserve of the Hunter Central Rivers Catchment management Area this being Goulburn River National Park (4 records). The four records exclusively from this conservation reserve indicate the associated area as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Manage threats degrading habitat.
- Protect habitat from clearing and disturbance.

Relevant Priority Actions for the locality

None relevant.

Ausfeld's Wattle (*Acacia ausfeldii*) (V)

Acacia ausfeldii is mostly found on flat sandy ground in remnant roadside patches of eucalypt woodland. Established plants are likely to be killed by fire, as mature and juvenile plants have a single-stemmed growth form. It is associated with species including *Eucalyptus albens, E. blakelyi* and *Callitris* spp., with an understorey dominated by *Cassinia* spp. and grasses.

Acacia ausfeldii is likely to have a dormant soil seedbank from which germination is stimulated by fire, however a small fraction of seeds have been observed to germinate in the absence of fire. Flowers from August to October.

Found to the east of Dubbo in the Mudgee Ulan - Gulgong area, of the NSW South Western Slopes bioregion, with some occurrences in the adjoining bioregions of Brigalow Belt South and the Sydney Basin. Also recorded in Munghorn Gap Nature Reserve in 1963 and in Victoria.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Protect populations present in conservation reserves, state forests and leasehold lands from adverse grazing regimes or adverse fire regimes.
- Reduce road side disturbance and protect from weed invasion, grazing and small scale clearing.
- Consider installing bollards or fences to protect plants from disturbance.

Relevant Priority Actions for the locality

1. Identify threats and determine recovery strategies.

Kennedia retrorsa (V)

This species is a climbing herb with stems having rusty or white pubescent hairs. Leaves 3-foliolate; leaflets broad-elliptic to obovate or circular, 3-13 cm long, 3-10 cm wide, upper surface pubescent, lower surface paler, rusty to whitish pubescent; stipules ovate, ca 5 mm long. Flowers pink-purple to scarlet, pod compressed, 6 cm long, densely hairy; seeds ca 4, ovoid. Grows on fertile soils generally of basalt origin or influence. Flowers in spring.

Regional Conservation Status

Kennedia retrorsa is known to occur within 2 conservation reserves of the Hunter Central Rivers Catchment management Area including: Goulburn River National Park (5 records) and Wollemi National Park (4 records). A total of 9 records have been collated from habitat contained within these reserves with the database analysis indicating both these National Parks as a potential strongholds or areas of importance for this species.

Focus of Recovery Effort

- Ensure that personnel planning and undertaking hazard reduction burns are able to identify the species and are aware of its habitat.

Grazing should be kept at minimal levels within *K. retrorsa* habitat.

- Protect areas of known habitat from clearing.
- Survey of known populations, and potential habitat, is required to gain greater insight into the current status of the species, threats to its persistence, and management actions required.

Relevant Priority Actions for the locality

None relevant.

Cannons Stringybark (*Eucalyptus cannonii*) (V)

Tree to 15 m high; bark persistent throughout, grey to red-brown, stringy. Juvenile leaves disjunct, broad-lanceolate, glossy green, hispid. Adult leaves disjunct, lanceolate, 10-19 cm long, 1.5-2.5 cm wide, green, dull to semi-glossy, concolorous. Umbellasters 7-flowered; peduncle angular, 10-20 mm long; pedicels terete or angular, 1-4 mm long. Buds fusiform with a distinct medial rim, 8-16 mm long, 5-8 mm diam., scar absent; calyptra conical, as long and as wide as hypanthium, +/- angular. Fruit globose or turbinate, often with a distinct medial rim, +/- angular, 7-12 mm long, 10-15 mm diam.; disc raised; valves exserted. Flowers January – April.

The Capertee Stringybark *E. cannonii* is predominantly distributed between Rylstone and the Upper Wolgan valley of the Central Tablelands and Central West Slopes botanical subdivisions. (Hunter and White (1999) confirm this stating the distribution between east of Mudgee and east of Bathurst.

Regional Conservation Status

The Capertee Stringybark *E. cannonii* is present within at least one conservation reserve (i.e Avisford Nature Reserve, Gardens of Stone National Park, Wollemi National Park, Winburndale Nature Reserve), with the population size in Winburndale Nature Reserve numbering approximately 6,000 individuals (Briggs and Leigh 1995; Hunter and White, 1999). The total population of this species throughout its entire range is estimated to be greater than 10,000 individuals and is adequately conserved (Hunter and White, 1999). Further, Hunter and White (1999) consider that the vulnerable listing for this species is no longer appropriate due to the variation and size of populations within conservation reserves and the number of populations in non-productive lands of private ownership.

Notwithstanding the above comments on this species conservation status, it is important to note that there are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Discourage firewood collection of this species.
- Protect remnants by fencing to prevent stock access.
- Protect areas of known and potential habitat from clearing.
- Restore habitat by replanting with plants raised from locally-collected seed.
- Investigate appropriate fire intervals for the species.

- Where road or infrastructure maintenance activities are planned in potential habitat, thorough surveys should be conducted and appropriate protection measures should be implemented if the species is present.

Relevant Priority Actions for the locality

1. Identify location, tenure and threats at extant sites. (High priority)

2. Revegetate targeted areas with locally-collected seed. (Medium priority)

Pokolbin Mallee (*Eucalyptus pumila)* (V)

A mallee growing to 6 m, bark smooth, white, grey or grey brown shedding in short ribbons. Juvenile leaves are disjunct and ovate. Adult leaves lanceolate green, glossy and concolorous. 7 flowed, fruit with raised disc and exsert valves. Currently known only from a single population west of Pokolbin in the Hunter Valley. Historical records also exist for Wyong and Sandy Hollow, however, has not been recorded recently in these areas.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Protect known habitat from clearing, fragmentation and disturbance.
- Research into the demography and reproductive ecology of the species so that appropriate fire-free intervals and other guidelines for fire management can be determined. Preparation of site-specific fire management plans consistent with these.
- Survey potential habitat for new populations.

Relevant Priority Actions for the locality

None relevant.

*Homoranthus darwinioides** (V)

A spreading shrub, usually 1-1.5 m high growing on quartz rich sandstones and conglomerates between Merriwa and Dubbo. Leaves linear, terete, 2-5 mm long in some populations, 6-11 mm long in others, up to ca 1 mm wide. Flowers pendent on specialized 2-flowered shoots, each flower enclosed by 2 tardily shed bracteoles. Flowers in spring.

Regional Conservation Status

Ozothamnus tesselatus is known to occur within one conservation reserve of the Hunter Central Rivers Catchment management Area this being Goulburn River National Park (4 records). The four records exclusively from this conservation reserve indicate the associated area as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Rabbit eradication and control program.
- No further degradation or loss of potential habitat.
- Protect existing populations from stock and feral goats through appropriate fencing or controls.
- No further loss of extant populations.
- Baseline surveys required to confirm known and locate new populations.
- Survey for new populations

Relevant Priority Actions for the locality

1. Conduct surveys to locate new populations and extend the range of known populations. (Medium priority)

2. Establish monitoring sites to determine threats, long-term population viability and response to management. (Medium priority).

Snake Orchid (*Diuris pedunculata*) (V)

Snake Orchid a small ground orchid with flowering stem to 0.3 m, which emerges from a subsurface corm during late winter to flower. The flower is yellow, 15-20 mm across and bright yellow. This species is widely distributed throughout the western slopes from Narrandera to the Queensland border, where it is principally found in grassy floodplain woodlands.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Enjoy viewing and photographing native orchids but leave them in the wild.
- Assist with the control of feral pigs in habitat areas.
- Protect areas of known habitat from frequent fire.
- Protect known populations and habitat areas from grazing stock.
- Identify roadside populations and protect during road maintenance activities.
- Assist with the control of weeds in habitat areas.
- Protect areas of known or potential habitat from clearing or disturbance.

Relevant Priority Actions for the locality

1. Visit known populations and assess the local threats impacting on the species prior to determining recovery actions. (Low priority)

Painted Diuris [*Diuris tricolor* (syn *D. sheiffiana*)] (V)

Diuris tricolor a robust ground orchid with flowering stem to 0.4 m, which emerges from a subsurface corm during spring to flower. The flower is yellow, 25 mm across and has variable reddish purple lines and spots on the base dorsal sepal and labellum. This species is widely distributed throughout the western slopes from Narrandera to the Queensland border, where it is principally found in grassy Callitris woodlands. Eastern range extensions are known in the Muswellbrook locality approximately 80-100 km east of the study area where it is listed as an endangered population.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Avoid changing land use where Pine Donkey Orchid is known to survive.
- Instigate monitoring studies within known populations.
- Investigate regeneration including seed-set, germination and seedling survival.
- Conduct experimental studies on the effects of fire and grazing disturbance.
- Conduct searches for further populations.
- Organise proactive surveying in potential habitats.

Relevant Priority Actions for the locality

1. Annually monitor at least 5 populations that represent the spatial distribution of the species. (High priority)

2. Conduct baseline surveys to locate new populations and extend the ranges of currently known populations. Surveys should include all State Forests where suitable habitat occurs. (High priority)

3. Conduct surveys and assessments of less known sites to confirm presence of species and develop and implement conservation management agreements with landholders for high priority sites. (High priority)

4. Develop a fact sheet and distribute via community newsletters, regional shows and field days and by promoting the DEC threatened species website. (High priority)

5. Develop an Expression of Interest (EOI) for incentives targeted towards private landowners to locate new sites for conservation. (Medium priority)

6. Following surveys, assess the current conservation status and prepare & submit a nomination for de-listing if required. (Medium priority)

Digitaria porrecta (V)

This threatened grass is generally a spreading to erect greyish pubescent perennial, to 0.6 m high, swollen at the base; culms and sheaths hairy, especially near the nodes, becoming glabrous upwards. Leaves 2-3 mm wide with jagged margins. Racemes stiffly spreading at maturity, the lower in a whorl of 4 to 6 and to 30 cm long, bare at their bases for 4-11 cm, mostly unilaterally branched; the branches 3-12 cm long, bearing 3-13 paired or solitary spikelets. Flowers in summer.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Support local Landcare groups.
- Manage fire in areas of known habitat to maintain populations of Finger Panic Grass.
- Practice sustainable grazing to maintain native grass ground cover in areas of known and potential habitat.
- Identify roadside populations and areas of habitat and protect during roadside maintenance activities.
- Protect known populations and areas of potential habitat from clearing and disturbance.

Enter into Conservation Agreements to protect the main areas of *Digitaria porrecta*.

Relevant Priority Actions for the locality

1. Conduct targeted surveys in potential habitat. (Medium priority)

2. Conduct weed control, especially of invasive exotic grasses. (Medium priority)

3. Ensure awareness by managers and users of Travelling Stock Routes of the species' location and identification and requirements. (Medium priority)

Pomaderris queenslandica (E)

Pomaderris queenslandica is a small to medium sized shrub of widespread but rare occurrence throughout eastern NSW west from the Great Dividing Range. This species is typically found along ephemeral creeklines and protected midslopes in dry districts along the Great Dividing Range north from Peak Hill to Queensland.

Regional Conservation Status

The Scant Pomaderris is known to occur within 3 conservation reserve of the Hunter Central Rivers Catchment management Area this being Goulburn River National Park (two records), Manoboli Nature Reserve (one record) and Towari National Park (one record). A total of 4 records have been collated from habitat contained within these reserves. Insufficient data is available to draw conclusions from this database result, except to say that the species may be rare for region, undersurveyed (i.e. cryptic) or poorly understood. Given the habitat of this species it is considered that the Scant Pomaderris is a rare species for this region.

Focus of Recovery Effort

- Support local Landcare groups.
- Manage fire to maintain populations of Scant Pomaderris.
- Protect known populations from disturbance from logging or roadworks.
- Control introduced weeds.
- Protect areas of moist forest and woodland habitat from clearing and fragmentation.
- Notify the DEC of any new occurrences of the species.

Relevant Priority Actions for the locality

1. Conduct research to determine ecological requirements, including fire ecology, and undertake field studies to monitor seedling establishment and survivorship. May involve autecological study or literature search for information on similar species. (Medium priority)

2. Consider VCAs or similar agreements to protect and manage populations on private land. (High priority)

3. Determine need to collect seed for NSW Seedbank. Develop collection program in collaboration with BGT - multiple provenances. (Medium priority)

4. Ensure location of known populations are considered in fire plans and hazard reduction burn planning. (High priority)

5. Identify roadside populations and protect prior to undertaking road works. (Medium priority)

6. Investigate seed viability, germination, dormancy and longevity (in natural environment and in storage). (Medium priority)

7. Manage weeds at known populations. (Medium priority)

8. Survey known locations and nearby areas for additional populations. (Medium priority)

Denman Pomaderris (*Pomaderris reperta*) (E)

Pomaderris reperta is a highly restricted small shrub where it is only found within the Denman district. Habitat appears to be highly specialised, this being sheltered dry sclerophyll woodland and/or shrublands on quartz rich Tertiary conglomerates (I.e. Narrabeen Sandstones). It has been found in loose gravelly soils found along ephemeral creeklines.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Determine the need for an ex-situ conservation program.
- Protect areas of known and potential habitat from clearing.
- Monitor the health of the population at known sites.
- Map known sites and conduct surveys of potential habitat to locate new sites.

Relevant Priority Actions for the locality

1. Identify, map and survey potential habitat. (Medium priority)

*Prostanthera discolo*r (V)

Prostanthera discolor is an open erect small shrub with moderately dense to densely hairy aromatic branches and glabrous lanceolate leaves. Grows in dry sclerophyll forest in rocky gullies in the Sandy Hollow - Merriwa district.

Regional Conservation Status

Prostanthera discolor is known to occur within one conservation reserve of the Hunter Central Rivers Catchment management Area this being Goulburn River National Park (4 records). The four records exclusively from this conservation reserve indicate the associated area as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Protect areas of known and potential habitat from clearing and further fragmentation.
- Survey of known populations, and potential habitat, to gain greater insight into the current status of the species, threats to its persistence, and management actions required.

Relevant Priority Actions for the locality

1. Identify, map and survey potential habitat during flowering season (Sept - Oct), as per recommendations in Miller 1999. (Medium priority)

Prostanthera cryptandroides (V)

Prostanthera cryptandroides is a low divaricate shrub (0.3 - 2 m in height) with strongly aromatic, viscid, densely hairy branches. Leaves are narrow ovate, toothed to crenate and mostly glabrous. Flowers are lilac to mauve (flowers September to April). Grows in dry sclerophyll forest, often in rocky sites, chiefly from Lithgow to Sandy Hollow districts.

Regional Conservation Status

Prostanthera cryptandroides is known to occur within one conservation reserve of the Hunter Central Rivers Catchment management Area this being Goulburn River National Park (5 records). The five records exclusively from this conservation reserve indicate the associated area as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Manage fire regimes to allow intervals of greater than 8 years; it may be important to maintain unburnt refuge areas containing large numbers of individuals for long periods of time to assist in the survival of the currently unknown pollination vector(s).
- A buffer should be placed around sub-populations to conserve seed stored in the soil.
- Protect known habitat, maintaining continuity between individuals within sub-populations, and avoid artificially creating new sub-populations.

Relevant Priority Actions for the locality

1. Identify, map and survey potential habitat as per advice from Miller 2000. (Medium priority)

Prostanthera stricta (V)

An erect shrub to 2 m high and to 3 m diam., aromatic; branches densely hairy with spreading hairs; glandular. Leaves with lamina ovate, 8-13 mm long, 5-9 mm wide; apex obtuse; base obtuse to rounded; margins entire and often recurved; surfaces mid green, densely hairy with spreading hairs; petiole c. 1 mm long. Flowers in a terminal botryoid; bracteoles persistent, 3-3.5 mm long. Calyx 4-4.5 mm long; tube c. 2 mm long; upper lobe 2 mm long, not enlarged in fruit. Corolla 6-9 mm long, pale mauve to deep mauve-purple, with dark pink-mauve dots in throat. Distribution and occurrence: Grows in sclerophyll forest, in sandy alluvium near watercourses; in the Widden Valley district. NSW subdivisions: CT, CWS.

Regional Conservation Status

Prostanthera stricta is known to occur within one conservation reserve of the Hunter Central Rivers Catchment management Area this being Goulburn River National Park (4 records). The four records exclusively from this conservation reserve indicate the associated area as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Fencing, where appropriate, to reduce trampling and grazing.
- Fencing in some circumstances may also reduce the threat of pathogenic organisms by minimising intrusion by visitors and stock into sensitive areas.
- Habitat should be managed to maintain continuity between individual plants within sub-populations and to avoid artificially creating new sub-populations.
- A buffer should be placed around sub-populations to conserve soil-stored seed.
- Fire regimes should be managed to allow intervals of greater than 8 years. It may be important to maintain unburnt “refuge” areas containing large numbers of the species for long periods of time to allow survival of the as yet unknown pollination vector(s).

Relevant Priority Actions for the locality

1. Conduct research and undertake field studies to determine fire ecology, response to disturbance and seedbank characteristics. (Medium priority)

2. Identify, map and survey potential habitat during flowering season (winter-spring), as per recommendations in Miller 1999. (Medium priority)

Commersonia rosea (E)

Commersonia rosea is a prostrate shrub (0.1 - 0.3 m high) with long (about 60 cm) trailing branches. Flowers have been observed in August and November, January - February. Habitat is restricted to scrub or heath on soils derived from Triassic sandstone (Narrabeen) within the Sandy Hollow district.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Environmental and demographic stochasticity due to its small population size
- Disturbance associated with track maintenance
- Inappropriate fire regimes
- Future land development should tenure change

Relevant Priority Actions for the locality

None relevant.

Lasiopetalum longistamineum (V)

Lasiopetalum longistamineum is a spreading shrub to 1.5 m generally flowering in spring. This species is restricted to the central west of NSW on rich alluvial soils in the Mt Dangar - Gungal area within Merriwa and Muswellbrook Local Government Areas. A couple of sites are recorded within Goulburn River National Park.

Regional Conservation Status

Lasiopetalum longistamineum is known to occur within one conservation reserve of the Hunter Central Rivers Catchment management Area this being Goulburn River National Park (1 record). Insufficient data is available to draw conclusions from this database result, except to say that the species may be rare for region, undersurveyed (i.e. cryptic) or poorly understood. Given the habitat and its prescribed distribution it is considered that *Lasiopetalum longistamineum* is a rare species for this region.

Focus of Recovery Effort

- Protect habitat from clearing and disturbance.
- Survey of known populations, and potential habitat, is required to gain greater insight into the current status of the species, threats to its persistence, and management actions required.

Relevant Priority Actions for the locality

1. Identify, map and survey potential habitat. (Medium priority)

Thesium australe (V)

The Australe Toadflax is an erect perennial herb to 40 cm high, pale green to yellow-green, glabrous; stems 1-several, little-branched, wiry, striate. Leaves linear, usually 1-4 cm long, 0.5-1.5 mm wide, apex acute, midrib decurrent, sessile; lowest leaves scale-like. Flowers solitary, axillary, green-yellow; peduncle 1-3 mm long, subtended by leaf with 2 opposite bracteoles; pedicel very short. Flowers spring to summer.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Protect known populations from changes to land use.
- Do not undertake road works, pasture modification or other changes in land use that may affect populations.
- Do not increase grazing pressures on sites where populations persist - reduce grazing pressures where possible.
- Undertake weed control in and adjacent to populations, taking care to spray or dig out only target weeds.
- Mark sites and potential habitat onto maps (of the farm, shire, region, etc) used for planning (e.g. road works, residential and infrastructure developments, remnant protection, rehabilitation).
- Search for new populations in potential habitat.

Relevant Priority Actions for the locality

1. Support funding for management work in habitat for the species and carry out habitat maintenance and protection at known locations for the species. (High priority)

Booroolong Frog (*Litoria booroolongensis*) (**E)**

The Booroolong Frog is restricted to NSW and north-eastern Victoria, predominantly along the western-flowing streams of the Great Dividing Range. It has disappeared from the Northern Tablelands and is now rare throughout most of the remainder of its range. Most recent records are from the south-west slopes of NSW. This species lives along permanent streams with some fringing vegetation cover such as ferns, sedges or grasses. Adults occur on or near cobble banks and other rock structures within stream margins and is sometimes found basking in the sun on exposed rocks near flowing water during summer. It shelters under rocks or amongst vegetation near the ground on the stream edge.

Breeding occurs in spring and early summer and tadpoles metamorphose in late summer to early autumn. Eggs are laid in submerged rock crevices and tadpoles grow in slow-flowing connected or isolated pools.

Regional Conservation Status

The Booroolong Frog is known to occur within 2 conservation reserves of the Hunter Central Rivers Catchment management Area including: Crawney Pass CCA Zone 1 National Park (one record) and Mt Royal National Park (1 record). A total of 2 records have been collated from habitat contained within these reserves with the database analysis indicating the conservation reserves occurring on or adjacent to the northern tablelands as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Retain riparian native vegetation.
- Maintain natural stream channel morphology.
- Reduce the stocking of introduced fish in streams where the species occurs.
- Minimise the use of herbicides and pesticides adjacent to streams.
- Protect streams and streamside vegetation from disturbance by stock.
- Control weeds, particularly willows, and rehabilitate streamside habitats.

Relevant Priority Actions for the locality

1. Determine current distribution and abundance in relation to landscape and habitat quality attributes. (High priority)

2. Determine the impact of predation by introduced fish. (High priority)

3. Determine the influence of habitat disturbance on persistence, abundance and demography. (High priority)

4. Increase awareness about the species. (Medium priority)

5. Investigate less known potential locations of Booroolong Frog and subsequently develop, negotiate and implement conservation management agreements at confirmed high priority sites. . (Medium priority)

6. Use management agreements and incentives for riparian fencing and re-snagging to reduce further habitat degradation and enhance the extent of suitable habitat. (High priority)

Giant Barred Frog (*Mixophyes iteratus*) (E)

Giant Barred Frogs are large frogs, up to 115 mm in length. They are olive to dark brown above with paler or darker blotches, and cream to pale yellow below. The skin is finely granular. The pupil of the eye is vertical and the iris is pale golden in the upper half and brown in the lower half. The call is a deep ‘ork’ breaking into a series of ‘orks’ and grunts. The Giant Barred Frog can be most easily distinguished from other barred frog species by the black thighs with smaller yellow spots, distinct barring on the limbs, dark blotches on the sides, absence of a creamy stripe on the upper lip and the distinctive eye colour.

Giant Barred Frogs forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m. They breed around shallow, flowing rocky streams from late spring to summer. Females lay eggs onto moist creek banks or rocks above water level, from where tadpoles drop into the water when hatched. Tadpoles grow to a length of 80 mm and take up to 14 months before changing into frogs. When not breeding the frogs disperse hundreds of metres away from streams. They feed primarily on large insects and spiders.

The Giant Barred Frog occurs on the coast and ranges from south-eastern Queensland to the Hawkesbury River in NSW. North-eastern NSW, particularly the Coffs Harbour-Dorrigo area, is now a stronghold.

Regional Conservation Status

The Giant Barred Frog is known to occur within 4 conservation reserves of the Hunter Central Rivers Catchment management Area including: Coorabakh National Park (one record); Jilliby State Conservation Area (2 records) and Watagans National Park (16 records). A total of 19 records have been collated from habitat contained within these reserves with the database analysis indicating Watagans National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Manage burning off so that streamside habitats do not suffer loss of moisture or leaf-litter.
- Maintain vegetation and deep leaf-litter around streams.
- Manage upstream developments to minimise changes in water quality and flow.
- Be careful in the use of chemicals near streams and use alternatives where available.
- Minimise access to streams by cattle.
- Exclude logging in and around breeding habitat.
- Clean footwear, equipment and tyres before and after visiting frog sites.
- Only handle frogs when absolutely necessary.

Relevant Priority Actions for the locality

1. Control weeds in riparian areas. (Medium priority)

2. Protect habitat from impacting activities. (Medium priority)

Worm Skink (*Aprasia parapulchella*) (E)

The Pink-tailed Worm-lizard is worm-like, with a dark-brown head and nape, gradually merging with the pale grey or grey-brown body. The tail, nearly as long as its body, is pink or reddish-brown towards the tip. Its snout and tail are both rounded. There are no external ear openings. The broad, non-forked tongue, frequently used to wipe the eyes, and the presence of small hind-limb flaps, distinguishes it from a juvenile snake. Specimens grow to about 25 cm in length.

The Pink-tailed Worm Lizard is only known from the Central and Southern Tablelands, and the South Western Slopes. There is a concentration of populations in the Canberra/Queanbeyan Region. Other populations have been recorded near Cooma, Yass, Bathurst, Albury and West Wyalong. This species is also found in the Australian Capital Territory.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area. However, this species has been recorded in Goulburn River National Park, with the current status of this population unknown.

Focus of Recovery Effort

- Keep domestic dogs and cats indoors at night.
- Undertake feral animal control.
- Apply fire regimes that maintain structure and floristic diversity (e.g. patch burning).

- Search for the species in suitable habitat in areas that are proposed for development or management actions, and mark sites onto maps or plans.
- Do not collect bush rock or remove rocks for pasture management purposes.
- Do not destroy habitat and surrounding areas by ploughing.
- Do not allow heavy, prolonged grazing on habitat.
- Do not plant trees and shrubs into habitat.
- Control invasions of weeds and pasture species (but be wary of the impact of herbicide use in habitat); where possible use methods that directly target weeds, such as spot spraying and hand removal.
- Protect natural grassland remnants within the known distribution of the species.
- Ensure remnant populations remain connected or linked to each other. In cases where remnants have lost connective links, re-establish links by revegetating sites to act as stepping stones for dispersal.
- Mark sites and potential habitat onto maps used for planning hazard reduction burns.

Relevant Priority Actions for the locality

1. Implement habitat management guidelines in Buddigower Nature Reserve and Goulburn River National Park. (High priority)

2. Reserve or ensure long-term management of known populations. (High priority)

3. Undertake a review of threats at known sites. (High priority)

4. Undertake distribution modelling or remote sensing to identify potential distribution and habitat. (Medium priority)

5. Undertake research into biology, ecology and management. (Low priority)

6. Undertake survey in Goulburn River National Park to determine presence and distribution of species in reserve. (Medium priority)

7. Undertake surveys for the species in areas of identified potential habitat using survey guidelines. (High priority)

Collared Whipsnake (*Suta flagellum*) (V)

The Collared Whipsnake is a terrestrial, predominantly diurnal species that shelters under fallen timber, flat rocks, debris, in deep soil cracks, rock crevices, grass clumps, and animal burrows. It eats small lizards and snakes which are captured by chasing. Preferred habitats include open forests, woodlands or shrublands with an understorey of grass, shrubs or hummock grasslands on the slopes and plains. It is a western species that has been collected in Tibooburra and the vicinity of Sturt National Park.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Control vertebrate pest populations, e.g. goats, foxes, cats and rabbits.
- Reduce stock intensity or exclude grazing to allow regeneration of vegetation.
- Restrict cultivation around remnant habitat.
- Retain grasslands and ensure the full cycle of grass development such a seed set and tussock formation.
- Retain stick and leaf litter.

- Retain understorey shrubs.
- Retain fallen logs as habitat for this species, especially if large and embedded in the soil.
- Maintain Triodia (spinifex or porcupine grass).
- Prevent clearing of habitat such as nesting sites and food sources.

Relevant Priority Actions for the locality

1. Determine the current range and distribution of the species through intensive surveys, then identify at least 5 currently inhabited sites across the species range for recovery actions to be implemented. (High priority)

2. Erect fences around areas of suitable habitat to prevent trampling and grazing by stock or to buffer from cropping activities and to allow regeneration of habitat. (Medium priority)

3. Establish a comprehensive monitoring program across the 5 sites to determine the success or otherwise of recovery actions and to guide future actions. (High priority)

4. Establish and implement a joint pest control program between DEC and landholders for foxes and feral cats in and around areas of suitable habitat. (Medium priority)

5. Monitor rabbit warrens for Collared Whip Snakes prior to ripping or blasting and seek advice, permission & assistance to relocate the individual prior to destroying the warrens. (Medium priority)

6. Retain, where ever possible, all ground timber, fallen logs, rocks, grass cover, spinifex, understorey shrubs and soil cracks in areas of suitable habitat. (Medium priority)

7. Revegetate riparian strips, gullies and stream banks. (Medium priority)

Broad-headed Snake (*Hoplocephalus bungaroides*) (E)

The Broad-headed Snake (*Hoplocephalus bungaroides*) is a moderately sized venomous snake species restricted to exposed Hawkesbury sandstones of the Sydney region. It is black with numerous yellow markings arranged in irregular, narrow crossbands. Lizards and frogs form a major part of its diet. The Broad-headed Snake may give birth to 8-20 live young at a time. Heath and open woodland with an abundance of loose flat bush rock being a critical part of its shelter and foraging habitat.

Regional Conservation Status

The location accuracy of data supplied by the DECC (2008) is to course for a spatial analysis on this species. From the literature this species is known to occur within Wollemi and Yengo National Parks and Parr State Recreation Area for the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Maintain colonies in captivity for future re-introduction to depleted sites or sites undergoing restoration.
- Undertake feral goat control programs in sandstone escarpment areas.
- Retain woodland adjacent to sandstone escarpments, particularly large hollow-bearing trees.
- Retain sandstone rock in bushland on escarpment areas; implement LEPs, DCPs with suitable restrictions on the removal of bushrock.
- Limit vehicle and pedestrian access to and recreational use of sandstone escarpments where this species occurs.
- Restore rocky habitat to escarpments that have been disturbed.
- Report suspected illegal reptile collection or sale.
- Advocate the use of quarried sandstone or alternatives in preference to sandstone sourced from bushland on escarpments; implement a community and industry bushrock education strategy.

Relevant Priority Actions for the locality

None relevant.

Malleefowl (*Leipoa ocellata*) (E)

The Malleefowl is a mound building ground bird of central NSW and Victoria where it is found in habitats such as mallee, acacia, paperbark, sheoak and Eucalypt woodlands. Nest construction is initiated in the autumn, with breeding starting in spring after winter rains. Diet usually consists of invertebrates, seeds, fallen fruits and small vertebrates. Whilst difficult to detect live specimens of this species, mounds created by this species can persist long after the local extinction and is often used as an indicator of historical distribution.

Predominantly inhabits mallee communities, preferring the tall, dense and floristically-rich mallee found in higher rainfall (300-450 mm mean annual rainfall) areas. Less frequently found in other eucalypt woodlands (e.g., mixed Western Grey Box and Yellow Gum or Bimble Box, Ironbark-Callitris Pine, Callitris Pine, Mulga (*Acacia aneura*), and Gidgee(*A. cambagei*). Prefers areas of light sandy to sandy loam soils and habitats with a dense but discontinuous canopy, dense and variable shrub and herb layers.

A pair may occupy a range of between 50 and 500 ha, overlapping with those of their neighbours. Mainly forage in open areas on seeds of acacias and other native shrubs (Cassia, Beyeria, Bossiaea), buds, flowers and fruits of herbs and various shrubs, insects (cockroaches, ants, soil invertebrates), and cereals if available.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area. However, this species was recorded in Goulbourn River National Park in 1989, with the current status of this population unknown.

Focus of Recovery Effort

- Control vertebrate pest populations (e.g., foxes, cats and rabbits) which prey on the species, degrade habitat, or compete for resources.
- Implement appropriate fire regime so as to not burn all habitat and food resources within a locality at one time and to promote natural succession.
- Avoid disturbing the species. Deny access to people who may be involved in illegal collection.
- Reduce stocking intensity or exclude grazing in some areas to allow regeneration of vegetation and improve habitat quality (e.g. shelter, food and nest resources).
- Retain grasslands and allow grassland species to complete their lifecycle (i.e. seed set, germination, establishment, tussock formation).
- Retention of stick and leaf litter.
- Retain understorey shrubs and allow them to complete their life cycle (i.e. seed set, germination, establishment, growth to maturity).
- Retain fallen logs and ground debris.

Maintain *Triodia* (spinifex or porcupine grass) in the area.

- Buffer habitat areas from the impacts of other activities (e.g., cultivation).
- Prevent clearing of habitat.

Relevant Priority Actions for the locality

1. Conduct surveys in Goulburn River National Park to determine whether Malleefowl are still present. (Low priority)

Bush Stone-curlew (*Burhinus grallarius*) (E)

The Bush Stone-curlew (*Burhinus grallarius*) inhabits lightly timbered open forest and woodland areas with a grassy understorey (NPWS 1999; Blakers et al 1984; DEC 2006). Preferred habitat usually has good visibility at ground level, with this structure being more important than floristics (DEC 2006). In western NSW this species is known to utilise Box-Ironbark forests and patches of she-oaks (DEC 2006). Will also use dry open grassland and cropland with cover nearby (NPWS 1999). Nests in a shallow scrape on the ground (Lindsey 1992), near dead timber, usually under trees in open woodland with a short grassy understorey (NPWS 1999). Grass height should be less than 15cm (DEC 2006). Nocturnal, especially active on moonlit nights (NPWS 1999). Pairs defend approx 10-25ha when breeding, but may forage over an area of 250-600ha (DEC 2006). Small flocks may roam over 100km2 in the non-breeding season (Blakers et al 1984). At night, birds will travel up to 3km from a roost site to feeding grounds in open paddocks, wetlands, woodland remnants etc (DEC 2006).

Regional Conservation Status

The Bush Stone-curlew is known to occur within 3 conservation reserves of the Hunter Central Rivers Catchment management Area including: Cockle Bay Nature Reserve (18 records); Jilliby State Conservation Area (2 records); Rileys Island Nature Reserve (5 records). A total of 25 records have been collated from habitat contained within these reserves with the database analysis indicating Jilliby State Conservation Area as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Keep domestic dogs and cats indoors at night. Desex domestic dogs and cats.
- Undertake fox and feral cat control programs.
- Assess the appropriateness of dog and cat ownership in new subdivisions.
- Retain dead timber on the ground in open woodland areas.
- Remove cattle from paddocks containing nesting areas at least during breeding season or while eggs and chicks are in nest.
- Retain existing vegetation along roadsides, in paddocks and remnant stands of native trees.
- Fence off nesting sites.
- Fence off suitable woodland habitats, particularly those with unimproved pasture and an intact native ground plant layer.
- Increase the size of existing remnants, planting trees and establishing buffer zones of unimproved uncultivated pasture around woodland remnants.
- Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.

Relevant Priority Actions for the locality

1. Acquire Bush Stone-curlew habitat when land acquisition opportunities arise. Priority areas for habitat acquisition to be determined. (Low priority)

2. Identify and map Bush Stone-curlew habitat on DEC estate and crown lands within high priority CMAs - foraging, breeding and roosting habitat should be identified. Refer to recovery plan for habitat descriptions and Wildlife Atlas for records. (Low priority)

3. Prepare and implement management plans for at least 1 local Bush Stone-curlew population in each high priority CMA (see recovery plan for details). Source funding to implement management plans. Prepare and implement additional plans if possible. (Low priority)

4. Undertake community and field surveys within areas of habitat (breeding, foraging and roosting) in high priority CMAs to identify Bush Stone-curlew sites. Refer to recovery plan for survey methods. (Low priority).

Australian Painted Snipe (*Rostratula australis*) (E)

The Australian Painted Snipe occupies the fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds and consists of a scrape in the ground, lined with grasses and leaves. Breeding is often in response to local conditions; generally occurs from September to December. Foraging is generally nocturnal on mud-flats and in shallow water where it feeds on worms, molluscs, insects and some plant-matter.

Regional Conservation Status

The Australian Painted Snipe is known to occur within 1 conservation reserve of the Hunter Central Rivers Catchment management Area this being Pambalong Nature Reserve (one record). A single record has been collated from habitat contained within this reserve.

Focus of Recovery Effort

- Control foxes, feral dogs and cats.
- Protect swamps from fire during burning-off activities.
- Protect wetlands and watercourses from pollution.
- Limit the use of pesticides and other chemicals near wetlands and consider alternatives where available.

Protect wetlands and associated marshy areas from clearing or disturbance.

Relevant Priority Actions for the locality

1. Assess the species' status via review of past surveys and the literature, and by conducting and encouraging surveys in known and potential habitat in appropriate seasons. (High priority)

Square-tailed Kite (*Lophoictinia isura*) (V)

The Square-tailed Kite has a widespread distribution across virtually all of mainland Australia, excepting waterless desert (NPWS 1999). Typically inhabits tropical and temperate coastal forests and woodlands, and also inland along timbered watercourses (NPWS 1999). Appears to migrate seasonally, south in summer, north in winter (Blakers *et al* 1984).

In NSW, it is often associated with forests dominated by *Eucalyptus longifloria*, *Corymbia maculata* or *E elata, E smithii*. Also sighted within forests containing other eucalypts, *Angophora* spp and *Callitris* spp with a shrubby understorey and Box-Ironbark woodland (NPWS 1999).

Feeds on passerine birds, especially honeyeaters, nestling birds, rabbits, reptiles and carrion (NPWS 1999; Lindsey 1992). Nest is a substantial structure of sticks, usually constructed in a fork or on a large horizontal limb of *Angophora* spp or *Eucalyptus* spp approx 15-20m above the ground, along or near watercourses (Lindsey 1992; NPWS 1999).

Regional Conservation Status

The Square-tailed Kite is known to occur within 5 conservation reserves of the Hunter Central Rivers Catchment management Area including: Goulburn River National Park (one record); Khappinghat Nature Reserve (one record); Kooragang Nature Reserve (one record); Munghorn Gap Nature Reserve (4 records); Wollemi National Park (one record). A total of 8 records have been collated from habitat contained within these reserves with the database analysis indicating Munghorn Gap Nature Reserve as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Protect known habitat from fires of a frequency greater than that recommended for the retention of biodiversity.
- Retain and protect nesting and foraging habitat, particularly along watercourses.
- Report suspected illegal bird shooting and egg-collecting to DEC.

Relevant Priority Actions for the locality

1. Ensure implementation of management strategies that reduce disturbance of riparian areas. (Medium priority)

2. Identify and protect nest trees, and monitor reproduction. (High priority)

Gang-gang Cockatoo (*Callocephalon fimbriatum*) (V)

The Gang-gang Cockatoo (*Callocephalon fimbriatum*) inhabits tall montane forests and woodlands in summer, particularly heavily timbered mature wet sclerophyll forests. Also occurs in sub-alpine Snow Gum woodland and occasionally in temperate rainforests. Undertakes nomadic and seasonal movements, and in winter tends to occur at lower altitudes in drier, more open eucalypt forest and woodland, particularly Box-Ironbark associations, and in dry forest in coastal areas (NSW Scientific Committee). Feeds on green acacia seeds, eucalypt seeds, fruits and berries, including seeds, fruits and berries of introduced plant species (Lindsey 1992; Blakers et al 1984). Tends to exhaust one food supply before moving to another (Blakers et al 1984). Nests in hollows in large old trees, usually close to water. Shows strong nest site fidelity. Breeding occurs mainly in tall mature wet sclerophyll forests with a dense understorey (NSW Scientific Committee).

Regional Conservation Status

The Gang-gang Cockatoo is known to occur within 11 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (one record); Bouddi National Park (2 records); Goulburn River National Park (2 records); Jilliby State Conservation Area (3 records); Munghorn Gap Nature Reserve (7 records); Pambalong Nature Reserve (one record); Tomaree National Park (2 records); Watagans National Park (one record); Werakata National Park (2 records); Wollemi National Park (62 records); Yengo National Park (46 records). A total of 129 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Clearing of vegetation and degradation of habitat may reduce the abundance of optimal foraging and roosting habitat.
- Individual pairs show high fidelity to selected nesting trees (choosing nesting hollows of particular shape, position and structure), with clearing and frequent fire posing a threat to continued successful breeding.
- Climate change may alter the extent and nature of its preferred habitat (cool temperate vegetation).
- Susceptible to Psittacine cirovirus disease (PCD) which is spread through contaminated nest chambers. PCD is known to have increased near Bowral in the southern highlands of New South Wales over the past decade and constitutes a further threat to the species.

Relevant Priority Actions for the locality

1. Determine the status of representative local populations distributed across the species range. (High priority)

2. Investigate movement patterns of selected populations. (Low priority)

Glossy Black-Cockatoo (*Calyptorhynchus lathami*) (V)

The Glossy Black-cockatoo (*C. lathami*) has patchy distribution in a wide coastal band from Eungella, eastern Queensland, to Orbost, Victoria. In NSW it is found on the coast, tablelands and as far west as the Riverina and Pilliga Scrub. It feeds almost exclusively on Sheoak (*Allocasuarina* spp.) particularly the fruit of Forest Sheoak (*A. torulosa*) and Black Sheoak (*A. littoralis*) in coastal forests and Drooping Sheoak (*A. verticillata*) and *Allocasuarina gymnanthera* in western woodlands and timbered watercourses (Pizzey and Knight, 1997). Chewed cones (fruits) beneath these shrub species are indicative of Glossy Black-cockatoo (*C. lathami*) activity. This parrot species occupies large home ranges centred on breeding habitat containing large tree hollows near suitable water and foraging resources.

Regional Conservation Status

The Glossy Black-Cockatoo is known to occur within 38 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (8 records); Barrington Tops State Conservation Area (one record); Boorganna Nature Reserve (one record); Booti Booti National Park (one record); Bouddi National Park (12 records); Bretti Nature Reserve (one record); Brisbane Water National Park (28 records); Bugan Nature Reserve (one record); Cockle Bay Nature Reserve (one record); Coolah Tops National Park (5 records); Coorabakh National Park (one record); Cottan-Bimbang National Park (4 records); Goonook Nature Reserve (one record); Goulburn River National Park (18 records); Jilliby State Conservation Area (2 records); Karuah Nature Reserve (5 records); Khappinghat Nature Reserve (3 records); Killarney Nature Reserve (one record); Lake Macquarie State Conservation Area (one record); Manobalai Nature Reserve (5 records); Mount Royal National Park (7 records); Mummel Gulf National Park (one record); Myall Lakes National Park (9 records); Nowendoc National Park (5 records); Running Creek Nature Reserve (one record); Talawahl Nature Reserve (2 records); Tapin Tops National Park (4 records); The Cells State Conservation Area (3 records); The Glen Nature Reserve (3 records); Towarri National Park (one record); Wallaroo Nature Reserve (one record); Wallingat National Park (11 records); Watagans National Park (4 records); Werakata National Park (3 records); Wingen Maid Nature Reserve (4 records); Woko National Park (8 records); Wollemi National Park (66 records); Yengo National Park (27 records). A total of 260 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Reduce the impact of burning to retain diverse understorey species and in particular to permit the regeneration of she-oaks.
- Protect existing and future hollow-bearing trees for nest sites.
- Retain and protect areas of native forest and woodland containing she-oaks.
- Establish forested corridors linking remnant areas of habitat; include local she-oak species in bush revegetation works.
- Report suspected illegal bird trapping and egg-collecting to the DEC.

Relevant Priority Actions for the locality

1. Assist landholders who wish to enter into voluntary conservation agreements at key sites. (Medium priority)

2. Develop/encourage strategic planning approach for Glossy Black Cockatoo at the local and regional level. (High priority)

3. Encourage the restoration of foraging habitat that has been cleared or degraded by previous impacts. (Medium priority)

4. Identify and map key breeding and foraging habitat, similar to the mapping done by Robinson (2004) at St Georges Basin. (High priority)

5. Provide incentives for landholders to fence and manage key sites. (Medium priority)

Swift Parrot (*Lathamus discolor*) (E)

The Swift Parrot (*L. discolor*) breeds in Tasmania and islands of Bass Strait, migrating in winter to Victoria and coastal NSW. Isolated flocks are occasionally observed near Sydney, the Hunter Valley and sometimes to the Queensland Border (Frith, 1982). The Swift Parrot (*L. discolor*) feeds primarily on the blossom of Mugga Ironbark (*E. sideroxylon*), Narrow-leaved Ironbark (*E. crebra*), Swamp Mahogany (*E. robusta*) and Spotted Gum (*C. maculata*) while migrating through the Sydney Basin Bioregion.

Regional Conservation Status

The Swift Parrot is known to occur within 8 conservation reserves of the Hunter Central Rivers Catchment management Area including: Crowdy Bay National Park (one record); Goulburn River National Park (one record); Lake Macquarie State Conservation Area (2 records); Munghorn Gap Nature Reserve (one record); Myall Lakes National Park (one record); Tomaree National Park (one record); Werakata National Park (4 records); Wyrrabalong National Park (4 records). A total of 15 records have been collated from habitat contained within these reserves with the database analysis indicating Wyrrabalong National Park as a potential stronghold or area of importance for this species (although data is limited and inconclusive).

Focus of Recovery Effort

- Reduce collisions in areas where Swift Parrots are foraging by closing window blinds, letting windows get dirty. Alternatively hang wind chimes, mobiles etc in front of windows. Hang strips of fabric across wire mesh fences.
- Searches for the species should be conducted in suitable habitat in proposed development areas. Known feeding areas should be protected. DEC should be consulted for advice on reducing impact when planning development near feeding areas.
- Retain stands of winter-flowering feed-trees, particularly large mature individuals.
- Revegetate with winter-flowering tree species where appropriate.

Relevant Priority Actions for the locality

1. Enhance habitat for Swift Parrots by planting suitable tree species to complement natural regeneration or to enhance remnants (refer to species profile for regionally specific habitat information). (Medium priority)

2. Protect, manage and restore Swift Parrot habitat on private land through conservation agreements, management agreements and incentive payments (refer to species profile for regionally specific habitat information). (High priority)

Turquoise Parrot (*Neophema pulchella*) (V)

The Turquoise Parrot (*Neophema pulchella*) inhabits open eucalypt woodland and forest, especially with a grassy understorey and rocky outcrops (Lindsey 1992). Prefers the edge of eucalypt woodland adjoining clearings and also timbered ridges and creeklines in farmland (Blakers et al 1984; NPWS 1999). Birds may move from eucalypt woodland to pasture after the breeding season in some places (Blakers et al 1984). Usual forests/woodlands have mixed assemblages of Cypress Pine Callitris sp and a variety of eucalypts including White Box, Yellow Box, Red Box, Blakely's Red Gum, Red Stringybark, Bimble Box or Mulga Ironbark (NPWS 1999). Usually occurs in small family groups, forages on the ground for seeds (native and introduced) (Lindsey 1992; Blakers et al, 1984). Requires a reliable drinking supply (NPWS 1999). Nests may be located in hollows of small trees, in holes or stumps of dead eucalypts, fence posts or even logs lying on the ground (NPWS 1999). Suffered a major decline in numbers early this century (NPWS 1999; Lindsey 1992), possibly due to competition with livestock during drought and/or trapping (Blakers et al 1984). However, it appears this species now to have regained much of its former range (Blakers et al 1984; Lindsey 1992).

Regional Conservation Status

The Turquoise Parrot is known to occur within 7 conservation reserves of the Hunter Central Rivers Catchment management Area including: Brisbane Water National Park (4 records); Goulburn River

National Park (14 records); Munghorn Gap Nature Reserve (6 records); Myall Lakes National Park (7 records); Wallaroo Nature Reserve (one record); Wollemi National Park (49 records); Yengo National Park (one record). A total of 31 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Clearing of grassy-woodland and open forest habitat.
- Loss of hollow-bearing trees.
- Degradation of habitat through heavy grazing, firewood collection and establishment of exotic pastures.
- Predation by foxes and cats.
- Illegal trapping of birds and collection of eggs which also often results in the destruction of hollows.

Relevant Priority Actions for the locality

1. Control feral cats and foxes near high density populations (best practice: locally efficient and effective). (Medium priority)

2. Control feral goats and pigs of known or potential habitat. (Medium priority)

3. Encourage bird observer groups to undertake spot monitoring surveys at previously recorded locations. Enter data collected into Wildlife Atlas. (Medium priority)

4. Identify sites where the species is commonly observed and target for incentives and habitat management. (Medium priority)

5. Identify three targeted populations (per year over initial three years); focus recovery actions and adaptive management at these sites. (High priority)

6. Implement sympathetic habitat management in conservation reserves, council reserves and crown reserves where the species occurs. (Medium priority)

Superb Parrot (*Polytelis swansonii*) (V)

The Superb Parrot occupies naturally vegetated environments west of the Great Dividing Range from the central NSW to Victoria. This species is usually observed in Riverine and floodplain open forest and woodland particularly River Red Gum (*E. camaldulensis*). It is a sedentary species that exhibits a nomadic existence throughout its prescribed distribution. Tree hollows are particularly important for its breeding cycle, which occurs between July and November. Small flocks are often observed near major riparian corridors such as the Macquarie, Lachlan and Murrumbidgee River systems.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Retain and protect hollow-bearing trees.
- Retain and protect woodland remnants.
- Cover grain trucks and check all openings are properly sealed.
- Report grain spills to local authorities so they can be removed.
- Report suspected illegal bird trapping, egg collection or sales to NPWS.
- Remove feral bee colonies from hollows in Superb Parrot habitat, or report them to NPWS officers.

Relevant Priority Actions for the locality

None relevant.

Powerful Owl (*Ninox strenua*) (V)

The Powerful Owl (*N. strenua*) is found in a range of vegetation types from woodland and open forest to rainforest. In NSW it is distributed throughout the length of the Great Dividing Range and western slopes. The Powerful Owl (*N. strenua*) is a nocturnal, solitary, carnivorous owl that inhabits dense mountain gullies, coastal forests and woodlands, coastal scrubs, and pine plantations over a large range (approx. 400-1400 ha) (Pizzey and Knight, 1997).

Regional Conservation Status

The Powerful Owl is known to occur within 43 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (10 records); Barrington Tops State Conservation Area (2 records); Belford National Park (2 records); Ben Halls Gap National Park (2 records); Black Bulga State Conservation Area (one record); Booti Booti National Park (2 records); Bouddi National Park (6 records); Brisbane Water National Park (51 records); Coolah Tops National Park (2 records); Copeland Tops State Conservation Area (one record); Cottan-Bimbang National Park (8 records); Crawney Pass CCA Zone 1 National Park (one record); Ghin-Doo-Ee National Park (3 records); Goulburn River National Park (9 records); Jilliby State Conservation Area (4 records); Karuah Nature Reserve (one record); Khappinghat Nature Reserve (3 records); Killarney Nature Reserve (2 records); Kooragang Nature Reserve (one record); Lake Macquarie State Conservation Area (one record); Manobalai Nature Reserve (3 records); Medowie State Conservation Area (2 records); Moffats Swamp Nature Reserve (one record); Monkerai Nature Reserve (one record); Mount Royal National Park (6 records); Mummel Gulf National Park (6 records); Munghorn Gap Nature Reserve (8 records); Munmorah State Conservation Area (one record); Myall Lakes National Park (9 records); Nowendoc National Park (2 records); Talawahl Nature Reserve (4 records); Tapin Tops National Park (2 records); The Cells State Conservation Area (3 records); Tilligerry Nature Reserve (one record); Tomaree National Park (3 records); Wallarah National Park (one record); Wallaroo Nature Reserve (one record); Wallingat National Park (4 records); Wambina Nature Reserve (one record); Werakata National Park (one record); Woko National Park (5 records); Wollemi National Park (12 records); Yengo National Park (5 records). A total of 194 records have been collated from habitat contained within these reserves with the database analysis indicating Brisbane Water National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Apply low-intensity, mosaic pattern fuel reduction regimes.
- Searches for the species should be conducted in suitable habitat in proposed development areas and proposed forest harvesting compartments.
- Retain at least a 200 metre buffer of native vegetation around known nesting sites.
- Retain large stands of native vegetation, especially those containing hollow-bearing trees.
- Protect riparian vegetation to preserve roosting areas.
- Protect hollow-bearing trees for nest sites. Younger recruitment trees should also be retained to replace older trees in the long-term.
- Minimise visits to nests and other disturbances, including surveys using call playback, when owls are breeding.
- Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.

Relevant Priority Actions for the locality

1. Encourage private landholders to undertake management options to conserve and/or actively manage forest owl habitat. (Medium priority)

2. Implement a regional monitoring program. This will be undertaken once owl habitat models have been refined, validated and sampling strategy developed. (Medium priority)

3. Monitor and report on effectiveness of concurrence and licence conditions previously applied to reduce impacts of development on Powerful Owls and their habitats, by recording conditions, picking case studies and checking owl presence post development. (Medium priority)

4. Seek an ARC Linkage Grant or other joint funding opportunity to initiate research into identified key areas of the biology and ecology of the three large forest owls. (Low priority)

5. Seek scholarship funds for an identified aboriginal student to investigate the cultural and historic significance of the Powerful Owl. (Low priority)

Barking Owl (*Ninox connivens*) (V)

The Barking Owl (*Ninox connivens*) inhabits mainly woodland areas, but is also known to utilise open forest and partially cleared lands as part of its life cycle (NSW Scientific Committee, 1998). Pizzey and Knight (1997) report its habitat to consist of open forest, woodlands, dense scrubs, river red gums or other large trees near watercourses and paperbark woodlands. Barking Owls live in pairs and their territory size is generally large (greater than 100 ha). They use hollow-bearing trees for nesting purposes in association with open country for foraging. The primary diet of the Barking Owl comprises prey items such as small mammals and birds.

Regional Conservation Status

The Barking Owl is known to occur within 13 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (one record); Bouddi National Park (one record); Brisbane Water National Park (5 records); Coolah Tops National Park (3 records); Ghin-Doo-Ee National Park (one record); Goulburn River National Park (3 records); Manobalai Nature Reserve (one record); Myall Lakes National Park (2 records); Wambina Nature Reserve (2 records); Watagans National Park (one record); Werakata National Park (one record); Wollemi National Park (6 records); Yengo National Park (4 records). A total of 31 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park followed by the adjoining Yengo National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Apply mosaic pattern hazard reduction techniques to ensure the same areas are not burned too frequently.
- Retain standing dead trees.
- Retain woodland and open forest remnants, especially those containing hollow-bearing trees.
- Retain and enhance vegetation along watercourses and surrounding areas to protect roosting areas and habitat for prey.
- Retain a buffer of native vegetation at least 200 metres radius around known nest sites.
- Fence habitat remnants and protect from heavy grazing.

Relevant Priority Actions for the locality

None relevant.

Masked Owl (*Tyto novaehollandiae*) (V)

The Masked Owl (*T. novaehollandiae*) occupies a wide range of forest types, including wet and dry sclerophyll and rainforest and is thought to prefer drier forests and woodlands in flat or undulating country. This species prefers a mosaic of sparse and dense ground cover. Habitat includes forests, open woodlands, farmlands with large trees, adjacent cleared country, timbered watercourses, paperbark woodlands and caves (Pizzey and Knight, 1997).

Regional Conservation Status

The Masked Owl is known to occur within 30 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (12 records); Barrington Tops State Conservation Area (one record); Boorganna Nature Reserve (one record); Booti Booti National Park (2 records); Bouddi National Park (3 records); Brisbane Water National Park (5 records); Bugan Nature Reserve (one record); Coolah Tops National Park (2 records); Copeland Tops State Conservation Area (2 records); Cottan-Bimbang National Park (one record); Ghin-Doo-Ee National Park (one record); Goulburn River National Park (2 records); Jilliby State Conservation Area (one record); Killarney Nature Reserve (one record); Manobalai Nature Reserve (one record); Medowie State Conservation Area (4 records); Mount Royal National Park (4 records); Mummel Gulf National Park (2 records); Munghorn Gap Nature Reserve (one record); Myall Lakes National Park (7 records); Nowendoc National Park (one record); Tapin Tops National Park (3 records); The Cells State Conservation Area (one record); The Glen Nature Reserve (2 records); Tilligerry Nature Reserve (2 records); Tomaree National Park (2 records); Wallingat National Park (4 records); Watagans National Park (one record); Woko National Park (2 records); Wollemi National Park (4 records). A total of 76 records have been collated from habitat contained within these reserves with the database analysis indicating Barrington Tops National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Retain and protect stands of native vegetation, especially those with hollow-bearing trees.
- Retain hollow-bearing trees as well as large, mature trees that will provide hollows in the future.
- Limit the use of pesticides used in suitable native habitat.

Relevant Priority Actions for the locality

1. Encourage private landholders to undertake management options to conserve and/or actively manage forest owl habitat. (Medium priority)

2. Implement a regional monitoring program. This will be undertaken once owl habitat models have been refined, validated and sampling strategy developed. (Medium priority)

3. Monitor and report on effectiveness of concurrence and licence conditions previously applied to reduce impacts of development on Powerful Owls and their habitats, by recording conditions, picking case studies and checking owl presence post development. (Medium priority)

4. Seek an ARC Linkage Grant or other joint funding opportunity to initiate research into identified key areas of the biology and ecology of the three large forest owls. (Low priority)

5. Seek scholarship funds for an identified aboriginal student to investigate the cultural and historic significance of the Powerful Owl. (Low priority)

Gilbert's Whislter (*Pachycephala inornata*) (V)

Usually occurs in mallee, but also taller dry eucalypt woodland, melaleuca thickets, lignum, and partly cleared country (Blakers *et al* 1984; Lindsey 1992). Lives in pairs that defend permanent territories (Lindsey 1992). Forages mainly on the ground for large insects such as caterpillars and beetles (Blakers *et al* 1984; Lindsey 1992). Nests approximately 2-3 metres from the ground in a cup of bark and dry grass in an upright fork, on a dead stump, or occasionally in the disused nest of another bird (Lindsey 1992).

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

- Avoid burning mature mallee which provides valuable foraging habitat. Old growth mallee with intact shrub and litter layer is particularly important to protect from too-frequent fire.
- Identify and manage known and potential Gilbert's Whistler habitats, particularly those with an intact shrub understorey.
- Fence habitat and remove or reduce grazing pressure.

Relevant Priority Actions for the locality

1. Undertake spot monitoring surveys to determine continued presence at locations where the species has previously been found but not being comprehensively monitored. (High priority)

Brown Treecreeper (*Climacteris picumnus*) (V)

The Brown Treecreeper is a medium-sized insectivorous bird that occupies eucalypt woodlands, particularly open woodland lacking a dense understorey. It is sedentary and nests in tree hollows within permanent territories, breeding in pairs or communally in small groups. Birds forage on tree trunks and on the ground amongst leaf litter and on fallen logs for ants, beetles and larvae (Pizzey and Knight, 1997). The eastern subspecies of the Brown Treecreeper (*Climacteris picumnus victoriae*) is distributed through central NSW on the western side of the Great Dividing Range and sparsely scattered to the east of the Divide in drier areas such as the Cumberland Plain of Western Sydney, and in parts of the Hunter, Clarence, Richmond and Snowy River valleys (NSW Scientific Committee, 2001b).

The broad geographic range of the Brown Treecreeper has not changed but is now extinct in parts of its range. Declines in populations have been recorded from the Cumberland Plain, the New England Tablelands, the Inverell district, from Munghorn Gap Nature Reserve near Mudgee, and from travelling stock routes in the Parkes district (NSW Scientific Committee, 2001b). Reid (1999) identified the Brown Treecreeper as a 'decliner' in a review of bird species' status in the NSW sheep-wheatbelt. Habitat degradation, including loss of hollow bearing trees, threatens Brown Treecreeper populations. Grazing by stock in woodland areas leads to a decrease the diversity of ground-dwelling invertebrates decreasing the availability of food for the birds. In addition, Brown Treecreepers are likely to be threatened by such factors as increased competition with aggressive honeyeater species and increased levels of nest predation that are a consequence of fragmentation of habitat (NSW Scientific Committee, 2001b).

Regional Conservation Status

The Brown Treecreeper is known to occur within 9 conservation reserves of the Hunter Central Rivers Catchment management Area including: Ben Halls Gap National Park (one record); Durridgere CCA Zone 3 State Conservation Area (one record); Goulburn River National Park (26 records); Manobalai Nature Reserve (11 records); Munghorn Gap Nature Reserve (16 records); Werakata National Park (2 records); Wingen Maid Nature Reserve (one record); Wollemi National Park (82 records); Yengo National Park (one record). A total of 141 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Modify grazing management practices that will maintain or improve habitat values and still allow some grazing to occur at strategic times of the year.
- Do not allow further loss of dead standing or fallen timber from firewood collection or on-farm practices such as 'tidying up'; do not allow removal of hollow-bearing dead or living trees and stumps on private and public lands.
- Fencing of known habitat to protect natural features and to allow natural regeneration.

- Increase remnant size and connectivity through incentives and DEC threatened species extension services.

Relevant Priority Actions for the locality

1. Conduct ecological research to determine habitat and resource requirements, threats and conservation issues. (Low priority)

2. Identify key habitats or areas for protection and enhanced management through incentives. (High priority)

3. Implement sympathetic habitat management in conservation reserves, council reserves and crown reserves where the species occurs. (Low priority)

4. Undertake surveys for threatened woodland birds in new and existing conservation reserves containing suitable habitat to assess the species' conservation status and identify key breeding and foraging habitat. (Low priority)

Speckled Warbler (*Pyrrholaemus sagittatus*) (V)

The Speckled Warbler (*C. sagittatus*) inhabits woodlands with a grassy understorey, often on ridges or gullies. The species is sedentary, living in pairs or trios and nests on the ground in grass tussocks, dense litter and fallen branches. They forage on the ground and in the understorey for arthropods and seeds. Home ranges vary from 6-12 hectares. The preferred foraging habitat of Speckled Warbler (*C. sagittatus*) is areas with a combination of open grassy patches, leaf litter and shrub cover. This habitat is susceptible to degradation by stock and weed invasion. Nesting on the ground also makes them vulnerable to predation from exotic mammalian predators such as foxes and cats (NSW Scientific Committee, 2001a).

Regional Conservation Status

The Speckled Warbler is known to occur within 10 conservation reserves of the Hunter Central Rivers Catchment management Area including: Belford National Park (4 records); Durridgere CCA Zone 3 State Conservation Area (5 records); Goulburn River National Park (10 records); Manobalai Nature Reserve (6 records); Munghorn Gap Nature Reserve (3 records); Nowendoc National Park (one record); Werakata National Park (one record); Wingen Maid Nature Reserve (one record); Wollemi National Park (33 records); Yengo National Park (10 records). A total of 74 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Keep domestic dogs and cats indoors at night. Desex domestic dogs and cats. Assess the appropriateness of dog and cat ownership in new subdivisions.
- Undertake fox and feral cat control programs.
- NPWS should be consulted when planning development to minimise impact on populations.
- Retain dead timber on the ground in open woodland areas.
- Limit firewood collection.
- Retain existing vegetation along roadsides, in paddocks and remnant stands of native trees.
- Encourage regeneration of habitat by fencing remnant stands.
- Fence suitable woodland habitats, particularly those with unimproved pasture and an intact native ground plant layer.
- Increase the size of existing remnants, planting trees and establishing buffer zones of unimproved uncultivated pasture around woodland remnants.
- Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape.

- Report any new sightings of the speckled warbler to the Department of Environment and Conservation.

Relevant Priority Actions for the locality

1. Conduct ecological research to determine habitat and resource requirements, threats and conservation issues. (Low priority)

2. Identify key habitats or areas for protection and enhanced management through incentives. (High priority)

3. Implement sympathetic habitat management in conservation reserves, council reserves and crown reserves where the species occurs. (Low priority)

4. Undertake surveys for threatened woodland birds in new and existing conservation reserves containing suitable habitat to assess the species' conservation status and identify key breeding and foraging habitat. (Low priority)

Regent Honeyeater (*Anthochaera phrygia*) (E)

The Regent Honeyeater (*A. phrygia*) inhabits temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts in areas of low to moderate relief on the inland slopes of the Great Dividing Range. The species also visits coastal southern areas and the northern tablelands (Pizzey and Knight, 1997). The Regent Honeyeater is a highly nomadic, arboreal nectivore and insectivore that relies on an abundance of nectar sources. This species follows flowering cycles of Eucalyptus, particularly Red Ironbark (*E. sideroxylon*), White Box (*E. albens*), Yellow Box (*E. melliodora*), Yellow Gum (*E. leucoxylon*) and River Red Gum (*E. camaldulensis*) as well as the flowers of mistletoe growing on River She-oak (*Casuarina cunninghamiana*). On the NSW Central Coast, this species is known to feed on Swamp Mahogany (*E. robusta*), Spotted Gum (*C. maculata*) and Coastal Banksia (*Banksia integrifolia*).

Regional Conservation Status

The Regent Honeyeater is known to occur within 9 conservation reserves of the Hunter Central Rivers Catchment management Area including: Brisbane Water National Park (one record); Cockle Bay Nature Reserve (9 records); Goulburn River National Park (10 records); Munghorn Gap Nature Reserve (39 records); Myall Lakes National Park (one record); Wallingat National Park (one record); Werakata National Park (one record); Wollemi National Park (4 records); Yengo National Park (one record). A total of 67 records have been collated from habitat contained within these reserves with the database analysis indicating Munghorn Gap Nature Reserve as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Maintain a captive population of Regent Honeyeaters.
- Provide landholders and other community members with information on the ecology and conservation requirements of the Regent Honeyeater. Use incentives on private land to encourage landholders to manage key areas.
- Encourage landholders/agistees to remove stock from sensitive riparian breeding sites.
- No loss of mature key nectar tree species. Minimise the removal of mistletoes at key sites.
- Protect and enhance key breeding and foraging habitats.
- Encourage natural regeneration and increase the remnant size of known and potential Regent Honeyeater habitats.
- Continue treeplanting programs at key breeding and foraging locations.
- No further loss of known woodland and forest habitat throughout the range of the Regent Honeyeater from developments.

- Conduct research into habitat selection in non-breeding season and long-distance movements.
- Investigate impacts of interspecific competition for resources and nest predation by native birds.

Relevant Priority Actions for the locality

1. Conduct research into movement patterns of Regent Honeyeaters in the Hawkesbury-Nepean, Central West and Hunter – Central Rivers Catchments. (Medium priority)

2. Continue to assess the degree of movement between populations. (High priority)

3. Develop Regional/Local Plans. (High priority)

4. Ensure Regent Honeyeater habitat on Public Land is managed appropriately. (Medium priority)

5. Maintain captive exhibits. (High priority)

6. Participate in biannual Community Regent Honeyeater and Swift Parrot National Survey in preferred habitat. (Medium priority)

7. Promote awareness of the recovery efforts to the general community. (Medium priority)

8. Protect and enhance habitat containing ‘significant habitat’. (High priority)

9. Undertake on–ground habitat enhancement work in the Capertee Valley region of the Hawkesbury-Nepean, Central West and Hunter – Central Rivers Catchments. (High priority)

Black-chinned Honeyeater (*Melithreptus gularis gularis*) (V)

The eastern form of the Black-chinned Honeyeater (*Melithreptus gularis gularis*) is found predominantly west of the Great Dividing Range in a narrow belt through NSW into southern Queensland, and south into Victoria and South Australia where it occupies eucalypt woodlands within an approximate annual rainfall range of 400-700mm. In NSW, the species is mainly found in woodlands containing box-ironbark associations and River Red Gum. Black-chinned Honeyeaters are also known from drier coastal woodlands of the Cumberland Plain, Western Sydney and in the Hunter, Richmond and Clarence Valleys (NSW Scientific Committee, 2001c).

Regional Conservation Status

The Black-chinned Honeyeater is known to occur within 5 conservation reserves of the Hunter Central Rivers Catchment management Area including: Goulburn River National Park (5 records); Munghorn Gap Nature Reserve (7 records); Werakata National Park (15 records); Wollemi National Park (46 records); Yengo National Park (5 records). A total of 78 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Retain suitable woodland habitats, particularly those with unimproved pasture and an intact native ground plant layer.
- Increase the size and connectivity of existing remnants, planting trees and establishing buffer zones of unimproved uncultivated pasture around woodland remnants.

Relevant Priority Actions for the locality

1. Conduct ecological research to determine habitat and resource requirements, threats and conservation issues. (Medium priority)

2. Develop an Expression of Interest targeted towards private landowners to locate new sites and from this negotiate, develop and implement conservation management agreements. (Medium priority)

3. Identify key habitats or areas on a regional basis for protection and enhanced management through incentives. (High priority)

4. Implement sympathetic habitat management in conservation reserves, council reserves and crown reserves where the species occurs. (High priority)

5. Undertake surveys for threatened woodland birds in new and existing conservation reserves containing suitable habitat to assess the species' conservation status and identify key breeding and foraging habitat. (Medium priority)

Painted Honeyeater (*Grantiella picta*) (V)

The Painted Honeyeater (*Grantiella picta*) is a small nectivorous bird specialising in foraging on mistletoe. It largely occurs west of the Great Dividing Range and dry sub-coastal districts, with breeding occurring during November. Inhabits forest and woodland generally where there is an abundance of mistletoe (Blakers *et al* 1984; Lindsey 1992). Strongly migratory, breeding mainly in the interior southeast during spring and summer, and dispersing northward to spend the winter (Lindsey 1992).

Unusual amongst honeyeaters in its almost complete dependence upon berries or drupes of mistletoes of the *Amyema* genus (Lindsey 1992). Forages mainly in the upper canopy of trees. Nests in a frail dish suspended in the outer foliage of a bush or tree, from 3-10m above the ground (Lindsey 1992).Locally nomadic, with movements reportedly governed by the flowering and fruiting of mistletoes (Lindsey 1992; Blakers *et al* 1984).

Regional Conservation Status

The Painted Honeyeater is known to occur within 2 conservation reserves of the Hunter Central Rivers Catchment management Area including: Munghorn Gap Nature Reserve (8 records); Wollemi National Park (2 records). A total of 10 records have been collated from habitat contained within these reserves with the database analysis indicating Munghorn Gap Nature Reserve as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Manage grazing on sites where Painted Honeyeater habitat occurs.
- Encourage regeneration of habitat by fencing remnant stands and undertaking new plantings.
- Protect remnant woodland and open forest throughout the range of the species.
- Regenerate and replant local flora species to maintain breeding and foraging habitat.
- Conduct further research to increase understanding of habitat selection and nomadic movements of the Painted Honeyeater.

Relevant Priority Actions for the locality

1. Encourage and undertake studies to determine the species habitat and resource requirements. (High priority)

2. Encourage retention of natural densities of mistletoes, particularly *Amyema* sp. (High priority)

3. Promote sustainable grazing of habitat patches. (Medium priority)

4. Restore habitat in agriculturally-productive areas. (Medium priority)

Hooded Robin (*Melanodryas cucullata*) (V)

The Hooded Robin (*Melanodryas cucullata*) is distributed throughout south-eastern Australia, from Central Queensland, to Spencer Gulf, South Australia. The threatened form of the Hooded Robin occurs throughout NSW except for the north-west of the State where it inter-grades with the smaller northern form of the Hooded Robin. It occupies Eucalypt woodlands, Acacia shrublands and open forests. In temperate woodlands, the species favours open areas adjoining large woodland blocks, with areas of dead timber and sparse shrub cover. In semi-arid western NSW, the species favours open woodlands of Belah, Rosewood, Mulga and Cypress. Hooded Robins live in small family groups of pairs or trios, and build cup-shaped nests. Home ranges are relatively large averaging 18 ha for birds from the New England Tableland. The species feeds on the ground by pouncing on insects, and forages in areas with a mix of bare ground, ground cover and litter (NSW Scientific Committee, 2001d).

Regional Conservation Status

The Hooded Robin is known to occur within 7 conservation reserves of the Hunter Central Rivers Catchment management Area including: Crowdy Bay National Park (one record); Goulburn River National Park (2 records); Karuah Nature Reserve (one record); Munghorn Gap Nature Reserve (4 records); Myall Lakes National Park (one record); Werakata National Park (one record); Wollemi National Park (one record). A total of 11 records have been collated from habitat contained within these reserves with the database analysis indicating Munghorn Gap Nature Reserve as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Retain dead timber on the ground in open woodland areas.
- Enhance potential habitat through regeneration by reducing the intensity and duration of grazing.
- Fence habitat to protect from long-term, intense grazing.
- Increase the size of existing remnants, by planting trees and establishing buffer zones of un-modified, uncultivated pasture around woodland remnants.

Relevant Priority Actions for the locality

1. Conduct ecological research to determine habitat and resource requirements, threats and conservation issues. (Medium priority)

2. Develop habitat identification, management and enhancement guidelines for woodland birds. (High priority)

3. Identify key habitats or areas on a regional basis for protection and enhanced management through incentives. (High priority)

4. Undertake surveys for threatened woodland birds in new and existing conservation reserves containing suitable habitat to assess the species' conservation status and identify key breeding and foraging habitat. (Medium priority)

Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) (V)

The Grey-crowned Babbler (*P. temporalis*) is a species that lives and breeds in a highly co-ordinated group. Groups generally consist of a pair of breeding adults, which are accompanied by sub-adults or offspring ranging from 5-12 individuals, with some groups containing as many as 16 during excellent breeding conditions (Mark Aitkens, pers. obs.). Groups often forage and breed within a territory up to 12 ha in area, and often interact with adjoining groups during territory battles. Foraging activity ranges from ground rummaging to active searches of tree bark and branches. Aerial prey is also readily targeted during foraging activities, however their ability to collect such items is regarded as poor (Frith, 1982). Overnight roosting occurs within two nest types including breeding and dormitory style structures, with their relative usage dependant on the time of year. Breeding is most often during the spring period, immediately or soon after significant rainfall, with autumn breeding less frequent and only apparent during particularly good seasons. Breeding success is considered poor, with larger groups often more successful than smaller ones. Accordingly, it is apparent that Grey-crowned Babblers (*P. temporalis*) are a long-lived species, relying on continued breeding attempts by life-long breeding partners rather than successful short breeding life cycles (Frith, 1982).

Regional Conservation Status

The Grey-crowned Babbler is known to occur within 7 conservation reserves of the Hunter Central Rivers Catchment management Area including: Belford National Park (2 records); Goulburn River National Park (3 records); Munghorn Gap Nature Reserve (one record); Wallaroo Nature Reserve (one record); Werakata National Park (3 records); Wollemi National Park (3 records); Yengo National Park (one record). A total of 14 records have been collated from habitat contained within these reserves with the database analysis indicating both Wollemi National Park and Werakata National Park as potential strongholds or areas of importance for this species.

Focus of Recovery Effort

- Retain existing woodland vegetation.
- Retain dead timber on the ground in open woodland areas.
- Encourage regeneration of habitat by fencing remnant stands.
- Increase the size of existing remnants, planting trees and establishing buffer zones of unimproved uncultivated pasture around woodland remnants.

Relevant Priority Actions for the locality

1. Conduct ecological research to determine habitat and resource requirements, threats and conservation issues. (Medium priority)

2. Identify key habitats or areas for protection and enhanced management through management agreements and incentives. (High priority)

3. Undertake surveys for threatened woodland birds in new and existing conservation reserves containing suitable habitat to assess the species' conservation status and identify key breeding and foraging habitat. (Low priority)

Diamond Firetail (*Stagonopleura guttata*) (V)

The Diamond Firetail (*Stagonopleura guttata*) is a brightly coloured finch that occupies eucalypt woodlands, forests and mallee where there is a grassy understorey. Firetails build bottle-shaped nests in trees and bushes, and forage on the ground, largely for grass seeds and other plant material, but also for insects (Frith, 1982). This species is distributed through central and eastern NSW, extending north into southern and central Queensland and south through Victoria to the Eyre Peninsula, South Australia. In NSW, the species occurs predominantly west of the Great Dividing Range, although populations are known from drier coastal areas such as the Cumberland Plain of western Sydney and the Hunter, Clarence, Richmond and Snowy River valleys (NSW Scientific Committee, 2001e).

The Diamond Firetail is threatened by habitat clearing and fragmentation. Isolation and reductions in the size of vegetation remnants inhibits dispersal and increase their vulnerability to local extinction via stochastic events. Small, isolated populations also lose their long-term genetic viability (NSW Scientific Committee, 2001e). Further, Diamond Firetail populations appear unable to persist in areas that lack remnants of native vegetation larger than 200 ha. Habitat degradation, particularly overgrazing of the grass understorey, threatens the granivorous Diamond Firetail. In addition, an increased abundance of predators such as Pied Currawongs and Australian Ravens may increase nest predation in fragmented woodland remnants (NSW Scientific Committee, 2001e).

Regional Conservation Status

The Diamond Firetail is known to occur within 4 conservation reserves of the Hunter Central Rivers Catchment management Area including: Goulburn River National Park (3 records); Munghorn Gap Nature Reserve (6 records); Tuggolo Creek Nature Reserve (one record); Wollemi National Park (16 records). A total of 26 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Search for the species in suitable habitat in areas that are proposed for development or management actions.
- Retain dead timber on the ground in open woodland areas.
- Reduce heavy grazing by domestic stock in areas of known or potential habitat, to enable flowering and subsequent seeding of grasses and forbs that this species requires.

- Control weeds in areas of known habitat, especially the exotic, winter-fruiting shrubs such as cotoneasters, hawthorns, direct horns and privets that support Pied Currawongs.
- Retain and protect woodland, open forest, grassland and mallee habitat from clearing, fragmentation and disturbance; areas of 200 hectares or greater within woody vegetation are particularly significant, though this species also uses treeless grasslands in the Southern Tablelands.
- Expand and reconnect smaller fragments of habitat, by fencing and encouraging natural regeneration or applying revegetation techniques where regeneration fails.
- Ensure remnant populations remain connected or linked to each other; in cases where remnants have lost connective links, re-establish links by revegetating sites to act as stepping stones for dispersal.
- Mark sites onto maps or plans.

Relevant Priority Actions for the locality

1. Conduct ecological research to determine habitat and resource requirements, threats and conservation issues. (Medium priority)

2. Identify key habitats or areas for protection and enhanced management through management agreements and incentives. (High priority)

3. Undertake surveys for threatened woodland birds in new and existing conservation reserves containing suitable habitat to assess the species' conservation status and identify key breeding and foraging habitat. (Low priority)

Spotted-tailed Quoll (*Dasyurus maculatus*) (E)

The Spotted-tailed Quoll (*D. maculata*) inhabits a variety of habitats including dry to moist open forests or closed forests containing rock caves, hollow logs or trees for shelter / breeding. Populations of the Spotted-tailed Quoll (*D. maculata*) are very sensitive to changes in the predator-prey relationship of their chosen environment (Catling and Burt, 1995). An area containing an abundant source of medium sized mammals (0.2-6.0 kg) is likely to indicate that the given area may contain the Spotted-tailed Quoll (*D. maculata*) and not the European Red Fox (*V. vulpes*). Conversely, the opposite relationship is true, with a low abundance of medium sized mammals indicating the absence of the Spotted-tailed Quoll (*D. maculata*) due to the predatory influence of the European Fox (*V. vulpes*) (Catling and Burt, 1995).

Regional Conservation Status

The Spotted-tailed Quoll is known to occur within 27 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (24 records); Barrington Tops State Conservation Area (7 records); Belford National Park (2 records); Ben Halls Gap National Park (one record); Boorganna Nature Reserve (one record); Bouddi National Park (2 records); Brisbane Water National Park (17 records); Coorabakh National Park (one record); Copeland Tops State Conservation Area (6 records); Cottan-Bimbang National Park (6 records); Curracabundi National Park (5 records); Killarney Nature Reserve (one record); Monkeycot Nature Reserve (one record); Mount Royal National Park (20 records); Mummel Gulf National Park (one record); Myall Lakes National Park (14 records); Nowendoc National Park (80 records); Talawahl Nature Reserve (2 records); Tapin Tops National Park (7 records); The Cells State Conservation Area (2 records); The Glen Nature Reserve (2 records); Tomalla Nature Reserve (4 records); Tomaree National Park (one record); Wallaroo Nature Reserve (2 records); Watagans National Park (one record); Wollemi National Park (5 records); Yengo National Park (2 records). A total of 217 records have been collated from habitat contained within these reserves with the database analysis indicating Nowendoc National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Loss, fragmentation and degradation of habitat.

- Accidental poisoning during wild dog and fox control programs. Deliberate poisoning, shooting and trapping may also be an issue.
- Competition with introduced predators such as cats and foxes.

Relevant Priority Actions for the locality

None relevant.

Koala (*Phascolarctos cinereus*) (V)

The Koala (*Phascolarctos cinereus*) has a fragmented distribution from Townsville area in Queensland to southern Victoria, with isolated populations in southeastern South Australia and is widely distributed on either side of the Great Dividing Range. It is a large tree dwelling mammal that is a specialist feeder on a small selection of Eucalyptus trees. SEPP 44 lists a total of ten species statewide on which Koalas are reliant for food. At least 55 species of Eucalyptus and 11 non-Eucalypts are known foraging resources of the Koala. Population densities are typically much less than 10 per hectare. Habitat for the Koala is particularly sensitive to disturbances such as land clearing, logging, habitat fragmentation, predation by dogs and repetitive fire regimes.

Regional Conservation Status

The Koala is known to occur within 47 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barakee National Park (one record); Barrington Tops National Park (21 records); Ben Halls Gap National Park (2 records); Black Bulga State Conservation Area (one record); Booti Booti National Park (3 records); Brisbane Water National Park (65 records); Copeland Tops State Conservation Area (7 records); Cottan-Bimbang National Park (one record); Crowdy Bay National Park (one record); Curracabundi National Park (6 records); Darawank Nature Reserve (one record); Ghin-Doo-Ee National Park (6 records); Goonook Nature Reserve (3 records); Goulburn River National Park (one record); Jilliby State Conservation Area (6 records); Karuah Nature Reserve (15 records); Karuah State Conservation Area (one record); Khappinghat Nature Reserve (2 records); Killabakh Nature Reserve (one record); Killarney Nature Reserve (one record); Kooragang Nature Reserve (one record); Lake Macquarie State Conservation Area (one record); Manobalai Nature Reserve (2 records); Medowie State Conservation Area (8 records); Moffats Swamp Nature Reserve (3 records); Monkerai Nature Reserve (one record); Mount Royal National Park (7 records); Mummel Gulf National Park (one record); Munghorn Gap Nature Reserve (3 records); Myall Lakes National Park (40 records); Nowendoc National Park (3 records); Pulbah Island Nature Reserve (3 records); Talawahl Nature Reserve (one record); Tapin Tops National Park (17 records); The Cells State Conservation Area (3 records); The Glen Nature Reserve (2 records); Tilligerry Nature Reserve (33 records); Tomaree National Park (61 records); Wallaroo Nature Reserve (5 records); Wallingat National Park (12 records); Watagans National Park (one record); Watchimbark Nature Reserve (one record); Werakata National Park (one record); Woko National Park (one record); Wollemi National Park (7 records); Worimi Nature Reserve (4 records); Yengo National Park (48 records). A total of 415 records have been collated from habitat contained within these reserves with the database analysis indicating Yengo National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Undertake feral predator control.
- Apply low intensity, mosaic pattern fuel reduction burns in or adjacent to Koala habitat.
- Retain suitable habitat, especially areas dominated by preferred feed-tree species.
- Protect populations close to urban areas from attacks by domestic dogs.
- Identify road-kill blackspots and erect warning signs, reduce speed limits or provide safe crossing points to reduce Koala fatalities.
- Revegetate with suitable feed tree species and develop habitat corridors between populations.

Relevant Priority Actions for the locality

1. Identify small and isolated koala populations at risk of extinction, develop strategies for active management, monitoring and conservation and approach key stakeholders to negotiate conservation outcomes. (High priority)

2. Survey the northern, central and southern tablelands of NSW to determine primary and secondary food tree species and assess the status of koala populations in these areas. (High priority)

Squirrel Glider (*Petaurus norfolcensis*) (V)

The Squirrel Glider (*P. norfolcensis*) inhabits the drier sclerophyll forest and woodlands of southeastern Australia and is generally absent from the wetter coastal forests. This species usually occurs in biologically diverse woodlands and forests on moderately fertile soils below 600 m above sea level, particularly where there is high nectar-producing eucalypts and flowering shrubs. This species often feeds on nectar, pollen, eucalypt sap, Acacia gum and arthropods. Banksia, Xanthorrhea and Acacia also provide important food resources (Strahan, 1998). This species requires trees with hollows for nests and den sites. On the NSW Central Coast, the Squirrel Glider is most abundant in woodlands and forests with winter flowering eucalypts (i.e. Spotted Gum, Forest Redgum) and understorey with Banksia (*Banksia spinulosa*) and Wattle (*Acacia irrorata*). The highest densities recorded in this region were in woodlands dominated by Scribbly Gum (*Eucalyptus haemastoma*), Smooth-barked Apple (*Angophora costata*) and Red Bloodwood (*Corymbia maculata*) with banksia and xanthhorrohea understorey (Smith and Murray, 2003).

Regional Conservation Status

The Squirrel Glider is known to occur within 21 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops State Conservation Area (one record); Ben Halls Gap National Park (one record); Booti Booti National Park (5 records); Bouddi National Park (2 records); Brisbane Water National Park (one record); Coolah Tops National Park (5 records); Goulburn River National Park (one record); Karuah Nature Reserve (3 records); Khappinghat Nature Reserve (one record); Lake Macquarie State Conservation Area (3 records); Medowie State Conservation Area (3 records); Mount Royal National Park (one record); Munmorah State Conservation Area (3 records); Myall Lakes National Park (one record); Tilligerry Nature Reserve (2 records); Tomaree National Park (4 records); Wallarah National Park (one record); Werakata National Park (7 records); Wollemi National Park (15 records); Wyrrabalong National Park (4 records); Yengo National Park (4 records). A total of 68 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Retain den trees and recruitment trees (future hollow-bearing trees).
- Retain food resources, particularly sap-feeding trees and understorey feed species such as Acacias and banksias.
- Replace top one or two strands of barbed wire on fences with regular wire in and adjacent to habitat.
- Retain and protect areas of habitat, particularly mature or old growth forest containing hollow-bearing trees and sap-feeding trees.
- In urban and rural areas retain and rehabilitate habitat to maintain or increase the total area of habitat available, reduce edge effects, minimise foraging distances and increase the types of resources available.

Relevant Priority Actions for the locality

1. Conduct surveys and assessments of less known sites to confirm presence of species and negotiate, develop and implement conservation management agreements for high priority sites. (High priority)

2. Ensure the largest hollow bearing trees (including dead trees) are given highest priority for retention in PVP assessments and other environmental planning instruments, or other land assessment tools. (Medium priority)

Brush-tailed Rock-wallaby (*Petrogale penicillata*) (E)

The Brush-tailed Rock Wallaby (*Petrogale penicillata*) is a highly agile and distinctively marked medium-sized wallaby, which occupies rocky habitats. Habitats occupied by this species tend to take one of three forms: loose piles of large boulders containing a maze of subterranean holes and passageways; cliffs (usually over 15m high) with many mid-level ledges and with some caves and/or ledges covered by overhangs; and isolated rock stacks, usually sheer-sided and often girdled with fallen boulders (Short 1982). These habitats are likely to be a subset of those occupied by the species prior to European settlement, and may represent refuge sites in which competition and predation pressures are reduced. Vegetation forms a vital habitat component (especially in refuge sites in association with rock outcrops), but its importance has been largely overlooked in many areas.

Regional Conservation Status

The Brush-tailed Phascogale is known to occur within 10 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (5 records); Black Bulga State Conservation Area (one record); Copeland Tops State Conservation Area (one record); Cottan-Bimbang National Park (one record); Khappinghat Nature Reserve (3 records); Killarney Nature Reserve (one record); Mount Royal National Park (one record); Talawahl Nature Reserve (2 records); Tilligerry Nature Reserve (one record); Wallaroo Nature Reserve (one record). A total of 17 records have been collated from habitat contained within these reserves with the database analysis indicating Barrington Tops National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Raise landowners' awareness about the presence of Brush-tailed Rock-wallabies and provide information to assist in their management.
- Undertake feral predator control around colony sites.
- Undertake feral goat control around colony sites.
- Retain rocky habitat and adjacent open forest or grassland areas.
- Retain habitat corridors between colony sites.
- Protect colony sites from human interference or disturbance.

Relevant Priority Actions for the locality

None relevant.

Large-eared Pied Bat (*Chalinolobus dwyeri*) (V)

The Large-eared Pied Bat (*Chalinolobus dwyeri*) has a restricted distribution from south central Queensland to central and northern NSW and is localised and uncommon throughout its range, occurring in Rainforest, wet sclerophyll forest to dry sclerophyll forest and woodland habitats (Churchill, 1998). It has been recorded in the Richmond and Nightcap Ranges and near Singleton (NPWS, 2003). Strahan (1998) indicates a more extended range, with recordings from Rockhampton in central coastal Queensland to Bungonia in southern NSW.

Regional Conservation Status

The Large-eared Pied Bat is known to occur within 8 conservation reserves of the Hunter Central Rivers Catchment management Area including: Bouddi National Park (one record); Coolah Tops National Park (one record); Goulburn River National Park (10 records); Manobalai Nature Reserve (3 records); Munghorn Gap Nature Reserve (one record); Watagans National Park (one record); Wollemi National Park (44 records); Yengo National Park (20 records). A total of 81 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Protect known and potential habitat from burning at too-frequent intervals.
- Avoid damage to known roosting and maternity sites from mining activities, and from recreational caving by contacting the DEC prior to activities.
- Reduce the use of pesticides and consider alternatives where available.
- Protect known and potential forest and woodland habitat around cliffs, rock overhangs and old mine workings from clearing and isolation.

Relevant Priority Actions for the locality

1. Control feral goats in rock overhangs and caves in the species range. (Medium priority)

2. Determine location and attributes of maternity sites and restrict access where possible. (e.g. signage; bat-friendly, preferably external, gating of caves). (High priority)

3. Ensure protection of caves and overhangs in area of suitable geology when undertaking PVP assessments (offsets should include nearby remnants in high productivity) or other land assessment tools. (High priority)

4. Identify and protect roost habitat artificial structures (e.g. culverts, old buildings and derelict mines). (High priority)

5. Identify important foraging range and key habitat components for this species. (Medium priority)

6. Identify the effects of fragmentation on the species in a range of fragmented landscapes such as the farmland/forest interface. For example movement and persistence across a range of fragment sizes. (High priority)

7. Implement key threat abatement actions for longwall mining. (High priority)

8. Promote bats throughout the rural community as ecologically interesting and important, but sensitive to disturbance at caves/overhangs. (High priority)

9. Study the ecology, habitat requirements and population dynamics. (Medium priority)

10. Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes. (High priority)

Little Pied Bat (*Chalinolobus picatus*) (V)

The Little Pied bat (*C. picatus*) inhabits dry areas of southern Qld, NSW and SA. Very little is known about this species (Richards 1995c). It roosts in tree-hollows, dry caves and mine shafts, but has also been recorded in an abandoned house (DEC NRMAS-7 2004; Richards 1995c). Capable of dealing with aridity and heat, provided water is available within flight range (Richards 1995c).

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area. However, this species has been recorded in Munghorn Gap Nature Reserve with the current status of this population unknown.

Focus of Recovery Effort

- Control feral cats.
- Minimise the use of pesticides within or adjacent to areas where insectivorous bats occur.
- Retain foraging and roosting habitat.

Relevant Priority Actions for the locality

1. Develop and promote State-wide bat awareness programs for schools, CMAs, landholders and industry groups etc. (Low priority)

2. Identify areas of private land that contain high densities of trees with hollows and dead standing trees as areas of high conservation value for planning and land management instruments. (High priority)

3. Identify the effects of fragmentation on the species in a range of fragmented landscapes. (For example from cropping & cotton areas, grazing lands of high and low intensity to large remnants). (High priority)

4. Promote the conservation of these areas private land areas with key habitat values using measures such as incentive funding to landholders, off-setting and biobanking, acquisition for reserve establishment or other means. (High priority)

5. Research the degree of long-term fidelity to roost trees and roosting areas in order to assess their importance and the effects of their removal. (High priority)

6. Research the effectiveness of rehabilitation measures intended to increase bat populations in degraded landscapes, such as revegetating and installing bat boxes. (Low priority)

7. Research the roosting ecology of tree-roosting bats. For example identifying the attributes of key roosts. (High priority)

8. Study the ecology and habitat requirements in different western environments such as mallee, mulga, "invasive native scrub" and ironbark-cypress forest. (High priority)

9. Study the species biology such as reproductive capacity, longevity, mortality rate and life history, or thermal and energy requirements to better determine capacity to respond to changes in climate or recover from losses in the population. (Medium priority)

10. Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes. (High priority)

Eastern Freetail Bat (*Mormopterus norfolkensis*) (V)

The Eastern Free-tail Bat (*M. norfolkensis*) is known to frequent a variety of habitats including sclerophyll forests and woodlands. It has been recorded in a variety of forest types ranging from rainforest to dry-hardwood forest (Strahan, 1998). The Eastern Free-tail Bat (*M. norfolkensis*) hunts insects above the forest canopy or in clearings. It is known to roost in tree hollows, under loose bark and in houses and outbuildings (Churchill, 1998). Strahan (1998) indicates this species tends to be predominantly tree hollow dependant.

Regional Conservation Status

The Eastern Freetail-bat is known to occur within 9 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (one record); Belford National Park (2 records); Booti Booti National Park (one record); Lake Macquarie State Conservation Area (one record); Manobalai Nature Reserve (one record); Tomaree National Park (one record); Werakata National Park (one record); Wollemi National Park (2 records); Yengo National Park (3 records). A total of 13 records have been collated from habitat contained within these reserves with the database analysis indicating Yengo National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Loss of hollow-bearing trees.
- Loss of foraging habitat.
- Application of pesticides in or adjacent to foraging areas.

Relevant Priority Actions for the locality

1. Develop and promote State-wide bat awareness programs for schools, CMAs, landholders and industry groups etc. (Medium priority)

2. Identify areas of private land that contain high densities of large hollow-bearing trees as areas of high conservation value planning instruments and land management negotiations e.g. LEP, CAPs, PVPs. (High priority)

3. Identify important foraging range and key habitat components for this species. (Medium priority)

4. Identify the effects of fragmentation in a range of fragmented landscapes i.e. the farmland/forest interface and the urban/forest interface e.g. movement and persistence across a range of fragment sizes. (High priority)

5. Promote the conservation of these private land areas using measures such as incentive funding to landholders, off-setting and biobanking, acquisition for reserve establishment or other means. (High priority)

6. Research the degree of long-term fidelity to roost trees and roosting areas in order to assess their importance and the effects of their removal. (High priority)

7. Research the effectiveness of rehabilitation measures intended to increase bat populations in degraded landscapes, such as revegetating and installing bat boxes. (Medium priority)

8. Research the roosting ecology of tree-roosting bats. For example identifying the attributes of key roosts. (High priority)

9. Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes. (Medium priority)

Eastern Bentwing Bat (*Miniopterus schreibersii*) (V)

The Eastern Bentwing Bat (*M. scheibersii*) has been recorded in rainforest, wet and dry sclerophyll forest, and woodland (Strahan, 1998). Core habitat is restricted to a relatively small number of caves that are used for breeding. This species feeds on small insects at night above and beneath the canopy of well-timbered valleys (Strahan, 1998).

Regional Conservation Status

The Eastern Bentwing Bat is known to occur within 21 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops National Park (4 records); Belford National Park (2 records); Booti Booti National Park (one record); Bouddi National Park (16 records); Brisbane Water National Park (2 records); Cockle Bay Nature Reserve (5 records); Ghin-Doo-Ee National Park (one record); Goulburn River National Park (one record); Killabakh Nature Reserve (one record); Lake Macquarie State Conservation Area (2 records); Manobalai Nature Reserve (one record); Munghorn Gap Nature Reserve (one record); Myall Lakes National Park (5 records); Nowendoc National Park (one record); Talawahl Nature Reserve (one record); Wallaroo Nature Reserve (one record); Wamberal Lagoon Nature Reserve (one record); Werakata National Park (one record); Wollemi National Park (53 records); Wyrrabalong National Park (6 records); Yengo National Park (8 records). A total of 114 records have been collated from habitat contained within these reserves with the database analysis indicating Wollemi National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Damage to or disturbance of roosting caves, particularly during winter or breeding.
- Loss of foraging habitat.
- Application of pesticides in or adjacent to foraging areas.
- Predation by feral cats and foxes.

Relevant Priority Actions for the locality

1. Promote the conservation of these key roost areas using measures such as incentive funding to landholders, offseting and biobanking, acquisition for reserve establishment or other means. (Medium priority)

2. Establish a gating design for disused mines across species range that will not adversely impact species. Consultation with cave bat specialist prior to any gating operations. (Medium priority)

3. For roost caves vulnerable to human disturbance, monitor their visitation by people, particularly during winter and spring/summer maternity season and in school holidays. (Low priority)

4. Monitor the breeding success of a representative sample of maternity colonies in cave roosts over a number of years to determine the viability of regional populations. (High priority)

5. Promote bats throughout the rural community as ecologically interesting and important, but sensitive to disturbance at caves/disused mine tunnels. (Medium priority)

6. Research to identify important foraging range and key habitat components around significant roosts. (Medium priority)

7. Restrict access where possible to known maternity sites. (e.g.: signs; bat-friendly, preferably external gates at caves). (Low priority)

8. Search for significant roost sites and restrict access where possible (e.g. gating of caves). Significant includes maternity, hibernation and transient sites including in artificial structures. (Medium priority)

Large-footed Myotis (*Myotis adversus*) (V)

The Large-footed Myotis (*M. adversus*) inhabits a range of habitats from rainforests to sclerophyll forests in close proximity to creeks and lakes over which it forages for aquatic insects and small fish (Churchill, 1998). This species is known to roost in caves, mines and tunnels with tree hollow roosts recorded throughout it southern range (Menkhorst and Knight, 2001).

Regional Conservation Status

The Large-footed Myotis is known to occur within 5 conservation reserves of the Hunter Central Rivers Catchment management Area including: Belford National Park (2 records); Booti Booti National Park (one record); Mummel Gulf National Park (3 records); Nowendoc National Park (4 records); Wyrrabalong National Park (2 records). A total of 12 records have been collated from habitat contained within these reserves with the database analysis indicating Nowendoc National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Retain native vegetation along streams and rivers and around other waterbodies.
- Minimise the use of pesticides adjacent to foraging areas.
- Protect roosts from damage or disturbance.

Relevant Priority Actions for the locality

1. Encourage recovery of natural hydrological regimes, including retention and rehabilitation of riparian vegetation. (Medium priority)

2. Promote roosting habitat in new artificial structures within the species range. (Medium priority).

Eastern Long-eared Bat (*Nyctophilus timoriensis*) (V)

On the mainland, the Eastern Long-eared Bat (*N. timoriensis*) has been found in mostly semi-arid areas characterised by mallee, open savanna and Black Box communities (Churchill, 1998). In the Ulan district, the Eastern Long-eared Bat (*N. timoriensis*) has been caught in old growth Inland Scribbly Gum (*E. rossii*) and Blakely's Redgum (*E. blakelyi*) woodland of limited shrub understorey and numerous tree hollows (pers obs Mark Aitkens, 2005). This species appears to roost in tree hollows, fissures in branches and flaking bark (Churchill, 1998).

Regional Conservation Status

The Eastern Long-eared Bat is known to occur within 4 conservation reserves of the Hunter Central Rivers Catchment management Area including: Ben Halls Gap National Park (one record); Goulburn River National Park (10 records); Manobalai Nature Reserve (one record); Wollemi National Park (4 records). A total of 16 records have been collated from habitat contained within these reserves with the database analysis indicating Goulburn River National Park as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Retain remnant woodland and mallee vegetation.
- Retain hollow-bearing trees and provide for hollow tree recruitment.
- Minimise the use of pesticides in and adjacent to foraging areas.
- Protect roosts from damage or disturbance.

Relevant Priority Actions for the locality

1. Conduct surveys in preferred and potential habitat throughout the species range. (High priority)

2. Develop and promote a State-wide bat awareness programs for schools, CMAs, landholders and industry groups etc. (Medium priority)

3. Develop hazard reduction fire management regimes to protect foraging habitat. (High priority)

4. Encourage retention of the largest hollow bearing trees. (High priority)

5. Encourage the protection and enhancement of understorey vegetation. (Medium priority)

6. Identify areas of private land containing high densities of large, hollow-bearing trees (i.e. near to natural densities) as areas of high conservation value for this species. (Medium priority)

7. Research the degree of long-term fidelity to roost trees and roosting areas in order to assess their importance and the effects of their removal. (High priority)

8. Research the effectiveness of rehabilitation measures such as revegetating and installing bat boxes in degraded landscapes to increasing local bat populations. (Low priority)

9. Research the impacts of different fire regimes. (High priority)

10. Research the roosting ecology of this species. For example, to identify the attributes of key roosts. . (High priority)

11. Research using radio-tracking the foraging range and habitat, and other key habitat components. (High priority)

12. Study the biology, ecology and habitat requirements of the species in different western environments, such as mallee and ironbark-cypress forest. (Medium priority)

13. Undertake long-term monitoring of populations across tenures. (Medium priority)

Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) (V)

The Yellow-bellied Sheath-tailed Bat (*Saccolaimus flaviventris*) is known from relatively few, dispersed sites where it inhabits rainforests, sclerophyll forests and woodlands. This species has been noted to forage and breed throughout these habitats where suitable tree hollows are available for roosting (Churchill, 1998).

Regional Conservation Status

The Yellow-bellied Sheathtail-bat is known to occur within 5 conservation reserves of the Hunter Central Rivers Catchment management Area including: Barrington Tops State Conservation Area (one record); Booti Booti National Park (one record); Jilliby State Conservation Area (one record); Manobalai Nature Reserve (2 records); Wollemi National Park (one record). A total of 6 records have been collated from habitat contained within these reserves with the database analysis indicating Manobalai Nature Reserve as a potential stronghold or area of importance for this species.

Focus of Recovery Effort

- Raise landowners' awareness about the presence of the species and provide information on how their management actions will affect the species' survival.
- Conduct searches for the species in suitable habitat in proposed development areas.
- DEC should be consulted when planning development/s to minimise impact/s on populations.
- Retain stands of native vegetation, especially those with hollow-bearing trees (including dead trees), and retain other structures containing bats.
- Retain a buffer of vegetation around roost sites in vegetated areas.
- Protect hollow-bearing trees for breeding sites, including those on farmland; younger mature trees should also be retained to provide replacements for the older trees as they die and fall over.
- Reduce the use of pesticides in the environment.
- Encourage regeneration and replanting of local flora species to maintain bat foraging habitat.
- Assess the site's importance to the species' survival, including linkages provided between ecological resources across the broader landscape.
- Mark known sites and potential habitat onto maps used for planned poison-spraying activities.

Relevant Priority Actions for the locality

1. Develop and promote State-wide bat awareness programs for schools, CMAs, landholders and industry groups etc. (Medium priority)

2. Establish a community program to encourage the reporting of roost trees. (Medium priority)

3. Identify areas of private land that contain high densities of large, hollow-bearing trees as areas of high conservation value planning instruments and land management negotiations e.g. LEP, CAPs, PVPs. (High priority)

4. Identify the effects of fragmentation on the species in a range of fragmented landscapes. . (Low priority)

5. Research the degree of long-term fidelity to roost trees and roosting areas in order to assess their importance and the effects of their removal. (High priority)

6. Research the effectiveness of rehabilitation measures intended to increase bat populations in degraded landscapes, such as revegetating and installing bat boxes. (Low priority)

7. Research the roosting ecology of tree-roosting bats. For example identifying the attributes of key roosts. (High priority)

8. Study the ecology, habitat requirements and susceptibility to logging and other forestry practices of this little-known species. (Low priority)

9. Undertake long-term monitoring of populations cross tenure in conjunction with other bat species to document changes. (Medium priority)

10. Use radio-tracking to identify important foraging range and help interpret density of records. (High priority)

Endangered Populations

Weeping Myall (*Acacia pendula*) of the Hunter River Catchment (EP)

The endangered population of Weeping Myall (*Acacia pendula*) consists of a disjunct population of fewer than 1000 individuals within the Hunter River catchment at its eastern limit of distribution. It is a spreading tall shrub of 5-13 m in height with weeping habit. Leaves are sickle shaped and coloured a light blue-green. The extent of this population within the Hunter Catchment is restricted to 15 sites west from Muswellbrook and east from Sandy Hollow.

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

None listed.

Relevant Priority Actions listed for this Endangered Population

None listed.

Tiger Orchid (*Cymbidium canaliculatum*) of the Hunter River Catchment (EP)

Cymbidium canaliculatum is a large epiphytic orchid, commonly named the Tiger Orchid (Harden 1993), having a scattered distribution in northern and eastern Australia from northeast NSW, through Queensland and the Northern Territory to Western Australia (Harden 1993). In NSW it occurs within dry sclerophyll forests and woodlands of tablelands and western slopes, growing in hollows of trees (Bishop 1996, Harden 1993).

The Hunter Catchment population of *C. canaliculatum* refers to all plants of *C. canaliculatum* occurring within the Hunter Catchment, as defined by Australia's River Basins (Geoscience Australia 1997). The Hunter Catchment includes the local government areas of Cessnock, Maitland, Dungog, Singleton, Muswellbrook, Newcastle, Port Stephens, part of Mid-Western Regional and Upper Hunter Councils' local government areas.

Within the Hunter Catchment, *C. canaliculatum* is most commonly found in *Eucalyptus albens* (white box)-dominated woodlands, usually occurring singly or as a single clump, typically between two and six metres above the ground. It has been found, less commonly, to grow on *E. dawsonii* (slaty box), *E. crebra* (narrow-leaved ironbark), *E. moluccana* (grey box), *Angophora floribunda* (rough-barked apple), *Acacia salicina* (cooba) and on some other species (NSW Scientific Committee, 2006)

Regional Conservation Status

There are no recent records of this species within the conservation reserve network of the Hunter Central Rivers catchment management area.

Focus of Recovery Effort

None listed.

Relevant Priority Actions listed for this Endangered Population

None listed.

Endangered Ecological Communities

White Box Yellow Box Blakely's Redgum Woodland

White Box Yellow Box Blakely's Red Gum Woodland is found on relatively fertile soils on the tablelands and western slopes of NSW and generally occurs between the 400 and 800 mm isohyets extending from the western slopes, at an altitude of c. 170m to c. 1200 m, on the northern tablelands. The community occurs within the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands and NSW South Western Slopes Bioregions (NSW Scientific Committee, 2002).

White Box Yellow Box Blakely's Red Gum Woodland includes those woodlands where the characteristic tree species include one or more of the following species in varying proportions and combinations - White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*) or Blakely's Red Gum (*Eucalyptus blakelyi*). Grass and herbaceous species generally characterise the ground layer. In some locations, the tree overstorey may be absent as a result of past clearing or thinning and at these locations only an understorey may be present. Shrubs are generally sparse or absent, though they may be locally common (NSW Scientific Committee, 2002).

Woodlands with Eucalyptus albens are most common on the undulating country of the slopes region while *Eucalyptus blakelyi* and *Eucalyptus melliodora* predominate in grassy woodlands on the tablelands. Drier woodland areas dominated by *Eucalyptus albens* often form mosaics with areas dominated by *Eucalyptus blakelyi* and *Eucalyptus melliodora* occurring in more moist situations, while areas subject to waterlogging may be treeless. Western Grey Box (*Eucalyptus macrocarpa*) is often found in association with *Eucalyptus melliodora* and *Eucalyptus albens* on the south western slopes. Woodlands including *Eucalyptus crebra, Eucalyptus dawsonii* and *Eucalyptus moluccana* (and intergrades with *Eucalyptus albens*), for example in the Merriwa plateau, Goulburn River National Park and western Wollemi National Park, are also included. Intergrades between *Eucalyptus blakelyi* and *Eucalyptus tereticornis* may also occur here (NSW Scientific Committee, 2002).

The condition of remnants ranges from relatively good to highly degraded, such as paddock remnants with weedy understoreys and only a few hardy natives left. A number of less degraded remnants have survived in Travelling Stock Routes, cemeteries and reserves, although because of past and present management practices understorey species composition may differ between the two land uses. Some remnants of the community may consist of only an intact overstorey or an intact understorey, but may still have high conservation value due to the flora and fauna they support. Other sites may be important faunal habitat, have significant occurrences of particular species, form part of corridors or have the potential for recovery. The conservation value of remnants may be independent of remnant size (NSW Scientific Committee, 2002).

Regional Conservation Status

The community is poorly represented in conservation reserves. There are small occurrences of White Box Yellow Box Blakely's Red Gum Woodland in Border Ranges National Park, Goobang National Park, Goulburn River National Park, Manobalai Nature Reserve, Mt Kaputar National Park, Oxley Wild Rivers National Park, Queanbeyan Nature Reserve, Towarri National Park, Warrumbungle National Park, Wingen Maid Nature Reserve and Wollemi National Park. The community also occurs in the following State Conservation Areas, Copeton State Conservation Area, Lake Glenbawn State Conservation Area and Lake Keepit State Conservation Area (NSW Scientific Committee, 2002).

Focus of Recovery Effort

- Undertake control of rabbits, hares, foxes, pigs and goats (using methods that do not disturb the native plants and animals of the remnant).
- Do not harvest firewood from remnants (this includes living or standing dead trees and fallen material).
- Leave fallen timber on the ground.
- Manage stock to reduce grazing pressure in high quality remnants (i.e. those with high flora diversity or fauna habitat).
- Encourage regeneration by fencing remnants, controlling stock grazing and undertaking supplementary planting, if necessary.
- Erect on-site markers to alert maintenance staff to the presence of a high quality remnant or population of a threatened species.
- Undertake weed control (taking care to spray or dig out only target species).
- Protect all sites from further clearing and disturbance.
- Ensure remnants remain connected or linked to each other; in cases where remnants have lost connective links, re-establish them by revegetating sites to act as stepping stones for fauna, and flora (pollen and seed dispersal).

- Mark remnants onto maps (of the farm, shire, region, etc) and use to plan activities (e.g. remnant protection, rehabilitation or road, rail and infrastructure maintenance work). On-site markers can alert maintenance staff to the presence of a threatened species.

Relevant Priority Actions listed for this EEC

1. Collate existing survey and mapping data and use towards production of integrated and updatable map. (Medium priority)

2. Conservation Management Networks to identify key sites for protection or acquisition. (High priority)

3. Conservation Management Networks to negotiate protection of sites through management agreements and covenants. (High priority)

4. Determine optimal management regimes for management of high quality remnants (e.g. fire regimes). (Low priority)

5. Determine techniques for restoring degraded remnants. (Low priority)

6. Develop agreed guidelines for identification and assessment of remnant quality. (Low priority)

7. Identify methods for controlling particular introduced species identified as significantly threatening. (Low priority)

8. Install markers and signs along roads, tracks, rail & utility easements. (High priority)

9. Integrate conservation of Box-Gum Woodland with other landscape conservation programs. (Medium priority)

10. Investigate opportunities and promote examples where agricultural practices are integrated successfully with conservation. (Low priority)

11. Investigate use of remote sensing techniques to assist in future survey work. (Low priority)

12. Prepare management plans for high priority sites. (High priority)

13. Target Box-Gum Woodland sites for incentive and long-term stewardship schemes, especially on private land and TSRs. (High priority)

14. Target priority weeds for control. (High priority)