

7a Working Paper

Fauna Investigations

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*Pacific Highway Upgrade
Sapphire to Woolgoolga
Roads and Traffic Authority*

Fauna Investigations

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ABBREVIATIONS & DEFINITIONS

ANZECC	Australia and New Zealand Environment Conservation Council
CRAFTI	Comprehensive Regional Assessment Forest Type Inventory
DECC	NSW Department of Environment and Climate Change
DEWR	Commonwealth Department of Water Resources
EEC	Endangered Ecological Community
Endemic	Distribution restricted to a particular region or area
EP	Endangered Population
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth)
FM Act	Fisheries Management Act 1994
ha	Hectare
JANIS	Joint ANZECC/MCFFA/NFPS Implementation Sub-Committee
km	Kilometre
Local Area	Defined by NPWS (2001) as the area within a 10km radius of the study area
LGA	Local Government Area
m	Metre
MCFFA	The Ministerial Council on Fisheries, Forestry and Aquaculture
mm	Millimetre
NES	National Environmental Significance (Commonwealth)
NFPS	National Forestry Policy Statement
NP	National Park
NPWS	NSW National Parks and Wildlife Service (now included under DEC)
NR	Nature Reserve
SEPP	State Environmental Planning Policy
TSC Act	<i>Threatened Species Conservation Act 1995</i>

1. Introduction

1.1 Background to the Study

This report has been prepared by Connell Wagner Pty Ltd on behalf of the NSW Roads and Traffic Authority (RTA) to describe the investigations and findings of the fauna surveys undertaken for the Pacific Highway upgrade between Sapphire and Woolgoolga. A specialist frog survey was undertaken by Lewis Ecological Surveys with a separate working paper produced detailing these findings.

The proposed highway upgrade between Sapphire and Woolgoolga consists of:

- Duplication of the existing highway to dual carriageways from Sapphire to south of Woolgoolga;
- a bypass to the west of Woolgoolga involving construction of dual carriageways;
- provision of service roads for local traffic; and
- interchanges at Sapphire, Moonee Beach, Emerald Beach, Woolgoolga south and Arrawarra Beach Road.

This report describes the fauna and habitats of the study area from investigations undertaken during 2005. The impact of the proposed upgrade on the fauna, habitats, corridors and threatened fauna listed under the *Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is described in the Environment Assessment (EA) document produced under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The study design for the field surveys was originally developed in the context of a duplication of the Pacific Highway to dual carriageway with limited interchanges and service roads. Following the undertaking of fieldwork, it was confirmed that the proposal for the upgrade was in the Class M (motorway option) with the inclusion of a full service road.

The findings of flora surveys have been documented in a separate report prepared by Ecos Environmental Pty Ltd (Ecos 2005).

1.2 Study Objectives

The objectives of the fauna study were to:

- identify and describe the fauna habitats occurring within the study area;
- document the animal species recorded within the study area, highlighting any species listed on the TSC Act, the EPBC Act and the FM Act;
- investigate potential wildlife corridors extending from the study area to adjacent natural areas;
- determine the likelihood of occurrence of any threatened species, population and ecological community listed under the TSC Act and/or EPBC Act; and
- provide an overview of the broad ecological impacts of the proposal.

1.3 Description of Study Area

1.3.1 Locality

The study area consists of a corridor extending for 25 km from Sapphire on the northern outskirts of Coffs Harbour to Arrawarra Creek north of Woolgoolga. The study area is entirely within the Coffs Harbour Local Government Area (LGA) on the NSW north coast. The study area incorporates cleared land, residential areas, banana plantations, forested land, State Forests and Nature Reserves. The majority of the highway duplication section falls within the existing road reserve, while the bypass section traverses private and public land (Wedding Bells State Forest). Several key habitats and corridors identified in the NPWS *Key Habitats and Corridors in North East NSW* study (NPWS 1999a) occur in the study area.

1.3.2 Bioregional Context

The study area is located in the NSW North Coast Bioregion. This Bioregion is part of a zone known as the Macleay–McPherson overlap, which covers an area from Barrington Tops in NSW to Lamington National Park in South East Queensland. This zone is characterised by an overlap in distribution of tropical species from the north east and temperate species from the south east of the eastern seaboard. The environmental characteristics allied with this overlap are associated with a highly diverse array of species with the forests of the NSW North Coast Bioregion (the 'north eastern forests') regarded as one of Australia's most diverse ecosystems (NPWS 2003b).

There are numerous examples of biological diversity within the NSW North Coast Bioregion. Over 400 species of forest vertebrates are found in the region, the macropod communities being among the most diverse on the east coast (NPWS 2003). The NSW North Coast Bioregion also supports Australia's second highest diversity of birds, containing approximately 181 species (Gilmore & Parnaby 1994). Several endemic species, including those at or approaching their distributional limits, and over 70 threatened species are found in the NSW North Coast Bioregion (Gilmore & Parnaby 1994).

NPWS (1999) identified the NSW North Coast Bioregion as containing one of the two major peaks of eucalypt diversity in Australia. In addition to this, four of the five major rainforest groups all have significant occurrences in the region (Floyd 1990). The Comprehensive Regional Assessment (CRA) of the NSW North Coast Bioregion identified 157 forest ecosystems of which 137 are eucalypt dominated. Of these, 31 meet the JANIS criteria for rarity and a further 19 meet the JANIS criteria for vulnerability.

2. Fauna Survey Methods

2.1 Survey Design

Fauna surveys were undertaken over three sessions, from February 24 to March 9 2005, May 9 to 22 2005 and December 14 to 16 2005. The aim of the fauna survey was to maximise the detection of threatened fauna species occurring within the study area. The survey was designed using '*Threatened Species Survey and Assessment: Guidelines for developments and activities (working draft)*' (DEC 2004) as a guide, and took into consideration the following issues:

- stratification, sampling and replication;
- targeted species, Endangered Populations (EPs) and Endangered Ecological Communities (EECs);
- species-specific survey methods and minimum sampling effort;
- optimal climatic and seasonal conditions;
- migratory species movements;
- data collection; and
- the limitations of the survey approach.

The following sections discuss how these issues were addressed in the survey design.

2.1.1 Stratification, Sampling and Replication

The study area was stratified to ensure the full range of potential habitats and vegetation types were evaluated. The initial stratification process used vegetation structure (for example, forest, woodland, shrubland) to identify broad habitat types. These habitat types correlated with the broad ecological types identified in the flora survey design and followed the structural classification of Walker and Hopkins (1990). Further stratification was then undertaken on the basis of variation in biophysical attributes (such as topography, soil type and landform element) and floristics (that is, species composition). These stratification units guided sampling intensity with replication governed by Comprehensive Regional Assessment Forest Type Inventory (CRAFTI) vegetation types. Survey sites varied from 25 ha to around 7.5 ha in which survey effort was focused. Survey site locations within survey units were generally randomly selected after considering:

- the need for replicate sites to evaluate heterogeneity or relative diversity of large areas, and verify consistency within the survey unit;
- the statistical methods used to analyse the data;
- the presence of transition zones and special habitats (eg. water bodies, rocky outcrops and cliffs); and
- factors such as disturbance, fire, flooding or distance from watering points.

In accordance with DEC (2004), sample sites were selected to avoid bias from edge effects and local disturbances where possible, and were situated using the following criteria:

- away from the boundaries of an environmental stratum;
- in homogeneous vegetation considered to be representative of the strata; and
- away from, or free from, local disturbances such as roads, mines, quarries and eroded areas.

Where only one sampling site was placed within a stratification unit, it was located in an area which best represented the unit. Sites were preselected using key ecological characteristics representative of the study area, enabling an extrapolation of results to describe areas of reduced survey coverage.

2.1.2 Optimal Climatic and Seasonal Conditions

As far as possible, the survey was designed so as to incorporate the effects of seasonality and to establish baseline data covering a range of considerations such as:

- relative abundance of foraging resources (eg flowering eucalypts);

- location and relative importance of overwintering habitats (eg tree hollows);
- influence of season on species activity (eg microchiropteran bats, frogs).

Studies were completed in three parts covering the summer and autumn periods. Two round of surveys focused on the detection of species that are likely to occupy the study area during the warmer months (December and early March), with another round of surveys focusing on seasonal variations associated with the cooler months (late May). This approach has effectively provided an opportunity to examine seasonal changes, such as levels of microchiropteran bat activity, without introducing other variables such as fire, drought and chronic disturbance.

2.1.3 *Habitat Resources*

Data on habitat resources was collected to assist in the assessment of the likelihood of threatened species and in the delineation of core areas of habitat for target species. Habitat attributes targeted during the survey included:

- the location, size class and number of tree hollows, tree species and status (dead or alive);
- the location of potential roost sites for cave-roosting bats, such as culverts and bridges;
- the type and abundance of foraging resources (eg *Allocasuarina*; nectar-producing trees and shrubs; rough-barked trees; mistletoe; koala feed trees);
- the cover of fallen timber, leaf litter and rock; and
- weed cover.

General habitat data was collected in accordance with standardised habitat proformas to ensure continuity between different recorders (see Appendix A).

2.1.4 *Data Collection*

Standard proformas were used to record field data so that information was collected in a consistent format and to ensure continuity between recorders. A number of different proformas were used depending on the species or habitat being surveyed. Standard information recorded at each site included: location (using Global Positioning System), site identifier, date, and observer.

2.1.5 *Limitations*

Designing a survey to address specific outcomes (eg threatened species impact assessment) may inherently bias the resultant data set in favour of the targeted species. Therefore, the absence of a species from survey data does not necessarily mean it does not inhabit the survey area. It may simply mean that the species was not detected at that time with the survey method adopted and the prevailing seasonal or climatic conditions. Similarly, presence data, especially from animal surveys, is rarely sufficiently systematic to estimate population size or range. Such data is usually only indicative of the presence of individuals of a local population. To overcome this limitation, consideration has been given to the presence in the survey area (or surrounding land) of the known or likely habitat components for a species through habitat assessments.

Similar limitations apply to the use of databases for the interpretation of presence and absence survey data. Records of DEC's Atlas of NSW Wildlife are representative of available information, which is limited by the scope or intent of past surveys or observations. Accordingly, these databases have been used as an indication of species' presence in an area.

To overcome some of the problems associated with seasonality, bat sampling was undertaken during warmer and cooler months of summer-autumn, and Swift Parrot surveys were undertaken during the autumn session of fieldwork, the timing of which coincided with the time of year when the species was most likely to be in the study area.

2.1.6 *Target Species/Populations*

Examination of the DEC Wildlife Atlas Database and EPBC Protected Matters Report for the local area were used to identify threatened species, endangered populations and migratory species recorded or likely to occur in the local area. The preliminary list of target threatened species/populations (Table 2-1) was refined through a

general review of broad habitat types that are known to occur within the study area. Species clearly exhibiting preferences for habitats not represented in the study area were eliminated from the target species list, thereby focusing field studies and impact assessments on the remaining threatened species. Threatened species for which there were no database records, but were considered likely to occur (on the basis of habitat suitability) were also targeted.

Table 2-1: Preliminary List of Threatened Fauna Species

Scientific Name	Common Name	Conservation Status		Potential Habitat Present	Local Records	Within Known Distribution
		TSC Act	EPBC Act			
REPTILES						
<i>Coeranoscincus reticulatus</i>	Three-toed Snake-tooth Skink	V	V	√	×	√
<i>Emydura signata</i>	Bellinger River Emydura	V	V	×	×	×
<i>Hoplocephalus stephensii</i>	Stephen's Banded Snake	V	—	√	√	√
<i>Hoplocephalus bitorquatus</i>	Pale-headed Snake	V	—	√	×	√
DIURNAL BIRDS						
<i>Calidris alba</i>	Sanderling	V	—	×	√	√
<i>Calidris tenuirostris</i>	Great Knot	V	—	×	√	√
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V	—	√	√	√
<i>Charadrius leschenaultii</i>	Greater Sand Plover	V	—	×	×	√
<i>Charadrius mongolus</i>	Lesser Sand Plover	V	M	×	×	√
<i>Climacteris picumnus</i>	Brown Treecreeper	V	—	√	√	√
<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (eastern subspecies)	V	—	√	√	√
<i>Coracina lineata</i>	Barred Cuckoo-shrike	V	—	√	√	√
<i>Cyclopsitta diophthalma coxeni</i>	Coxen's Double-eyed Fig-Parrot	E	E	√	√	√
<i>Dromaius novaehollandiae</i>	Emu	E2	—	√	√	√
	NSW North Coast Bioregion and Port Stephens LGA Population					
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	E	—	√	√	√
<i>Erythrotriorchis radiatus</i>	Red Goshawk	E	V	√	×	√
<i>Esacus neglectus</i>	Beach Stone-curlew	E	—	×	√	√
<i>Grus rubicundus</i>	Brolga	V	—	×	√	√
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V	—	×	√	√
<i>Haematopus longirostris</i>	Pied Oystercatcher	V	—	×	√	√
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard	V	—	√	×	×
<i>Irediparra gallinacea</i>	Comb-crested Jacana	V	—	√	√	√

Table 2-1: Preliminary List of Threatened Fauna Species						
Scientific Name	Common Name	Conservation Status		Potential Habitat Present	Local Records	Within Known Distribution
		TSC Act	EPBC Act			
<i>Ixobrychus flavicollis</i>	Black Bittern	V	—	×	√	√
<i>Lathamus discolor</i>	Swift Parrot	E	E	√	√	√
<i>Lichenostomus fasciocularis</i>	Mangrove Honeyeater	V	—	×	×	√
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	V	—	×	×	√
<i>Limosa limosa</i>	Black-tailed Godwit	V	—	×	√	√
<i>Lophoictinia isura</i>	Square-tailed Kite	V	—	√	√	√
<i>Melanodryas cucullata</i>	Hooded Robin	V	—	√	×	√
<i>Melanodryas cucullata cucullata</i>	Hooded Robin (southeastern subspecies)					
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V	—	×	×	×
<i>Monarcha leucotis</i>	White-eared Monarch	V	—	×	√	√
<i>Pandion haliaetus</i>	Osprey	V	—	√	√	√
<i>Pezoporus wallicus wallicus</i>	Ground Parrot (eastern subspecies)	V	—	×	√	√
<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subspecies)	V	—	√	×	√
<i>Ptilinopus magnificus</i>	Wompoo Fruit-Dove	V	—	√	√	√
<i>Ptilinopus regina</i>	Rose-crowned Fruit-Dove	V	—	√	√	√
<i>Ptilinopus superbus</i>	Superb Fruit-Dove	V	—	√	√	√
<i>Rostratula benghalensis australis</i>	Painted Snipe (Australian subspecies)	E	—	×	×	√
<i>Rostratula australis</i>	Australian Painted Snipe	—	V			
<i>Sterna albifrons</i>	Little Tern	E	—	×	√	√
<i>Sterna fuscata</i>	Sooty Tern	V	—	×	√	√
<i>Stictonetta naevosa</i>	Freckled Duck	V	—	√	√	√
<i>Todiramphus chloris</i>	Collared Kingfisher	V	—	×	√	√
<i>Turnix melanogaster</i>	Black-breasted Button-quail	E	V	√	×	√
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E	E	√	√	√
NOCTURNAL BIRDS						
<i>Botaurus poiciloptilus</i>	Australasian Bittern	V	—	×	×	√
<i>Burhinus grallarius</i>	Bush Stone-curlew	E	—	√	√	√

Table 2-1: Preliminary List of Threatened Fauna Species						
Scientific Name	Common Name	Conservation Status		Potential Habitat Present	Local Records	Within Known Distribution
		TSC Act	EPBC Act			
<i>Ninox connivens</i>	Barking Owl	V	—	√	×	√
<i>Ninox strenua</i>	Powerful Owl	V	—	√	√	√
<i>Tyto capensis</i>	Grass Owl	V	—	√	√	√
<i>Tyto novaehollandiae</i>	Masked Owl	V	—	√	√	√
<i>Tyto tenebricosa</i>	Sooty Owl	V	—	√	√	√
MAMMALS (EXCLUDING BATS)						
<i>Aepyprymnus rufescens</i>	Rufous Bettong	V	—	√	×	√
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	—	√	×	√
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	—	√	√	√
<i>Dasyurus maculatus maculatus</i>	Spotted-tailed Quoll (SE Mainland Population)	—	E	√	√	√
<i>Petaurus australis</i>	Yellow-bellied Glider	V	—	√	√	√
<i>Petaurus norfolcensis</i>	Squirrel Glider	V	—	√	√	√
<i>Potorous tridactylus</i>	Long-nosed Potoroo	V	—	√	×	√
<i>Potorous tridactylus tridactylus</i>	Long-nosed Potoroo (SE Mainland Population)	—	V	√	×	√
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	V	—	√	√	√
<i>Phascolarctos cinereus</i>	Koala	V	—	√	√	√
<i>Planigale maculata</i>	Common Planigale	V	—	√	√	√
BATS						
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	√	×	√
<i>Chalinolobus nigrogriseus</i>	Hoary Wattled Bat	V	—	√	√	√
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	—	√	√	√
<i>Kerivoula papuensis</i>	Golden-tipped Bat	V	—	√	√	√
<i>Miniopterus australis</i>	Little Bent-wing Bat	V	—	√	√	√
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bent-wing Bat	V	—	√	√	√
<i>Mormopterus norfolkensis</i>	East Coast Freetail Bat	V	—	√	√	√
<i>Myotis adversus</i>	Large-footed Myotis	V	—	√	√	√
<i>Nyctophilus bifax</i>	Eastern Long-eared Bat	V	—	√	×	√
<i>Pteropus alecto</i>	Black Flying-Fox	V	—	√	×	√
<i>Pteropus poliocephalus</i>	Grey-headed Flying-Fox	V	V	√	√	√
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V	—	√	×	√

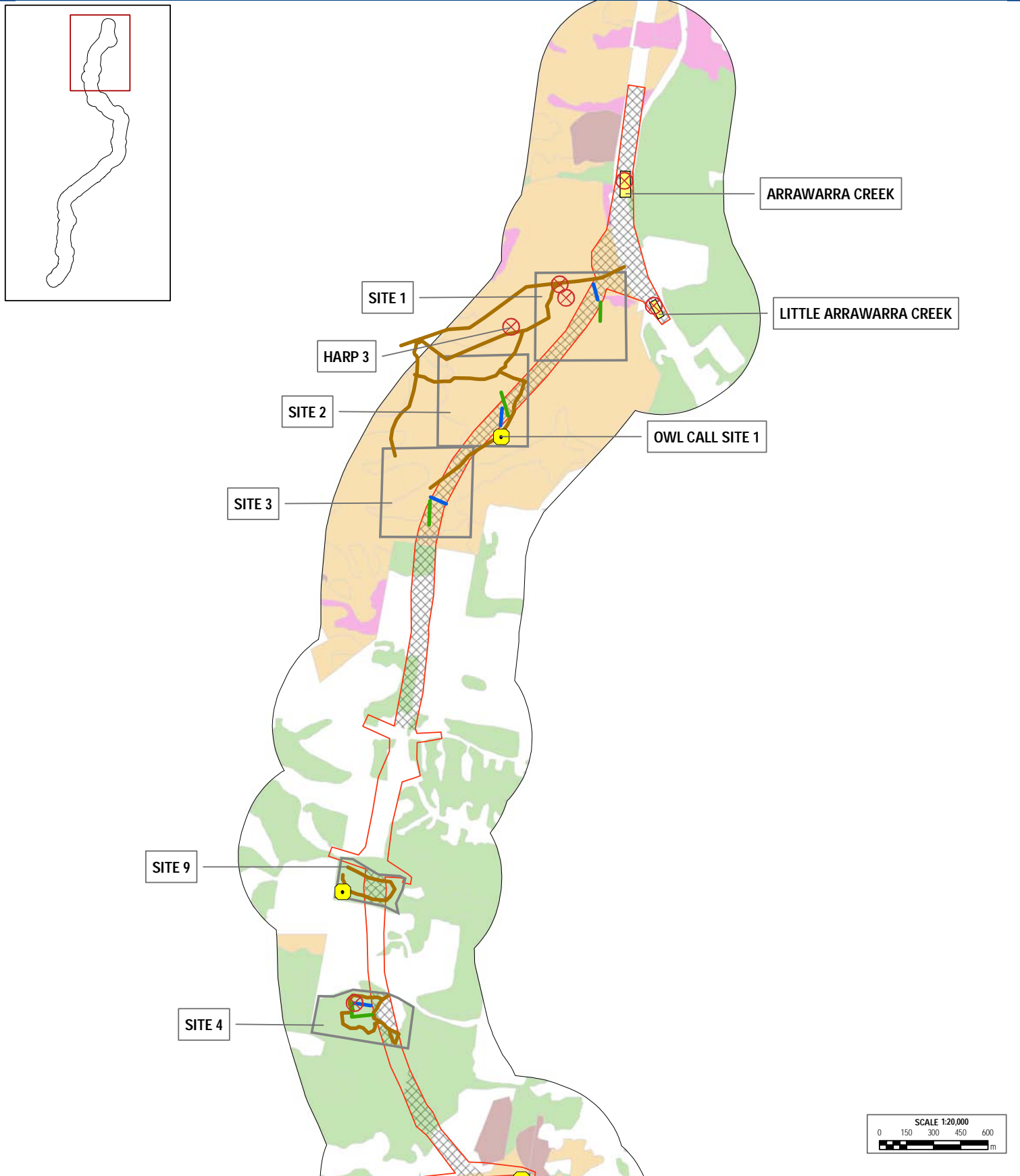
Table 2-1: Preliminary List of Threatened Fauna Species						
Scientific Name	Common Name	Conservation Status		Potential Habitat Present	Local Records	Within Known Distribution
		TSC Act	EPBC Act			
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	—	√	√	√
<i>Syconycteris australis</i>	Common Blossom-bat	V	—	√	√	√
<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V	—	√	×	√
INVERTEBRATES						
<i>Petalura gigantea</i>	Giant Dragonfly	E	—	√	×	√
<i>Phyllodes imperialis</i>	Moth (Southern subspecies)	E	E	×	×	√
MIGRATORY SPECIES LISTED UNDER EPBC ACT						
<i>Gallinago hardwickii</i>	Latham's Snipe	—	M	×	√	√
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	—	M	√	√	√
<i>Hirundapus caudacutus</i>	White-throated Needletail	—	M	√	√	√
<i>Monarcha melanopsis</i>	Black-faced Monarch	—	M	√	√	√
<i>Monarcha trivirgatus</i>	Spectacled Monarch	—	M	√	√	√
<i>Myiagra cyanoleuca</i>	Satin Flycatcher	—	M	√	√	√
<i>Numenius phaeopus</i>	Whimbrel	—	M	×	√	√
<i>Rhipidura rufifrons</i>	Rufous Fantail	—	M	√	√	√
<i>Rostratula benghalensis</i>	Painted Snipe	—	M	×	×	√

Survey Methods and Minimum Sampling Effort

A combination of specific survey methods (designed to target particular species or faunal groups), and general survey methods (designed to record a range of faunal groups during a survey session), were used to maximise the detection of target species within the study area (Table 2-2). While a separate specialist frog survey was undertaken during optimal seasonal and climatic conditions, any observations of frog species made while undertaking other fauna surveys were noted. Fauna survey effort at each survey site is summarised in Table 2-3. The location of each survey site is illustrated in Figure 2-1 : Fauna Survey Locations

Survey techniques are described in more detail in Section 2.2 of this report.

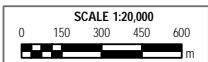
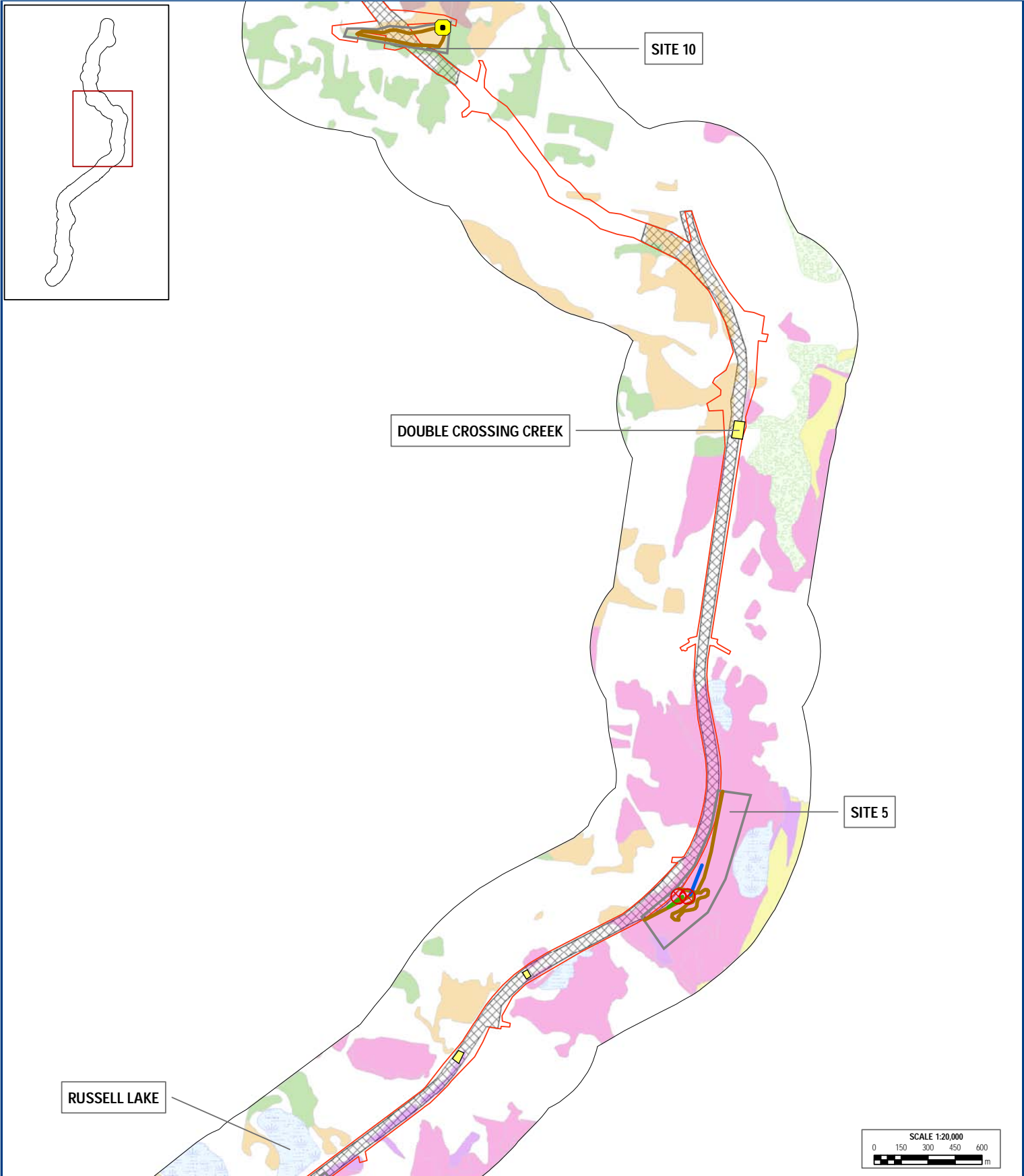
Table 2-2: Target Threatened Fauna Survey Techniques	
Technique	Targeted Species
SPECIES-SPECIFIC TECHNIQUES	
Hair Tubes	Rufous Bettong (<i>Aepyprymnus rufescens</i>) Spotted-tailed Quoll (<i>Dasyurus maculatus</i>) Brush-tailed Phascogale (<i>Phascogale tapoatafa</i>) Long-nosed Potoroo (<i>Potorous tridactylus</i>) Common Planigale (<i>Planigale maculata</i>)



LEGEND					
			Broad Habitat Types		



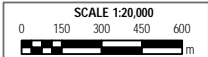
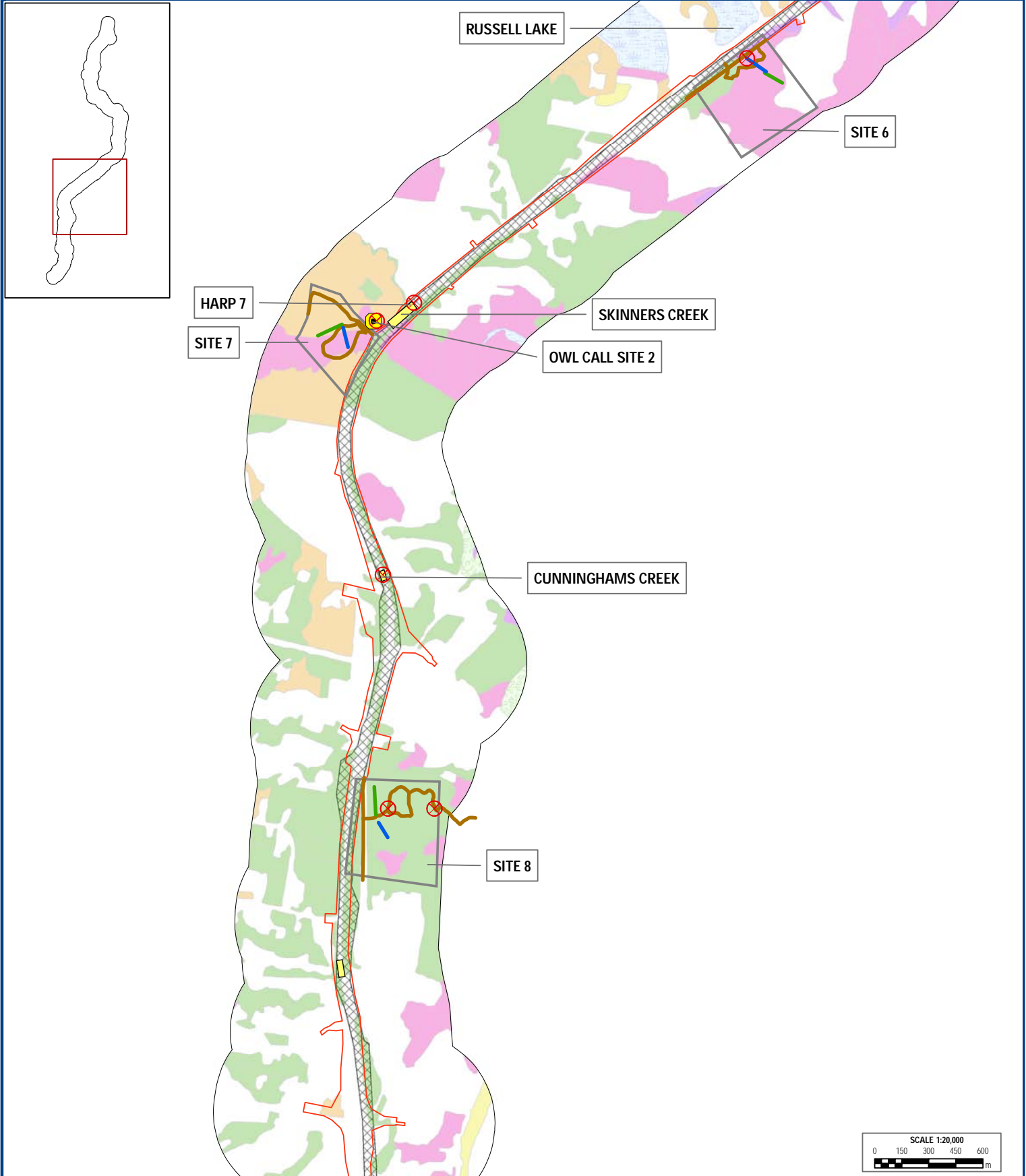
FIGURE 2.1a
FAUNA SURVEY
SITE LOCATIONS



LEGEND					
			Broad Habitat Types		



FIGURE 2.1b
 FAUNA SURVEY
 SITE LOCATIONS



LEGEND					
	Harp Trap		Fauna Survey Study Area		Spotlighting
	Owl Call Site		Fauna Survey Site		Elliot Trap Line
	Preferred Option		Hollow-bearing Tree Survey		Hair Tube Line
			Broad Habitat Types		
	Coastal Sand Scrub		Natural Grassland		Freshwater Wetland
	Dry Open Forest		Swamp Oak Floodplain Forest		Estuarine
	Moist Open Forest		Swamp Sclerophyll Forest		Culvert Habitat
			Plantations		



FIGURE 2.1c
FAUNA SURVEY
SITE LOCATIONS

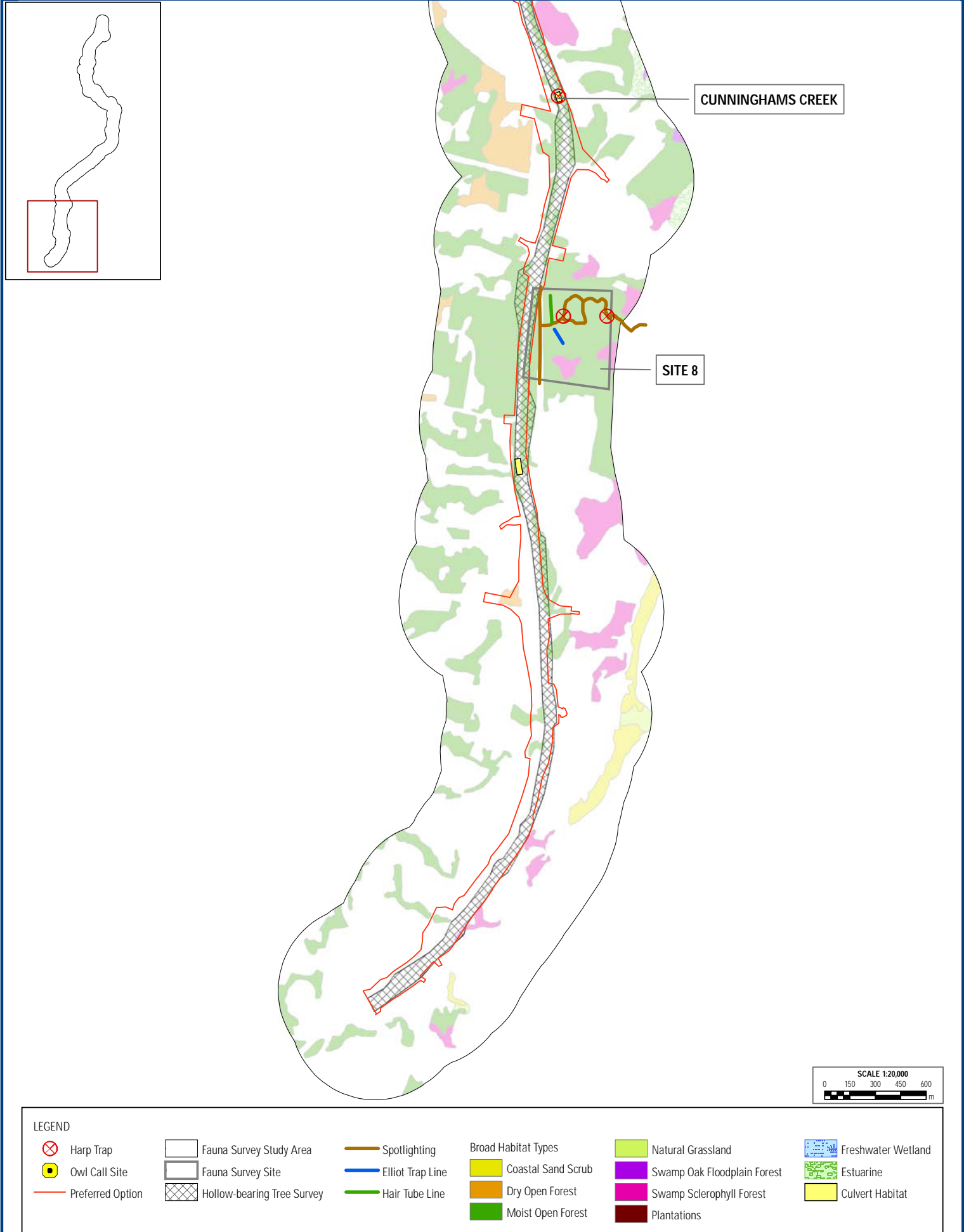


Table 2-2: Target Threatened Fauna Survey Techniques	
Technique	Targeted Species
Arboreal Elliott Trapping	Squirrel Glider (<i>Petaurus norfolcensis</i>) Brush-tailed Phascogale (<i>Phascogale tapoatafa</i>)
Harp Trapping	Large-eared Pied Bat (<i>Chalinolobus dwyeri</i>) Hoary Wattled Bat (<i>Chalinolobus nigrogriseus</i>) Eastern False Pipistrelle (<i>Falsistrellus tasmaniensis</i>) Little Bent-wing Bat (<i>Miniopterus australis</i>) Eastern Bent-wing Bat (<i>Miniopterus schreibersii oceanensis</i>) East Coast Freetail Bat (<i>Mormopterus norfolkensis</i>) Large-footed Myotis (<i>Myotis adversus</i>) Eastern Long-eared Bat (<i>Nyctophilus bifax</i>) Yellow-bellied Sheath-tail-bat (<i>Saccolaimus flaviventris</i>) Common Blossom-bat (<i>Syconycteris australis</i>) Eastern Cave Bat (<i>Vespadelus troughtoni</i>) Golden-tipped Bat (<i>Kerivoula papuensis</i>)
Bat Calls (recording of microbat echolocation calls)	Large-eared Pied Bat (<i>Chalinolobus dwyeri</i>) Hoary Wattled Bat (<i>Chalinolobus nigrogriseus</i>) Little Bent-wing Bat (<i>Miniopterus australis</i>) Eastern Bent-wing Bat (<i>Miniopterus schreibersii oceanensis</i>) East Coast Freetail Bat (<i>Mormopterus norfolkensis</i>) Large-footed Myotis (<i>Myotis adversus</i>) Yellow-bellied Sheath-tail-bat (<i>Saccolaimus flaviventris</i>) Greater Broad-nosed Bat (<i>Scoteanax rueppellii</i>) Eastern Cave Bat (<i>Vespadelus troughtoni</i>)

Table 2-2: Target Threatened Fauna Survey Techniques	
Technique	Targeted Species
Diurnal Bird Census	<p>Glossy Black-Cockatoo (<i>Calyptorhynchus lathamii</i>)</p> <p>Brown Treecreeper (<i>Climacteris picumnus</i>)</p> <p>Barred Cuckoo-shrike (<i>Coracina lineata</i>)</p> <p>Emu (<i>Dromaius novaehollandiae</i>)</p> <p>Red Goshawk (<i>Erythrotriorchis radiatus</i>)</p> <p>Black-breasted Buzzard (<i>Hamirostra melanosternon</i>)</p> <p>Swift Parrot (<i>Lathamus discolor</i>)</p> <p>Square-tailed Kite (<i>Lophoictinia isura</i>)</p> <p>Hooded Robin (<i>Melanodryas cucullata</i>)</p> <p>Osprey (<i>Pandion haliaetus</i>)</p> <p>Grey-crowned Babbler (<i>Pomatostomus temporalis temporalis</i>)</p> <p>Rose-crowned Fruit-Dove (<i>Ptilinopus regina</i>)</p> <p>Superb Fruit-Dove (<i>Ptilinopus superbus</i>)</p> <p>Freckled Duck (<i>Stictonetta naevosa</i>)</p> <p>Black-breasted Button-quail (<i>Turnix melanogaster</i>)</p> <p>Regent Honeyeater (<i>Xanthomyza phrygia</i>)</p> <p>White-bellied Sea-Eagle (<i>Haliaeetus leucogaster</i>)</p> <p>White-throated Needletail (<i>Hirundapus caudacutus</i>)</p> <p>Black-faced Monarch (<i>Monarcha melanopsis</i>)</p> <p>Spectacled Monarch (<i>Monarcha trivirgatus</i>)</p> <p>Satin Flycatcher (<i>Myiagra cyanoleuca</i>)</p> <p>Rufous Fantail (<i>Rhipidura rufifrons</i>)</p>
Call Playback	<p>Wallum Froglet (<i>Crinia tinnula</i>)</p> <p>Wallum Sedge Frog (<i>Litoria olongburensis</i>)</p> <p>Stuttering Frog (<i>Mixophyes balbus</i>)</p> <p>Giant Barred Frog (<i>Mixophyes iteratus</i>)</p> <p>Barking Owl (<i>Ninox connivens</i>)</p> <p>Powerful Owl (<i>Ninox strenua</i>)</p> <p>Masked Owl (<i>Tyto novaehollandiae</i>)</p> <p>Sooty Owl (<i>Tyto tenebricosa</i>)</p> <p>Yellow-bellied Glider (<i>Petaurus australis</i>)</p> <p>Koala (<i>Phascolarctos cinereus</i>)</p>
GENERAL SURVEY TECHNIQUES	

Table 2-2: Target Threatened Fauna Survey Techniques	
Technique	Targeted Species
Spotlighting	<p>Wallum Froglet (<i>Crinia tinnula</i>)</p> <p>Green and Golden Bell Frog (<i>Litoria aurea</i>)</p> <p>Green Thighed Frog (<i>Litoria brevipalmata</i>)</p> <p>Wallum Sedge Frog (<i>Litoria olongburensis</i>)</p> <p>Stuttering Frog (<i>Mixophyes balbus</i>)</p> <p>Giant Barred Frog (<i>Mixophyes iteratus</i>)</p> <p>Stephen's Banded Snake (<i>Hoplocephalus stephensii</i>)</p> <p>Pale-headed Snake (<i>Hoplocephalus bitorquatus</i>)</p> <p>Bush Stone-curlew (<i>Burhinus grallarius</i>)</p> <p>Barking Owl (<i>Ninox connivens</i>)</p> <p>Powerful Owl (<i>Ninox strenua</i>)</p> <p>Grass Owl (<i>Tyto capensis</i>)</p> <p>Masked Owl (<i>Tyto novaehollandiae</i>)</p> <p>Sooty Owl (<i>Tyto tenebricosa</i>)</p> <p>Rufous Bettong (<i>Aepyprymnus rufescens</i>)</p> <p>Spotted-tailed Quoll (<i>Dasyurus maculatus</i>)</p> <p>Yellow-bellied Glider (<i>Petaurus australis</i>)</p> <p>Squirrel Glider (<i>Petaurus norfolcensis</i>)</p> <p>Brush-tailed Phascogale (<i>Phascogale tapoatafa</i>)</p> <p>Long-nosed Potoroo (<i>Potorous tridactylus</i>)</p> <p>Koala (<i>Phascolarctos cinereus</i>)</p> <p>Black Flying-Fox (<i>Pteropus alecto</i>)</p> <p>Grey-headed Flying-Fox (<i>Pteropus poliocephalus</i>)</p> <p>Yellow-bellied Sheath-tail-bat (<i>Saccolaimus flaviventris</i>)</p>

Table 2-2: Target Threatened Fauna Survey Techniques	
Technique	Targeted Species
Habitat Searches	Wallum Froglet (<i>Crinia tinnula</i>)
	Green and Golden Bell Frog (<i>Litoria aurea</i>)
	Green Thighed Frog (<i>Litoria brevipalmata</i>)
	Wallum Sedge Frog (<i>Litoria olongburensis</i>)
	Stuttering Frog (<i>Mixophyes balbus</i>)
	Giant Barred Frog (<i>Mixophyes iteratus</i>)
	Three-toed Snake-tooth Skink (<i>Coeranoscincus reticulatus</i>)
	Stephen's Banded Snake (<i>Hoplocephalus stephensii</i>)
	Pale-headed Snake (<i>Hoplocephalus bitorquatus</i>)
	Glossy Black-Cockatoo (<i>Calyptorhynchus lathami</i>)
	Barred Cuckoo-shrike (<i>Coracina lineata</i>)
	Emu (<i>Dromaius novaehollandiae</i>)
	Swift Parrot (<i>Lathamus discolor</i>)
	Osprey (<i>Pandion haliaetus</i>)
	Regent Honeyeater (<i>Xanthomyza phrygia</i>)
	Bush Stone-curlew (<i>Burhinus grallarius</i>)
	Barking Owl (<i>Ninox connivens</i>)
	Powerful Owl (<i>Ninox strenua</i>)
	Grass Owl (<i>Tyto capensis</i>)
	Masked Owl (<i>Tyto novaehollandiae</i>)
	Sooty Owl (<i>Tyto tenebricosa</i>)
	Rufous Bettong (<i>Aepyprymnus rufescens</i>)
	Spotted-tailed Quoll (<i>Dasyurus maculatus</i>)
	Yellow-bellied Glider (<i>Petaurus australis</i>)
	Koala (<i>Phascolarctos cinereus</i>)
	Black Flying-Fox (<i>Pteropus alecto</i>)
Grey-headed Flying-Fox (<i>Pteropus poliocephalus</i>)	

Figure 2-1 : Fauna Survey Locations

Table 2-3: Fauna Survey Effort and Site Locations

B = B-size Elliott Trap S = Small Hair Tube L = Large Hair Tube 0 = no. of trap nights (0) = over no. of days or nights (0) = over no. of consecutive days or nights

Site Reference	Broad Habitat Type	Vegetation Type (CRAFTI)	Hair Tubes	Arboreal Trapping	Spot-lighting	Habitat Searches	Harp Trapping	Owl Call Playback	Bat Calls	Diurnal Bird Census
			Trap Nights	Trap Nights	Person Hours	Person Hours	Trap Nights	Person Hours	Person Hours	Person Hours
Site 1	Dry Open Forest	Dry Blackbutt	S40(4) L40(4) 3 rd – 7 th March	B24(4) 3 rd – 7 th March	11(4) 28 th Feb 1 st & 4 th March 15 th May	4(1) 7 th March	8(4) 3 rd – 7 th March		5.5(4) 28 th Feb 1 st & 4 th March 15 th May	2(3) 2 nd & 5 th March 18 th May
Site 2	Dry Open Forest grading into Moist Open Forest	Dry Blackbutt and Spotted Gum – Ironbark/ Grey Gum	S80(8) L80(8) 26 th Feb – 7 th March	B24(4) 26 th Feb – 2 nd March	7(3) 26 th & 28 th Feb & 3 rd March	4(1) 7 th March			3.5(3) 26 th & 28 th Feb & 3 rd March	1.5(3) 27 th Feb – 1 st March
Site 3	Dry Open Forest	Spotted Gum – Ironbark/ Grey Gum	S80(8) L80(8) 26 th Feb – 7 th March	B24(4) 26 th Feb – 2 nd March	6(2) 26 th Feb & 3 rd March				3(2) 26 th Feb & 3 rd March	1.5(3) 27 th Feb – 1 st March
Site 4	Dry Open Forest grading into Moist Open Forest (regrowth)	Flooded Gum and Narrow-leaved White Mahogany	S40(4) L40(4) 16 th – 20 th May	B24(4) 16 th – 20 th May	6(4) 16 th - 19 th May	2(1) 20 th May	2(2) 18 th - 20 th May			2(2) 17 th & 18 th May
Site 5	Swamp Sclerophyll Forest	Paperbark	S40(4) L40(4) 3 rd – 7 th March	B24(4) 3 rd – 7 th March	6(3) 7 th & 8 th March & 14 th May		4(3) 5 th - 8 th March		3(3) 7 th & 8 th March & 14 th May	1(2) 4 th & 5 th March
Site 6	Moist Open Forest grading into Swamp Sclerophyll Forest	Blackbutt-Bloodwood/ Apple and Paperbark	S40(4) L40(4) 15 th – 19 th May	B24(4) 15 th – 19 th May	6(3) 14 th 17 th & 18 th May	3(2) 16 th & 20 th May	3(3) 15 th - 18 th May		3(3) 14 th 17 th & 18 th May	6(3) 14 th 16 th & 18 th May

Table 2-3: Fauna Survey Effort and Site Locations

B = B-size Elliott Trap S = Small Hair Tube L = Large Hair Tube 0 = no. of trap nights (0) = over no. of days or nights (0) = over no. of consecutive days or nights

Site Reference	Broad Habitat Type	Vegetation Type (CRAFTI)	Hair Tubes	Arboreal Trapping	Spot-lighting	Habitat Searches	Harp Trapping	Owl Call Playback	Bat Calls	Diurnal Bird Census
			Trap Nights	Trap Nights	Person Hours	Person Hours	Trap Nights	Person Hours	Person Hours	Person Hours
Site 7	Dry Open Forest grading into Swamp Sclerophyll Forest	Brush Box (incorrectly mapped) and Dry Blackbutt	S40(4) L40(4) 10 th - 15 th May	B24(4) 10 th - 15 th May	10(5) 10 th 11 th 14 th – 16 th May	2(1) 16 th May			5(5) 10 th 11 th 14 th – 16 th May	5(3) 11 th 14 th & 16 th May
Site 8	Dry Open Forest grading into Swamp Sclerophyll Forest	Blackbutt-Bloodwood/Apple and Paperbark	S40(4) L40(4) 10 th - 15 th May	B30(4) 10 th - 15 th May	8(4) 10 th 11 th 13 th & 14 th May	2(1) 11 th May	5(3) 10 th - 13 th May		4(4) 10 th 11 th 13 th & 14 th May	8(4) 10 th 11 th 14 th & 15 th May
Site 9	Moist Open Forest				3(1) 14 th December	2(1) 14 th December		1.5(1) 14 th December	1.5(1) 14 th December	
Site 10	Dry Open Forest grading into Moist Open Forest				3(1) 15 th December	2(1) 15 th December		1.5(1) 15 th December	1.5(1) 15 th December	
Owl Call Site 1	Dry Open Forest	Dry Blackbutt						8(8) 26 th & 28 th Feb – 6 th March	8(8) 26 th & 28 th Feb – 6 th March	
Owl Call Site 2	Dry Open Forest grading into Swamp Sclerophyll Forest	Brush Box (incorrectly mapped)						8(8) 1 st – 8 th March	8(8) 1 st – 8 th March	
Double Crossing Creek	Bridge	N/A				1(1) 19 th May			12(1) 19 th May	2(1) 5 th March

Table 2-3: Fauna Survey Effort and Site Locations

B = B-size Elliott Trap S = Small Hair Tube L = Large Hair Tube 0 = no. of trap nights (0) = over no. of days or nights (0) = over no. of consecutive days or nights

Site Reference	Broad Habitat Type	Vegetation Type (CRAFTI)	Hair Tubes	Arboreal Trapping	Spot-lighting	Habitat Searches	Harp Trapping	Owl Call Playback	Bat Calls	Diurnal Bird Census
			Trap Nights	Trap Nights	Person Hours	Person Hours	Trap Nights	Person Hours	Person Hours	Person Hours
Arrawarra Creek	Bridge	N/A				1(1) 18 th May	3(3) 18 th – 21 st May			
Little Arrawarra Creek	Bridge	N/A				1(1) 19 th May	3(3) 18 th – 21 st May			
Cunninghams Creek	Bridge	N/A				1(1) 10 th May	3(3) 10 th – 13 th May		12(1) 10 th May	
Skinner's Creek	Bridge	N/A				1(1) 18 th May	2(2) 16 th – 18 th May			
Russel Lake	Open Waterbody	Water								2(1) 19 th May
HARP3	Dry Open Forest	Dry Blackbutt					4(4) 3 rd – 7 th March			
HARP7	Dry Open Forest grading into Swamp Sclerophyll Forest	Brush Box (incorrectly mapped) and Dry Blackbutt					2(2) 12 th - 14 th May			
Hollow-bearing Tree Survey	N/A	N/A				80 25 th 28 th Feb, 1 st 3 rd 5 th March, 11 th & 17 th May, 14 th 15 th December				

2.2 Description of Survey Methods Used

2.2.1 Species-Specific Survey Methods

Amphibians

Prior to the decision to proceed with a specialist frog survey due to the lack of suitable weather conditions during the fauna survey periods, the following activities were undertaken to detect amphibian species.

The amphibian field surveys focused on Wallum Froglet (*Crinia tinnula*), Green and Golden Bell Frog (*Litoria aurea*), Green Thighed Frog (*Litoria brevipalmata*), Wallum Sedge Frog (*Litoria oblongburensis*), Stuttering Frog (*Mixophyes balbus*) and the Giant Barred Frog (*Mixophyes iteratus*). A total of 62 hours were spent surveying for frogs within the study area.

Nocturnal surveys for Wallum Froglet (*Crinia tinnula*) were conducted in areas of suitable habitat during wet weather in May 2005. Not all areas of potential Wallum Froglet habitat within the study area were accessed during the study, since the focus of amphibian field surveys was primarily on the proposed highway footprint. For example, an area of known Wallum Froglet habitat occurring outside the road reserve near Double Crossing Creek was not surveyed. Nocturnal surveys included call playback, spotlighting and habitat searches. Windy conditions during wet weather in May reduced the listening ability of observers and surveys were suspended when very windy conditions were encountered on the 13th May 2005.

Nocturnal streamside searches were conducted at Site 1 and Site 4 during some wet weather in May, however this was not considered adequate to detect all threatened species present due to the cooler temperatures and likely reduced activity of many targeted threatened species such as Stuttering Barred Frog (*Mixophyes balbus*), Giant Barred Frog (*Mixophyes iteratus*) and the Green Thighed Frog (*Litoria brevipalmata*). Further nocturnal streamside searches were not conducted within the study area due to unsuitable weather conditions (lack of rainfall) during surveys in February-March and the seasonality of the May surveys.

A driving transect near sites 1,2,3 was undertaken for around 2 hours during some minor rainfall in March 2005. However the small amount of rainfall experienced is unlikely to have resulted in much amphibian activity and as such the presence/absence of species during this survey could not be considered an accurate representation of the actual species present.

Due to the lack of rainfall during the February-March surveys and the cooler temperatures during the May surveys it is unlikely that the occurrence of threatened frog species such as the Green and Golden Bell Frog (*Litoria aurea*), Green Thighed Frog (*Litoria brevipalmata*), Wallum Sedge Frog (*Litoria oblongburensis*), Stuttering Frog (*Mixophyes balbus*) and the Giant Barred Frog (*Mixophyes iteratus*) was adequately examined. As such it was determined that a specialist amphibian survey be undertaken over the 2005-2006 summer period during optimal weather conditions. This survey was undertaken by Lewis Ecological Surveys with the results presented in the Frog Working Paper.

Diurnal Birds

Diurnal bird surveys were conducted using the area search method (Loyn 1986). Surveys were conducted mostly during the early morning with some surveys undertaken on dusk. The census period was extended to 30 minutes in each study site, in an area of around two hectares (20m x 1km) to increase the effectiveness of this method. Threatened diurnal birds expected to occur in the study area are listed in Table 2-1. A total of 31 hours of diurnal bird surveying was undertaken within the study area. Opportunistic bird observations were also recorded during other field investigations such as habitat searches, trap checking and hollow-bearing tree surveys.

Avian species capable of migrating to the study area were targeted during a suitable season during the fauna survey. For example, targeted searches for the Swift Parrot (*Lathamus discolor*) were undertaken during the flowering period of winter-flowering tree species such as Forest Red Gum (*Eucalyptus tereticornis*).

Nocturnal Birds

Call Playback

Owl call sites were located in areas of suitable habitat that were likely to carry sound the most effectively and where incoming birds could be detected. Call playback was undertaken after a 10 minute listening period, using a 15W

amplifier to broadcast calls for approximately five minutes for each target species. This was followed by a 10 minute listening period and then 10 minutes spent spotlighting the surrounding area. Once a target species was encountered, call playback for that species ceased at that site to reduce potential disturbance to that species.

Owl call playback was undertaken for approximately one hour each night for eight nights at two sites within the study area, eight nights being the recommended number of nights to survey for Masked Owl (*Tyto novaehollandiae*) (DEC 2004). Owl call playback was also undertaken at other sites during field surveys. A total of 19 hours of owl call playback was undertaken in the study area.

Whilst every effort was made to locate owl call sites away from traffic noises, some difficulty in hearing was experienced at Owl Call Site 2. As such it is likely that the distance from this site that owls could be heard by the observer would have been less than the 800m described by DEC (2004). Additional limitations of this survey method are that some individual owls never respond to call playback (DEC 2004) and some may not respond vocally to playback within 500m of core nesting and roosting areas.

Nocturnal bird species targeted during call playback included Powerful Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*), Sooty Owl (*T. tenebricosa*), Barking Owl (*Ninox connivens*), and Bush Stone-curlew (*Burhinus grallarius*).

Mammals (Excluding Bats)

Elliott Trapping

Eight arboreal B-size Elliott trap transects were set within the study area for four nights each. Each transect consisted of six traps. Traps were mounted on trees approximately two metres above the ground and baited with a mixture of rolled oats, peanut butter and honey. The tree trunk was sprayed liberally with a honey-water mix around the trap to attract arboreal mammal species. Traps were checked early in the morning, with captured individuals identified and released at the point of capture. Arboreal traps targeted Squirrel Glider (*Petaurus norfolcensis*) and Brush-tailed Phascogale (*Phascogale tapoatafa*). A total of 192 trap nights were undertaken in the study area.

Hair Tubes

Eight ground hair tube transects were set within the study area, for four days and nights, with the exception of Sites 2 and 3 which were left for 8 days and nights. Each hair tube transect consisted of 10 large (90mm diameter) and 10 small (50mm diameter) hair tubes laid in pairs (one small and one large) approximately 10m apart. A total of 800 hair tube trap nights were sampled in the study area.

Most hair tubes were baited with a mixture of rolled oats, peanut butter and honey, with the pair at the start and end of the transect baited with meat (canned Tuna). Hair samples were sent to Barbara Triggs of Dead Finish, a recognised expert in animal hair analysis, for identification.

Target species included Rufous Bettong (*Aepyprymnus rufescens*), Spotted-tailed Quoll (*Dasyurus maculatus*), Long-nosed Potoroo (*Potorous tridactylus*), Brush-tailed Phascogale (*Phascogale tapoatafa*) and Common Planigale (*Planigale maculata*).

Call Playback

Call playback was used at owl call sites to target the Yellow-bellied Glider (*Petaurus australis*) and Koala (*Phascolarctos cinereus*) in accordance with the technique described above for nocturnal birds.

Bats

Ultrasonic Echolocation Detection

Ultrasonic bat echolocation calls were recorded using three ANABAT II bat detectors, with either tape or digital (ZCAIM) recording devices. Units were generally positioned in flyways in forests, under bridges, near waterbodies or carried during nocturnal spotlighting. Typically bat detectors were used for at least one hour per night at each bat call site (Table 2-3) and left overnight in sheltered locations such as under bridges and in culverts. A total of 70 hours of bat call recording was undertaken.

It is possible that in areas where bat detectors could not be left overnight, the complete range of species present was not sampled. It is considered, however, that the combination of bat call recording with harp trapping employed in this study is likely to have produced a reasonable assessment of species occurring within the study area.

Bat call analysis was undertaken by Ray Williams (of Ecotone Ecological Consultants) a recognised expert in bat call analysis.

Harp Trapping

Harp trapping was used in combination with ultrasonic bat call detection to maximise the detection of target threatened microchiropteran bat species. Harp trapping was particularly useful for threatened species not easily detected with ultrasonic detectors such as the Golden-tipped Bat (*Kerivoula papuensis*) and the Eastern Long-eared Bat (*Nyctophilus bifax*). A total of 39 trap nights were undertaken.

Harp traps were set at survey sites containing suitable habitat, generally across flyways in forests, under bridges and across narrow creeks or drainage lines. Traps were usually set for two consecutive nights at each harp trapping site (Table 2-3), however some were removed after one night if more suitable sites were found or if adverse weather conditions were encountered. Adverse weather conditions such as strong wind, heavy rain and very cold conditions were avoided as much as possible during survey. All three harp traps were removed on 13th May 2005 due to adverse weather conditions, and reinstated on 15th May 2005 when conditions improved.

Where traps were set over water, they were placed at a sufficient height so that in the case of rainfall, rising water would not come close to the bag. In cases where a sufficient height could not be achieved, traps were not placed over water. Shade-cloth was used where necessary to block flight around the trap and direct bats into the trap. Additionally, ropes were used to tether harp traps to surrounding vegetation so they remained upright.

Traps were generally checked and cleared around two hours after dusk and on dawn. If traps were checked after dawn, bats were kept in a dark, quiet, warm place until dusk and then released at the point of capture.

2.2.2 General Survey Methods

Habitat Searches

Habitat searches were used to record:

- reptiles and amphibians sheltering under rocks, logs, peeling bark, leaf litter and dumped rubbish;
- mammal scats (including Koala, macropod and predator scats) at the base of trees or along tracks and runways;
- tracks in soft substrate;
- owl pellets beneath trees
- bat roost sites under bridges or within culverts;
- nest/den sites within logs, tree bases or tree trunks;
- guano or moth remains at the base of hollow-bearing trees (diagnostic of the presence of tree-roosting bats);
- 'V'-shaped incision marks on smooth-trunked trees (diagnostic of Yellow-bellied Glider);
- Swift Parrot and Regent Honeyeater in the canopy of flowering eucalypts;
- chewed Casuarina cones (diagnostic of Glossy Black-cockatoo);
- opportunistic bird observations; and
- other signs of fauna within the study area.

These searches included searching leaf litter, tree bases, tree trunks and peeling bark, looking under and in fallen logs, under moveable rocks and dumped rubbish, under bridges, and opportunistic bird surveys. Culverts were inspected only from the exterior, due to OH&S confined spaces requirements preventing these structures being entered.

Searches were generally undertaken during warm weather before mid-morning, with windy, cold and rainy conditions avoided. All efforts were made to minimise habitat disturbance and any habitat moved was put back into place as best as possible. Scats and owl pellets were sent to Barbara Triggs of Dead Finish, a recognised expert in scat and owl pellet analysis.

A total of 25 hours were spent on habitat searches within the study area. Opportunistic habitat searches were also conducted during the hollow-bearing tree survey (discussed below) and bridge inspections.

Spotlighting

Nocturnal spotlighting was undertaken by foot with 55 Watt spotlights for a minimum of two person hours (1 hr x 2 people) each night per spotlighting transect. This method targeted arboreal and terrestrial mammal species, amphibians and reptiles that may be active during the night, as well as roosting diurnal birds. Species were either identified visually or by call. A total of 66 hours were spent spotlighting within the study area.

Windy conditions during May surveys may have resulted in fewer species being active, and reduced the listening ability of observers. This may have reduced the probability of detecting some species. Additionally surveys were suspended when very windy conditions were encountered on the 13th May 2005.

Hollow-bearing Tree Survey

A survey of hollow-bearing trees was undertaken in order to determine the extent of breeding/roosting habitat for hollow-dependant fauna in the survey area (Figure 2-1). Information collected for each tree included GPS coordinates, tree species or status (dead or alive), and the number and size of hollows. Each tree was tagged and marked with flagging tape for later identification by surveyors.

Approximately 50 survey hours were spent searching for hollow-bearing trees along the route of the proposed upgrade. As can be seen in Figure 2-1, the entire road footprint was not surveyed as a result of property access constraints.

Bird observations and habitat searches were also undertaken opportunistically during hollow-bearing tree surveys.

3. Results

3.1 Broad Habitat Types

Seven broad habitat types were recorded in the survey area: Dry Open Forest, Moist Open Forest, Rainforest, Swamp Sclerophyll Forest, Swamp Oak Floodplain Forest, Freshwater Wetland and Estuarine Wetland. Dry Open Forest, Moist Open Forest and Swamp Sclerophyll Forest make up the majority of habitat types in the study area (Figure 3-1).

A description of the broad habitat types is provided below, with detailed vegetation community classifications provided in the Flora Working Paper.

3.1.1 Dry Open Forest

Dry Open Forest within the study area comprises the following three sub-types:

- Blackbutt (*Eucalyptus pilularis*) Open Forest

This sub-type is a tall to very tall open forest with a canopy dominated by Blackbutt (*Eucalyptus pilularis*), and an understorey dominated by shrub and small tree species, Blackwood Wattle (*Acacia melanoxylon*), Turpentine (*Syncarpia glomulifera*), White Bottlebrush (*Callistemon salignus*), Lantana (*Lantana camara*), Cheese Tree (*Glochidion ferdinandii*), and Common Tea Tree (*Leptospermum polygalifolium* ssp. *polygalifolium*). The dense grassy understorey is dominated by Forest Wire Grass (*Entolasia stricta*), Blady Grass (*Imperata cylindrica*), Bracken Fern (*Pteridium esculentum*) and Common Mat Rush (*Lomandra longifolia*). This habitat is common in both the northern and southern halves of the study area, and is generally in good condition with few environmental weeds, with the exception of Lantana. The Blackbutt Open Forest in the north of the study area (Wedding Bells State Forests) contains the greatest density of tree hollows within the study area.

- Grey Gum-Grey Ironbark-White Mahogany Open Forest

This sub-type is a tall open forest (15 to 28 m) with a canopy dominated by Grey Gum (*Eucalyptus propinqua*), Grey Ironbark (*Eucalyptus siderophloia*) and White Mahogany (*Eucalyptus acmenoides*). The moderately dense mid-stratum is dominated by small trees and shrubs such as Turpentine (*Syncarpia glomulifera*), Lantana (*Lantana camara*), Blackwood Wattle (*Acacia melanoxylon*) and Forest Oak (*Allocasuarina torulosa*). The dense groundcover is dominated by grassy and herbaceous species, such as Blady Grass (*Imperata cylindrica*), Bracken Fern (*Pteridium esculentum*), Common Mat Rush (*Lomandra longifolia*), Poison Pratia (*Pratia purpurascens*) and Kangaroo Grass (*Themeda australis*). This habitat occurs in the northern half of the survey area, mainly north of Woolgoolga Creek Road. This habitat is generally in good condition with few weeds, apart from Lantana.

- Spotted Gum Open Forest

This sub-type is a tall open forest (20 – 30 m) dominated by Spotted Gum. Grey Gum (*Eucalyptus propinqua*) and Broad-leaved Ironbark (*Eucalyptus siderophloia*) occur as sub-dominants. The understorey is dominated by small trees and shrubs, such as Lantana, Blackwood Wattle and Forest Oak. The dense groundcover is dominated by grass and herbaceous species such as Blady Grass, Bracken Fern, Common Mat Rush, Poison Pratia and Kangaroo Grass.

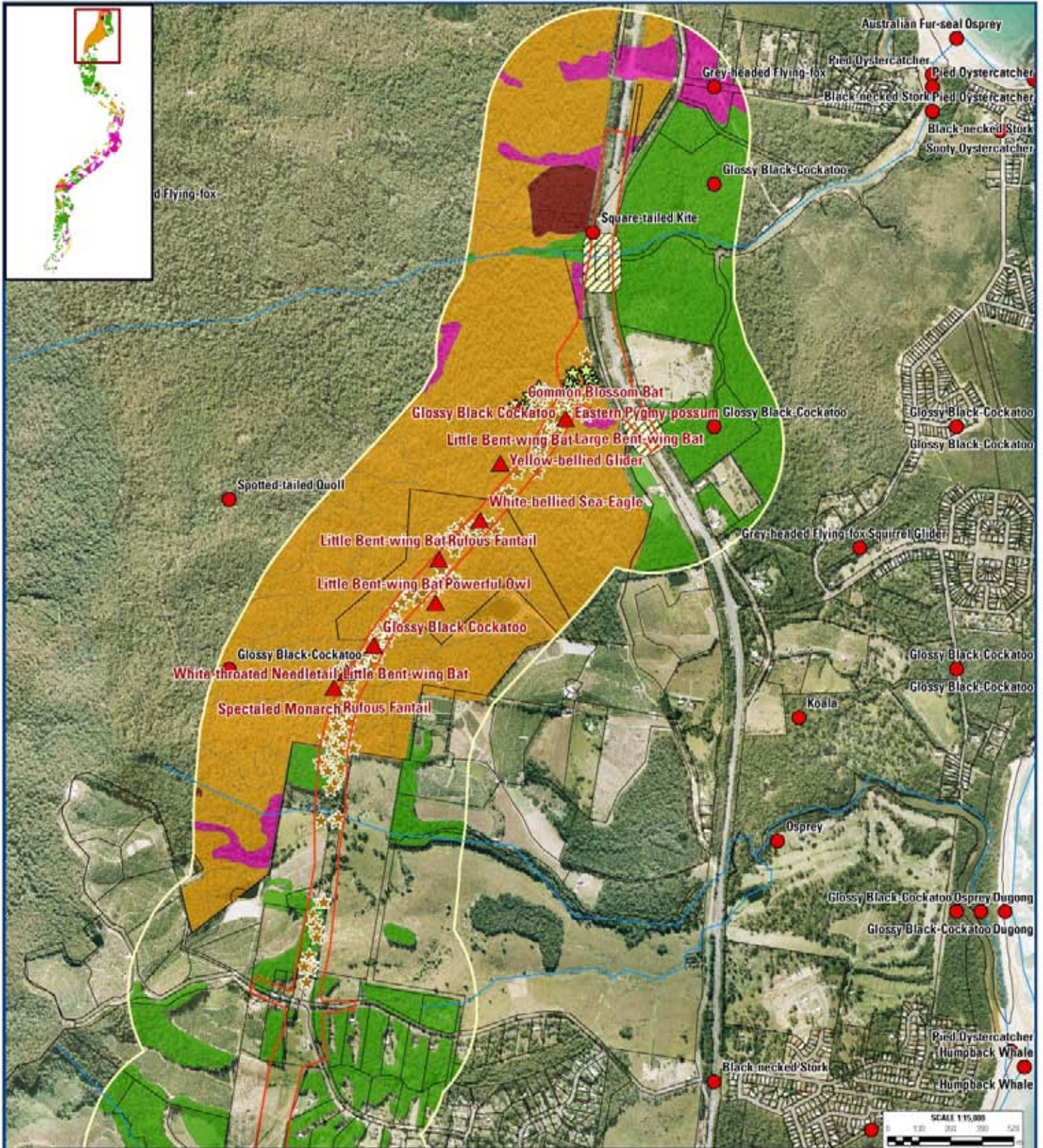
This habitat occurs on upper hill slopes in the northern half of the study area at Woolgoolga Creek Road and Wedding Bells State Forest north of Bark Hut Road, and is in a generally good condition with few weeds.

3.1.2 Moist Open Forest

Moist Open Forest habitat within the study area comprises the following two sub-types:

- Flooded Gum Open Forest

This sub-type is a tall to very tall (20 to 40 m) open forest occurring on the floodplain of larger drainage lines, sometimes extending to adjacent lower hillslopes. The canopy is dominated by Flooded Gum (*Eucalyptus grandis*), while the understorey is dominated by shrubs and vines such as Murrogun (*Cryptocarya microneura*), Morinda (*Morinda*



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0 100 200 300 400

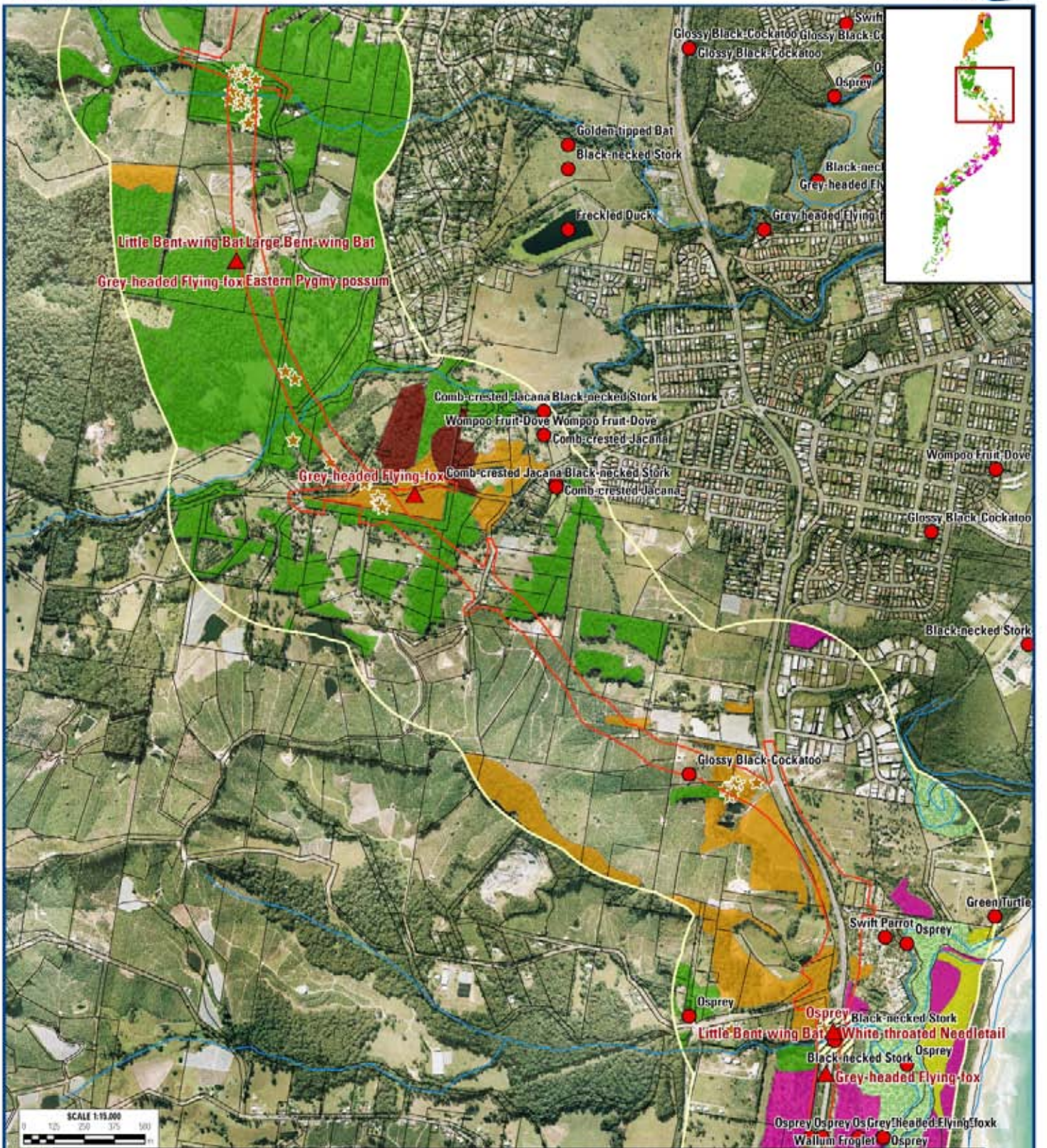
LEGEND

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|--|--|-------------------------------|----------------------------|
| ▲ Threatened Fauna Species - Connell Wagner Survey | ★ Hollow-bearing Trees | Broad Habitat Types | ■ Swamp Sclerophyll Forest |
| ● Threatened Fauna Species - NPWS July 2005 | ☆ Glossy Black Cockatoo Foraging Trees | ■ Coastal Sand Scrub | ■ Plantations |
| — Preferred Option | — Major Creek | ■ Dry Open Forest | ■ Freshwater Wetland |
| □ Fauna Survey Study Area | ▨ Culvert Habitat | ■ Moist Open Forest | ■ Estuarine |
| □ Property Boundary | | ■ Natural Grassland | |
| | | ■ Swamp Oak Floodplain Forest | |



NOTE: sensitive species appear
Not For Public Display

FIGURE 3.1a
THREATENED FAUNA
AND FAUNA HABITAT



SCALE 1:15,000
0 125 250 375 500 m

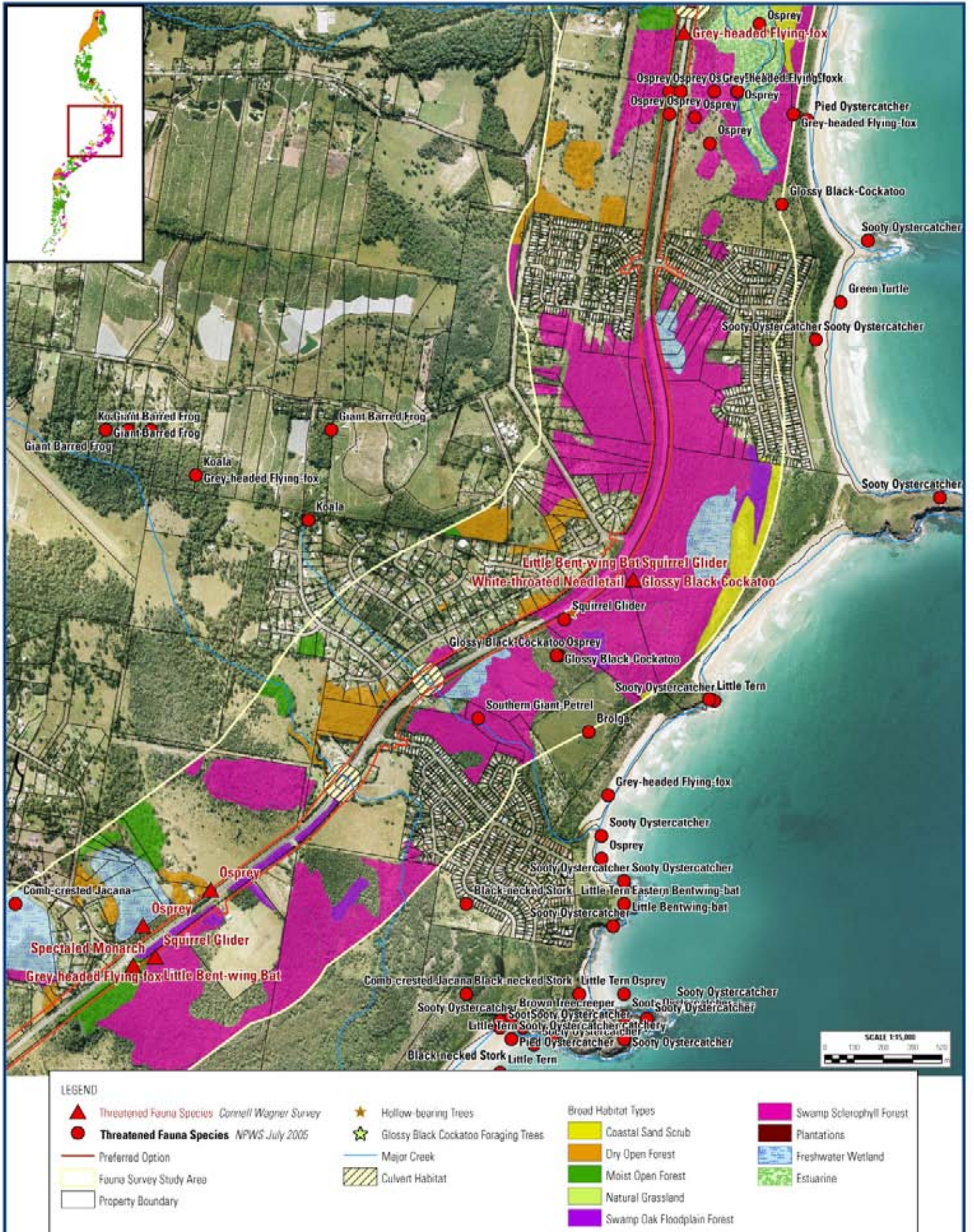
LEGEND

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| ▲ Threatened Fauna Species Connell Wagner Survey | ★ Hollow-bearing Trees | Broad Habitat Types | ■ Swamp Sclerophyll Forest |
| ● Threatened Fauna Species NPWS July 2005 | ☆ Glossy Black Cockatoo Foraging Trees | ■ Coastal Sand Scrub | ■ Plantations |
| — Preferred Option | — Major Creek | ■ Dry Open Forest | ■ Freshwater Wetland |
| — Fauna Survey Study Area | ▨ Culvert Habitat | ■ Moist Open Forest | ■ Estuarine |
| □ Property Boundary | | ■ Natural Grassland | |
| | | ■ Swamp Oak Floodplain Forest | |



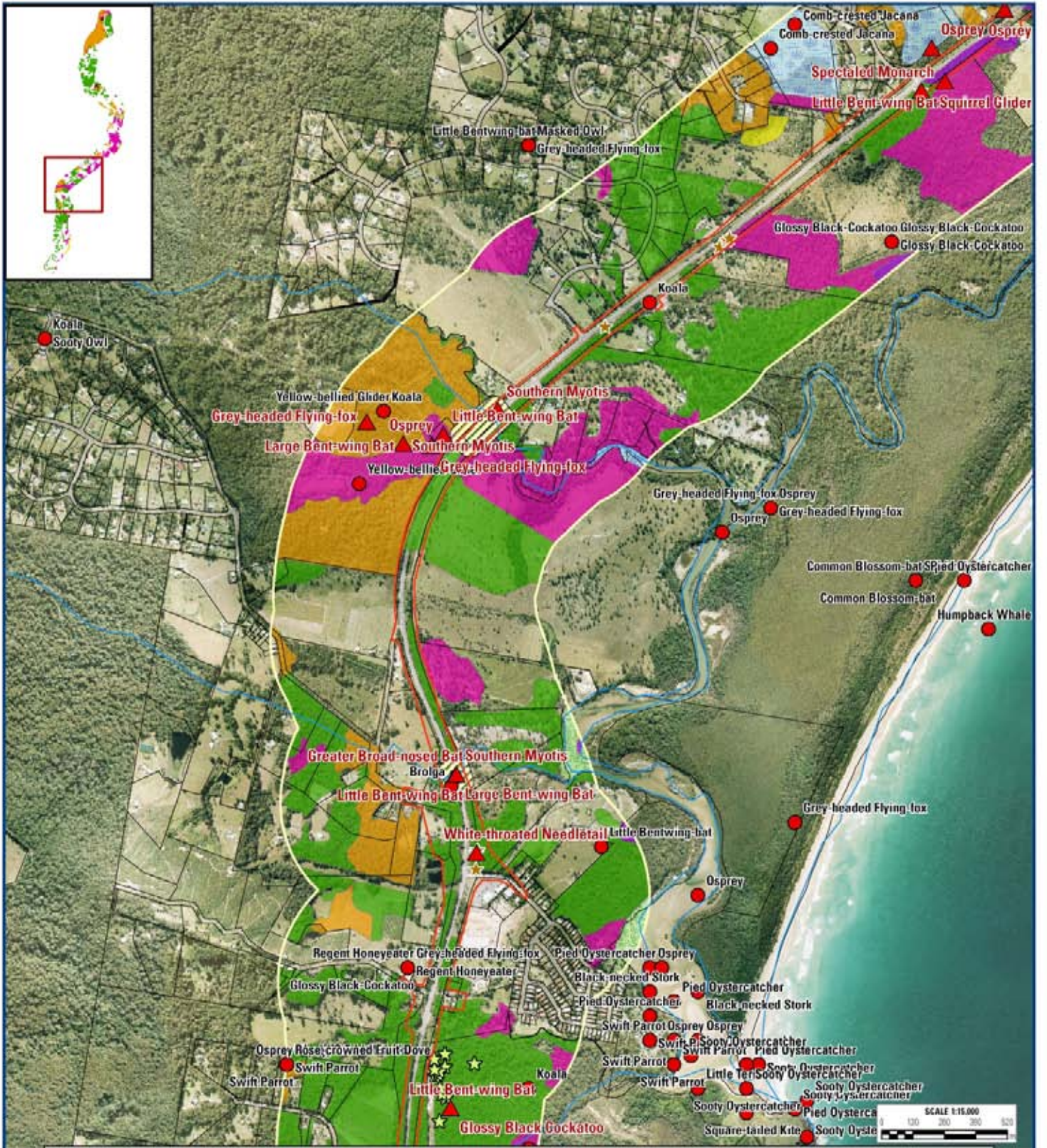
NOTE: sensitive species appear
Not For Public Display

FIGURE 3.1b
THREATENED FAUNA
AND FAUNA HABITAT



NOTE: sensitive species appear
Not For Public Display

FIGURE 3.1c
THREATENED FAUNA
AND FAUNA HABITAT

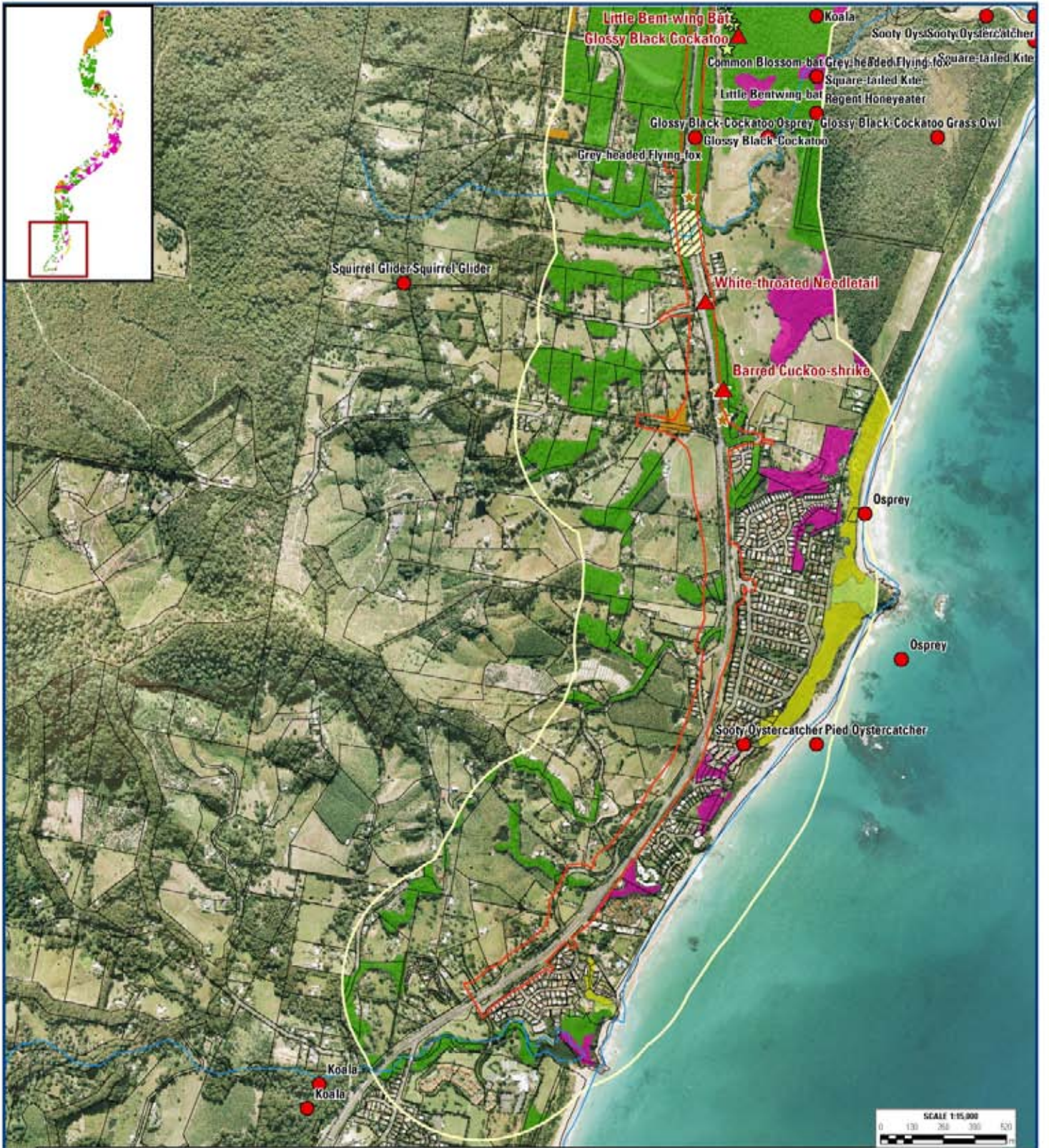


LEGEND

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|---|--------------------------------------|-----------------------------|--------------------------|
| Threatened Fauna Species Connell Wagner Survey | Hollow-bearing Trees | Broad Habitat Types | Swamp Sclerophyll Forest |
| Threatened Fauna Species NPWS July 2005 | Glossy Black Cockatoo Foraging Trees | Coastal Sand Scrub | Plantations |
| Preferred Option | Major Creek | Dry Open Forest | Freshwater Wetland |
| Fauna Survey Study Area | Culvert Habitat | Moist Open Forest | Estuarine |
| Property Boundary | | Natural Grassland | |
| | | Swamp Oak Floodplain Forest | |

SCALE 1:15,000
120 240 360 480





LEGEND

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|---|--------------------------------------|-----------------------------|--------------------------|
| Threatened Fauna Species Connell Wagner Survey | Hollow-bearing Trees | Broad Habitat Types | Swamp Sclerophyll Forest |
| Threatened Fauna Species NPWS July 2005 | Glossy Black Cockatoo Foraging Trees | Coastal Sand Scrub | Plantations |
| Preferred Option | Major Creek | Dry Open Forest | Freshwater Wetland |
| Fauna Survey Study Area | Culvert Habitat | Moist Open Forest | Estuarine |
| Property Boundary | | Natural Grassland | |
| | | Swamp Oak Floodplain Forest | |



jasminoides), Common Mock Olive (*Notelaea longifolia*), Narrow-leaf Palm Lily (*Cordyline stricta*), Lantana and Barb-wire Vine (*Smilax australis*). The understorey is dominated by ferns such as Gristle Fern (*Blechnum cartilagineum*), Rasp Fern (*Doodia aspera*), and Maidenhair Fern (*Adiantum formosusum*), with Ottochloa Grass occurring as a co-dominant. This habitat occurs in small, scattered areas in the north (e.g. Arrawarra Creek and Woolgoolga Creek) and in the south (e.g. Sugar Mill Creek) of the study area, and exhibits moderately high levels of environmental weeds in some areas.

- White Mahogany Open Forest

This sub-type is a tall open forest (15 – 28 m) occurring mostly on mid to upper hill slopes of protected aspect in the northern half of the survey area, mainly north of Woolgoolga Creek Road. The canopy is dominated by White Mahogany (*Eucalyptus acmenoides*), with Grey Gum, Broad-leaved Ironbark and Tallowwood occurring as sub-dominants. The understorey is dominated by Forest Oak, Native Guava (*Eupomatia laurina*), Lantana and Morinda. A mixture of grass and fern species, such as Gristle Fern, Ottochloa Grass, Rasp Fern, Common Mat Rush and Barbed Wire Vine dominate the groundcover.

3.1.3 Rainforest

Rainforest within the study area comprises both Littoral and Lowland Rainforest. A small area (approximately 0.5ha) of Lowland rainforest dominated by Strangler Fig (*Ficus watkinsiana*) and Native Olive (*Olea paniculata*) occurs on the floodplain of Woolgoolga Creek. Brush Cherry (*Syzygium australe*), Silky Myrtle (*Decaspermum humile*), Hard Quandong (*Elaeocarpus obovatus*), and Common Lily Pily (*Acmena smithii*) are also common. This habitat type provides potential foraging habitat for frugivorous (fruit-eating) species such as fruit-doves. Drainage lines provide suitable habitat for various frog species, including terrestrial species such as the Stuttering Frog (*Mixophyes balbus*) and Giant Barred Frog (*Mixophyes iteratus*).

Littoral Rainforest occurs within the study area as a tall to very tall (18-25m) open to closed forest dominated by Brush Box (*Lophostemon confertus*), Guioa (*Guioa semiglauca*), and Native Olive (*Olea paniculata*). It is restricted to a few gullies at the southern end of the corridor at Sapphire Beach within within 0.5km of the sea in an urban area of Coffs Harbour.

Rainforest provides habitat for a wide range of threatened fauna including, but not limited to:

<i>Coracina lineata</i>	Barred Cuckoo-shrike
<i>Cyclopsitta diophthalma</i>	Double-eyed Fig-parrot
<i>Erythroriorchus radiatus</i>	Red Goshawk
<i>Lophoictinia isura</i>	Square-tailed Kite
<i>Monarcha leucotis</i>	White-eared Monarch
<i>Ninox strenua</i>	Powerful Owl
<i>Ptilinopus magnificus</i>	Wompoo Fruit-dove
<i>Ptilinopus regina</i>	Rose-crowned Fruit-dove
<i>Ptilinopus superba</i>	Superb Fruit-dove
<i>Tyto tenebricosa</i>	Sooty Owl
<i>Cercartetus nanus</i>	Eastern Pygmy-possum
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll
<i>Kerivoula papuensis</i>	Golden-tipped Bat
<i>Miniopterus australis</i>	Little Bentwing-bat (foraging only, cave-roosting)
<i>Miniopterus schreibersii</i>	Common Bentwing-bat (foraging only, cave-roosting)
<i>Myotis adversus</i>	Large-footed Myotis
<i>Potorous tridactylus</i>	Long-nosed Potoroo
<i>Pteropus alecto</i>	Black Flying-fox
<i>Scoteanax rueppelli</i>	Greater Broad-nosed Bat
<i>Coeranoscincus reticulatus</i>	Three-toed Snake-tooth Skink
<i>Hoplocephalus bitorquatus</i>	Pale-headed Snake
<i>Hoplocephalus stephensii</i>	Stephens' Banded Snake
<i>Mixophyes balbus</i>	Stuttering Frog
<i>Mixophyes iteratus</i>	Giant Barred Frog

Pteropus poliocephalus

Greyheaded flying fox

3.1.4 Swamp Sclerophyll Forest

Swamp Sclerophyll Forest within the study area occurs on seasonally waterlogged floodplain or swampy creek lines at the edge of coastal hills and the floodplain. It is predominantly characterised by Broad-leaved Paperbark (*Melaleuca quinquenervia*), although small areas are dominated by other species such as Red Mahogany (*Eucalyptus resinifera*) or Smooth-barked Apple (*Angophora leiocarpa*). The canopy is generally low to mid-high (8 to 15 m). This habitat is common along the low-lying central part of the corridor between the Bucca Road and Double Crossing Creek south of Woolgoolga, but also in narrow bands along swampy drainage lines in the north and south of the survey area

Swamp Sclerophyll Forest within the study area provides habitat for a broad range of animals, including many that are dependent on trees for food, nesting or roosting (Law *et al.* 2000). The blossoms of Swamp Mahogany (*Eucalyptus robusta*) and Broad-leaf Paperbark (*Melaleuca quinquenervia*) are also an important food source for the Grey-headed Flying Fox (*Pteropus poliocephalus*) and Common Blossom Bat (*Sycoonycteris australis*) (Law 1994), as well as the Yellow-bellied Glider (*Petaurus australis*), Squirrel Glider (*Petaurus norfolcensis*), Regent Honeyeater (*Xanthomyza phrygia*) and Swift Parrot (*Lathamus discolor*). Other species for which Swamp Sclerophyll Forest provides potential habitat include the Osprey (*Pandion haliaetus*), Australasian Bittern (*Botaurus poiciloptilus*), Large-footed Myotis (*Myotis adversus*), *Litoria olongburensis* and Wallum Froglet (*Crinia tinnula*). Swamp Sclerophyll Forest also provides potential habitat for Koala (*Phascolarctos cinereus*), which feeds on a selection of preferred eucalypt species including Swamp Mahogany.

3.1.5 Swamp Oak Floodplain Forest

This habitat types occurs as a low (8 to 15 m) woodland and open forest with a grassy understorey. The canopy is dominated by Swamp Oak (*Casuarina glauca*). This habitat is limited to the disturbed/previously cleared road reserve between the Emerald Beach intersection and Stony Creek Road, adjacent to Swamp Sclerophyll Forest dominated by Broad-leaf Paperbark.

Unlike most other coastal floodplain communities, Swamp Oak Floodplain Forest is not a significant habitat for waterbirds (Goodrick 1970). However, the Glossy Black Cockatoo (*Calyptorhynchus lathami lathami*) may utilise food resources within this habitat (Marchant & Higgins 1990). Other fauna likely to utilise Swamp Oak Floodplain Forest include the Squirrel Glider (*Petaurus norfolcensis*) and several species of frogs in the families Myobatrachidae (southern frogs) and Hylidae (tree frogs).

3.1.6 Aquatic Habitats

The study area contains several creeks and drainage lines with intact native vegetation, providing shelter/foraging/breeding habitat for frogs including potential habitat for threatened frogs such as Green Thighed Frog (*Litoria brevipalmata*), Giant Barred Frog (*Mixophyes iteratus*) and Stuttering Frog (*M. balbus*). These habitats are also known to be used as foraging habitat by various threatened bat species.

Culverts and bridges crossing the creeklines and drainage lines are also likely to be used as roost sites for cave-dwelling bats, including the threatened *Myotis adversus* (Large-footed Myotis) and *Miniopterus australis* (Little Bent-wing Bat), which were captured in traps located under bridges.

Freshwater wetland habitat within the study area provides suitable habitat for a number of threatened species listed under the TSC Act, particularly threatened wetland birds such as the Comb-crested Jacana (*Irediparra gallinacea*) and Freckled Duck (*Stictonetta naevosa*) and frogs such as Green and Golden Bell Frog (*Litoria aurea*).

Watercourses within the study area, such as creeklines, provide potential habitat for fish. Table 3-3 details the aquatic species, populations and ecological communities listed as 'threatened' under the *Fisheries Management Act 1994* (FM Act), together with their distribution and/or habitat associations.

3.1.7 Estuarine Habitats

One very small area of estuarine vegetation was intersected by the projected footprint in the tidal zone of Double Crossing Creek south of Woolgoolga. Dominant species present included Saltwater Couch (*Sporobolus virginicus*) and Swamp Oak (*Casuarina glauca*).

Coastal Saltmarsh provides habitat for a diverse invertebrate fauna, which includes both marine (crabs and molluscs) and terrestrial (insects and spiders) elements. During tidal flooding a number of fish species utilise saltmarsh habitats. Grazing by macropods may occur between tidal events. Some coastal saltmarshes provide important high tide roosts for migratory wading birds, and a range of other birds also utilise coastal saltmarsh as habitat. Diversity of macrofauna in mangrove forests adjacent to saltmarsh has been found to be greater than in mangroves that do not border saltmarsh (Yerman & Ross 2004)

Figure 3-1: Threatened Fauna and Fauna Habitat

3.2 Fauna Habitats

3.2.1 Hollow-bearing trees

Approximately 197 trees bearing hollows ranging in size from small (less than 10 cm) to large (greater than 30 cm) were recorded during the fauna field survey. Since the entire road footprint was not surveyed the actual number of hollow-bearing trees to be impacted is likely to be greater.

Most of the hollow-bearing trees were recorded within Dry Open Forest along the four kilometre deviation through Wedding Bells State Forest in the north of the study area (Figure 3-1). Most of the hollows in this section were associated with stags (dead standing trees) which had been ring-barked during past forestry management practices.

The range of hollow sizes provides an array of nesting/roosting/shelter habitat for threatened hollow-dependent fauna, including large forest birds such as the Masked Owl, Powerful Owl and Glossy Black-cockatoo (which require large hollows), arboreal mammals such as the Brush-tailed Phascogale, Yellow-bellied Glider and Squirrel Glider (which require small to medium-sized hollows), and hollow-dependent microchiropteran bats which can roost in very small hollows, fissures and crevices.

3.2.2 Foraging resources

Several tree species which flower during winter, including Broad-leaved Paperbark (*Melaleuca quinquenervia*), Tallowwood (*Eucalyptus microcorys*) occur relatively commonly throughout the study area. A number of threatened species require winter flowering species to supply food year-round, or to coincide with migratory movements. As such, the presence or absence of winter flowering species is considered a limiting factor for a number of threatened species. It should be noted that winter flowering is not restricted to these species.

Throughout the study area, smooth-barked eucalypts, such as Spotted Gum (*Corymbia variegata*), Pink Bloodwood (*C. intermedia*), and Grey Gum (*Eucalyptus propinqua*) provide important foraging substrates for Yellow-bellied Glider (*Petaurus australis*) and Squirrel Glider (*P. norfolcensis*).

3.3 Threatened Fauna Species within the Study Area

Of the 156 fauna species recorded in the study area (Appendix B), 13 are listed as threatened under the TSC Act. Only one is also listed as threatened under the EPBC Act. A list of the threatened fauna species recorded in the study area, together with their essential habitat requirements, is provided in Table 3-1. In addition to these threatened species, four bird species listed as 'migratory' under the EPBC Act were recorded. Atlas of NSW Wildlife data indicates that threatened species additional to that recorded during the field surveys have the potential to occur in the study area. An assessment of the potential of these additional species occurring in the study area is provided in Table 3-2.

Frog species are addressed in a separate working paper.

Table 3-1: Essential Habitat Requirements for Threatened Species Recorded in Study Area

Species	Large, contiguous habitats	Winter flowering trees	Tree Hollows	Specialist Habitat
Birds				
Glossy Black-Cockatoo (<i>Calyptorhynchus lathamii</i>)			√	<i>Allocasuarina</i> sp.
Barred-Cuckoo-shrike (<i>Coracina lineata</i>)				<i>Rainforest</i>
Osprey (<i>Pandion heliaetus</i>)				<i>Tall stags; shallow estuaries containing suitable fish 25-30cm</i>
Nocturnal Birds				
Powerful Owl (<i>Ninox strenua</i>)			√	

Table 3-1: Essential Habitat Requirements for Threatened Species Recorded in Study Area

Species	Large, contiguous habitats	Winter flowering trees	Tree Hollows	Specialist Habitat
Mammals (excluding bats)				
Eastern Pygmy-possum (<i>Cercartetus nanus</i>)		√	√	
Squirrel Glider (<i>Petaurus norfolcensis</i>)		√	√	
Yellow-bellied Glider (<i>Petaurus australis</i>)		√	√	
Bats				
Grey-headed Flying-Fox (<i>Pteropus poliocephalus</i>)		√		
Large-footed Myotis (<i>Myotis adversus</i>)				Water bodies, roost sites in culverts & under bridges
Little Bent-wing Bat (<i>Miniopterus australis</i>)				roost sites in culverts & under bridges
Large Bent-wing Bat (<i>Miniopterus schreibersii</i>)				roost sites in culverts & under bridges
Greater Broad-nosed Bat (<i>Scoteanax rueppellii</i>)			√	
Common Blossom Bat (<i>Syconycteris australis</i>)		√		Combination of heath and coastal rainforest

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
REPTILES					
<i>Coeranoscincus reticulatus</i>	Three-toed Snake-tooth Skink	V	V	Inhabits rainforests and adjacent wet sclerophyll forests, where it is usually found in rotting logs or under fallen timber (Cogger 2000).	Potential. Suitable habitat present.
<i>Emydura signata</i>	Bellinger River Emydura	V	V	Restricted to the Bellinger River NSW	Unlikely. Outside known distribution.
<i>Hoplocephalus stephensii</i>	Stephen's Banded Snake	V	—	Found in a variety of habitats from rainforest through wet and moist sclerophyll forests to dry sclerophyll forests (NPWS 2005e). However it is most commonly found in wet to moist forests with rocky outcrops, cliffs or ridges and tends to favour ecotones between wet and dry forests (NPWS 2005e). It most frequently uses gaps in the peeling bark of large senescent or dead trees for daytime shelter (NPWS 2005e). However it can use hollow trunks, limbs, epiphytes, vine thickets, rock crevices or rock slabs (NPWS 2005e).	Unlikely. Rocky outcrops, cliffs and ridges absent from study area.
DIURNAL BIRDS					
<i>Calidris alba</i>	Sanderling	V	—	Occur in coastal areas on low beaches, near reefs and inlets along tidal mudflats and bare open coastal lagoons (NPWS 1999a). Rarely seen in near-coastal wetlands such as lagoons, hypersaline lakes, saltponds and samphire flats (NPWS 1999a)	Low Potential. Potential habitat near Double Crossing Creek.
<i>Calidris tenuirostris</i>	Great Knot	V	—	Sheltered coastal habitats containing large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons (NPWS 1999q). Often recorded on sandy beaches with mudflats nearby, sandy spits and inlets, or exposed reefs or rock platforms (Morris 1989; Higgins & Davies 1996).	Low Potential. Potential habitat near Double Crossing Creek.
<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	V	—	During summer in dense, tall, wet forests of mountains and gullies, alpine woodlands (Morcombe 2004). In winter they occur at lower altitudes in drier more open forests and woodlands, particularly box-ironbark assemblages (Shields & Chrome 1992). They sometimes inhabit woodland, farms and suburbs in autumn/winter (Simpson & Day 2004).	Unlikely. Suitable habitat absent.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V	—	Associated with a variety of forest types containing <i>Allocasuarina</i> species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000, NPWS 1997, NPWS 1999b). Intact drier forest types with less rugged landscapes are preferred (NPWS 1999b). Nests in large trees with large hollows (Environment Australia 2000).	Recorded in study area.
<i>Charadrius leschenaultii</i>	Greater Sand Plover	V	—	Entirely coastal in NSW, foraging on intertidal sand and mudflats in estuaries, roosting during high tide on sandy beaches or rocky shores (NPWS 1999c)	Low Potential. Potential habitat near Double Crossing Creek.
<i>Climacteris picumnus</i> <i>Climacteris picumnus victoriae</i>	Brown Treecreeper Brown Treecreeper (eastern subspecies)	V V	— —	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. The Brown Treecreeper occupies eucalypt woodlands, particularly open woodland lacking a dense understorey. It is sedentary and nests in tree hollows within permanent territories. (NSW Scientific Committee 2001a).	Potential. Suitable habitat present.
<i>Coracina lineata</i>	Barred Cuckoo-shrike	V	—	Associated with subtropical, dry and littoral rainforests and is restricted to below 500m elevation (NPWS 2005f).	Recorded in study area.
<i>Cyclopsitta diophthalma coxeni</i>	Coxen's Double-eyed Fig-Parrot	E	E	Associated with upland (to 1200masl) to lowland rainforests, tropical semi-deciduous vine thickets and gallery forests, usually containing fig trees (Marchant & Higgins 1993). Probably prefer subtropical lowland rainforest (Holmes 1994). Usually in large tracks of forests, particularly near edges, rarely in partly cleared or fragmented rainforest (Marchant & Higgins 1993).	Potential. Suitable habitat present.
<i>Dromaius novaehollandiae</i> NSW North Coast Bioregion and Port Stephens LGA Population	Emu	E2	—	Occupies a range of mainly open habitats including plains, grasslands, woodlands, shrubs and occasionally forest (NSW Scientific Committee 2002a). Not found in rainforest (Simpson & Day 1999).	Potential. Suitable habitat present.
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	E	—	Associated with tropical and warm temperate terrestrial wetlands,	Potential. Suitable habitat

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				estuarine and littoral habitats, and occasionally woodlands and grasslands floodplains (Marchant & Higgins 1993). Forages in fresh or saline waters up to 0.5m deep, mainly in open fresh waters, extensive sheets of shallow water over grasslands or sedgeland, mangroves, mudflats, shallow swamps with short emergent vegetation and permanent billabongs and pools on floodplains (Marchant & Higgins 1993; NPWS 2005g).	present.
<i>Erythrotriorchis radiatus</i>	Red Goshawk	E	V	Associated with forests and woodlands with a mosaic of vegetation types, an abundance of birds and permanent water. In NSW, this species is thought to favour mixed subtropical rainforest, Melaleuca Swamp Forest, and open eucalypt forest along rivers, often in rugged terrain (Marchant & Higgins 1993; NPWS 1999e).	Potential. Suitable habitat present.
<i>Esacus neglectus</i>	Beach Stone-curlew	E	—	Beaches, mudflats, reefs and especially islands (Blakers et al. 1984). Open undisturbed beaches, islands, reefs, intertidal sand and mudflats, preferably with estuaries or mangroves nearby (NPWS 1999f).	Low Potential. Potential habitat near Double Crossing Creek.
<i>Grantiella picta</i>	Painted Honeyeater	V		Associated with dry woodland / forest habitats. Woodlands, which are laden with Mistletoes (esp. <i>Amyema spp.</i>), are particularly important as this species feeds almost exclusively on mistletoe nectar and fruit (Environment Australia 2000).	Unlikely. Suitable habitat absent.
<i>Grus rubicundus</i>	Brolga	V	—	During breeding season mostly near shallow freshwater marshes or freshwater meadows (Marchant & Higgins 1993). During non-breeding seasons congregates near deep, permanent freshwater marshes, mostly foraging in nearby field, pastures and fallow fields and occasionally foraging in littoral zones of marshes (Marchant & Higgins 1993).	Unlikely. Preferred habitat absent from study area.
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V	—	A coastal species that inhabits rock coastlines, coral cays, reefs and occasionally sandy beaches (Marchant & Higgins 1993; Simpson & Day 1999).	Unlikely. Suitable habitat absent from study area.
<i>Haematopus longirostris</i>	Pied Oystercatcher	V	—	Roosts and forages on sandy beaches, sand banks, mudflats and	Low Potential. Potential habitat

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				estuaries (Marchant & Higgins 1993, Simpson & Day 1999).	near Double Crossing Creek.
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard	V	—	Open forests, riverine woodlands, scrubs and heathlands of inland areas(Simpson & Day 1999).	Unlikely. Preferred habitat absent from the study area.
<i>Irediparra gallinacea</i>	Comb-crested Jacana	V	—	Freshwater wetlands, such as lagoons, billabongs, swamps, lakes and reservoirs, generally with abundant floating aquatic vegetation (Marchant & Higgins 1993).	Potential. Suitable habitat present.
<i>Ixobrychus flavicollis</i>	Black Bittern	V	—	Occurs in both terrestrial and estuarine wetlands generally in areas of permanent water and dense vegetation (NPWS 1999g). In areas with permanent water it may occur in flooded grassland, forest, woodland, rainforest and mangroves (NPWS 1999g)	Unlikely. Preferred habitat absent from the study area.
<i>Lathamus discolor</i>	Swift Parrot	E	E	Associated with dry open eucalypt forests and woodlands with winter flowering eucalypts (Marchant & Higgins 1993). Often located in urban areas and farmlands with remnant eucalypts.	Potential. Suitable habitat present.
<i>Lichenostomus fasciocularis</i>	Mangrove Honeyeater	V	—	Lives in mangroves, frequently visiting flowering shrubs in towns adjacent to mangroves. Spends some of its' time feeding close to the mud in mangroves (Blakers et al. 1984; NPWS 2005h).	Low Potential. Potential habitat near Double Crossing Creek.
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	V	—	Known to favour estuarine mudflats, saltmarshes and reefs as feeding and roosting habitat (NPWS 1999r). In NSW this species tends to favour intertidal sand and mudflats in estuaries (Smith 1991).	Low Potential. Potential habitat near Double Crossing Creek.
<i>Limosa limosa</i>	Black-tailed Godwit	V	—	Primarily found along the coast on sandspits, lagoons and mudflats (NPWS 1999s). The species has also been found to occur inland on mudflats or shallow receding waters of portions of large muddy swamps or lakes (Pizzey & Knight 1997; Higgins & Davies 1996).	Low Potential. Potential habitat near Double Crossing Creek.
<i>Lophoictinia isura</i>	Square-tailed Kite	V	—	In coastal areas associated with tropical and temperate forests and woodlands on fertile soils with an abundance of passerine birds (Marchant & Higgins 1993, NPWS 1999h). May be recorded inland along timbered watercourses (NPWS 1999h). In NSW it is commonly associated with ridge or gully forests dominated by Woollybutt	Potential. Suitable habitat present.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				(<i>Eucalyptus logiflora</i>), Spotted Gum (<i>E. maculata</i>), or Peppermint Gum (<i>E. elata</i> , <i>E. smithii</i>) (NPWS 1999h).	
<i>Melanodryas cucullata</i> <i>Melanodryas cucullata cucullata</i>	Hooded Robin Hooded Robin (southeastern subspecies)	V	—	Associated with a wide range of Eucalypt woodlands, Acacia shrubland and open forests (Blakers et al. 1984). In temperate woodlands, the species favours open areas adjoining large woodland blocks, with areas of dead timber and sparse shrub cover (NSW Scientific Committee 2001b). Hooded Robin home ranges are relatively large, averaging 18ha for birds from the New England Tableland (NSW Scientific Committee 2001b).	Potential. Suitable habitat present.
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V	—	Predominantly associated with box-ironbark association woodlands and River Red Gum (NSW Scientific Committee 2001c). Also associated with drier coastal woodlands of the Cumberland Plain and the Hunter, Richmond and Clarence Valleys (NSW Scientific Committee 2001c).	Unlikely. Preferred habitat absent.
<i>Monarcha leucotis</i>	White-eared Monarch	V	—	Associated with lowland subtropical rainforest edges and remnants; littoral and floodplain rainforest, swamp sclerophyll with mesomorphic mid storey, coastal wet sclerophyll (Environment Australia 2000; NPWS 2005). It is thought to avoid moving into small remnants; preferring to move through areas of continuous forest (Environment Australia 2000).	Potential. Suitable habitat present.
<i>Pandion haliaetus</i>	Osprey	V	—	Associated with waterbodies including coastal waters, inlets, lakes, estuaries, beaches, offshore islands and sometimes along inland rivers (Schodde & Tidemann 1986; Clancy 1991; Olsen 1995). Osprey may nest on the ground, on sea cliffs or in trees (Olsen 1995). Osprey generally prefer emergent trees, often dead or partly dead with a broken off crown (Olsen 1995).	Recorded in study area.
<i>Pezoporus wallicus wallicus</i>	Ground Parrot (eastern subspecies)	V	—	Predominantly restricted to coastal heath and sedgeland that provide a high density of cover and food foraging resources (Blakers et al. 1984; Simpson & Day 1999).	Unlikely. Suitable habitat absent.
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler	V	—	Open woodlands dominated by mature eucalypts with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs (NSW Scientific	Unlikely. Suitable habitat

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
<i>temporalis</i>	(eastern subspecies)			Committee 2001d). This species avoids very wet areas (Blakers et al. 1984).	absent.
<i>Ptilinopus magnificus</i>	Wompoo Fruit-Dove	V	—	Associated with large, undisturbed patches of tall tropical or subtropical rainforest, at all altitudes, preferably with a diversity of fruit (Marchant & Higgins 1993; NPWS 2005k). Occasionally located in patches of monsoon rainforest, closed gallery forest, wet sclerophyll forest, tall open forest, open woodland or vine thickets near rainforest (Marchant & Higgins 1993; NPWS 2005k).	Low Potential. Marginal habitat present. Local records.
<i>Ptilinopus regina</i>	Rose-crowned Fruit-Dove	V	—	Tall tropical and subtropical, evergreen or semi-deciduous rainforests, especially with a dense growth of vines trees (Marchant & Higgins 1993). Also located in closed wet sclerophyll forest, gallery forests or sclerophyll woodlands with abundant fruiting trees, near or next to rainforest (NPWS 2005l). Is thought to prefer large areas of vegetation, but has been located in patches and occasionally in parks and gardens with fruiting trees (Marchant & Higgins 1993).	Potential. Suitable habitat present.
<i>Ptilinopus superbus</i>	Superb Fruit-Dove	V	—	Lives mainly within rainforests but will feed in adjacent mangroves or eucalypt forests (Blakers et al. 1984). Nests are well hidden within the rainforest habitat and are built in trees from 10 to 30m off the ground (Recher et al. 1995).	Potential. Suitable habitat present.
<i>Rostratula benghalensis australis</i>	Painted Snipe (Australian subspecies)	E	—	Shallow fresh water for breeding (Blakers et al. 1984) forages in marshes with moderate cover (Simpson & Day 1999).	Unlikely. Suitable habitat absent.
<i>Rostratula australis</i>	Australian Painted Snipe	—	V		
<i>Sterna albifrons</i>	Little Tern	E	—	Almost exclusively coastal, preferring sheltered areas (NPWS 1999o), however may occur several kilometres inland in harbours, inlets and rivers (Smith 1990). Australian birds breed on sandy beaches and sand	Unlikely. Suitable habitat absent.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				spits (Simpson & Day 1999).	
<i>Sterna fuscata</i>	Sooty Tern	V	—	Forages offshore, usually only observed onshore in breeding season or when storms force them to shelter (NPWS 1999p)	Unlikely. Suitable habitat absent.
<i>Stictonetta naevosa</i>	Freckled Duck	V	—	Associated with a variety of wetlands, such as heavily vegetated, large open lakes and their shores, creeks, farm dams, sewerage ponds and floodwaters (NPWS 1999u).	Potential. Suitable habitat present.
<i>Todiramphus chloris</i>	Collared Kingfisher	V	—	Virtually confined to mangrove lined sheltered coastal embayment, inlets, estuaries and adjacent tidal flats (Marchant & Higgins 1993).	Unlikely. Suitable habitat absent.
<i>Turnix melanogaster</i>	Black-breasted Button-quail	E	V	Dry rainforests, vine scrub or lantana thickets (Marchant & Higgins 1993). In NSW the species inhabits dry or subtropical forests which contain Brigalow, Belah, Bottletrees, Hoop Pine, Lantana, Ironbark, Wattle, Spotted Gum, Wallaby Grass or Rhodes Grass (Bennett 1985; Hughes & Hughes 1991). Observations in Lantana thickets and hoop pine plantations indicate this species may be able to utilise human modified (Blakers et al. 1984).	Potential. Suitable habitat present.
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E	E	Associated with temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts, and riparian forests of River Oak (<i>Casuarina cunninghamiana</i>) (Garnett 1993). Areas containing Swamp Mahogany (<i>Eucalyptus robusta</i>) in coastal areas have been observed to be utilised (NPWS 1997). The Regent Honeyeater primarily feeds on nectar from box and ironbark eucalypts and occasionally from banksias and mistletoes (NPWS 1995). As such it is reliant on locally abundant nectar sources with different flowering times to provide reliable supply of nectar (Environment Australia 2000).	Potential. Suitable habitat present.
NOCTURNAL BIRDS					
<i>Botaurus poiciloptilus</i>	Australasian Bittern	V	—	Terrestrial wetlands with tall dense vegetation, occasionally estuarine habitats (Marchant & Higgins 1993). Reedbeds, swamps, streams,	Unlikely. Suitable habitat absent.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				estuaries (Simpson & Day 2004).	
<i>Burhinus grallarius</i>	Bush Stone-curlew	E	—	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Pittwater Council 2000; Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed to lightly disturbed areas.	Unlikely. Suitable habitat absent.
<i>Ninox connivens</i>	Barking Owl	V	—	Associated with a variety of habitats such as savanna woodland, open eucalypt forests, wetland and riverine forest. The habitat is typically dominated by Eucalypts (often Redgum species), however often dominated by <i>Melaleuca</i> species in the tropics (NPWS 2003). It usually roosts in dense foliage in large trees such as River She-oak (<i>Allocasuarina cunninghamiana</i>), other <i>Casuarina</i> and <i>Allocasuarina</i> , eucalypts, <i>Angophora</i> , <i>Acacia</i> and rainforest species from streamside gallery forests (NPWS 2003). It usually nests near watercourses or wetlands (NPWS 2003) in large tree hollows with entrances averaging 2-29 metres above ground, depending on the forest or woodland structure and the canopy height (Debus 1997).	Unlikely. No records from Atlas of NSW Wildlife or EPBC Act Protected Matters Report, targeted during owl call surveys, with no response.
<i>Ninox strenua</i>	Powerful Owl	V	—	Powerful Owls are associated with a wide range of wet and dry forest types with a high density of prey, such as arboreal mammals, large birds and flying foxes (Environment Australia 2000, Debus & Chafer 1994). Large trees with hollows at least 0.5m deep are required for shelter and breeding (Environment Australia 2000).	Recorded in study area.
<i>Tyto capensis</i>	Grass Owl	V	—	Reported habitats include tall grass, swampy, sometimes tidal areas, mangrove fringes, grassy plains, coastal heaths, grassy woodland, cane grass, lignum, sedges, cumbungi, cane fields and grain stubble (Pizzey & Knight 1997). The Grass Owl nests on the ground within dense tall grass,	Unlikely. Suitable habitat absent.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				sedges, reeds and even sugarcane plantations (Pizzey & Knight 1997). The Grass Owl primarily feeds on rodents, hunting on the wing over heathland, grassland and sedgeland, as well as along the edge of sugar cane, crops and pastureland (Pizzey & Knight 1997).	
<i>Tyto novaehollandiae</i>	Masked Owl	V	—	Associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland (NPWS 2005m) and especially the ecotone between wet and dry forest, and non forest habitat (Environment Australia 2000). Known to utilise forest margins and isolated stands of trees within agricultural land (Hyem 1979) and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained (Kavanagh & Peake 1993).	Potential. Suitable habitat present.
<i>Tyto tenebricosa</i>	Sooty Owl	V	—	Sooty Owls are associated with tall wet old growth forest on fertile soil with a dense understorey and emergent tall Eucalyptus species (Environment Australia 2000, Debus 1994). Pairs roost in the daytime amongst dense vegetation, in tree hollows and sometimes in caves. The Sooty Owl is typically associated with an abundant and diverse supply of prey items and a selection of large tree hollows (Debus 1994, Garnett 1993, Hyem 1979).	Unlikely. Suitable habitat absent.
MAMMALS (EXCLUDING BATS)					
<i>Aepyprymnus rufescens</i>	Rufous Bettong	V	—	Prefer forests with a grassy to sparse understorey including coastal forest, tall wet sclerophyll forest and dry forests west of Great Dividing Range (NPWS 2005n). It is most commonly found on sites derived from sedimentary rock and in north eastern NSW in forests characterised by Spotted Gum (<i>Corymbia maculata</i> and <i>C. henryi</i>) (NPWS 2005n). It has been known to feed on introduced pasture species (NPWS 2005n).	Potential. Suitable habitat present.
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	—	Found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath (Menkhorst & Knight 2004). Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit	Recorded in study area.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				(Turner & Ward 1995). The presence of <i>Banksia</i> sp. and <i>Leptospermum</i> sp. are an important habitat feature (NPWS 2005v). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old birds nests and in the branch forks of tea-trees (Turner & Ward 1995).	
<i>Dasyurus maculatus</i> <i>Dasyurus maculatus maculatus</i>	Spotted-tailed Quoll Spotted-tailed Quoll (SE Mainland Population)	V —	— E	The Spotted-tailed Quoll inhabits a range of forest communities including wet and dry sclerophyll forests, coastal heathlands and rainforests (Mansergh 1984; NPWS 1999j), more frequently recorded near the ecotones of closed and open forest. This species requires habitat features such as maternal den sites, an abundance of food (birds and small mammals) and large areas of relatively intact vegetation to forage in (NPWS 1999j). Maternal den sites are logs with cryptic entrances; rock outcrops; windrows; burrows (Environment Australia 2000).	Potential. Suitable habitat present.
<i>Petaurus australis</i>	Yellow-bellied Glider	V	—	This species is restricted to tall mature forests, preferring productive tall open sclerophyll forests with a mosaic of tree species including some that flower in winter (Environment Australia 2000, Braithwaite 1984, Davey 1984, Kavanagh 1984; NPWS 1999k). Large hollows within mature trees are required for shelter, nesting and breeding (Henry & Craig 1984; NPWS 1999k).	Recorded in study area.
<i>Petaurus norfolcensis</i>	Squirrel Glider	V	—	Associated with dry hardwood forest and woodlands (Menkhorst et al. 1988; Quinn 1995). Habitats typically include gum barked and high nectar producing species, including winter flower species (Menkhorst et al. 1988). The presence of hollow bearing eucalypts is a critical habitat value (Quinn 1995).	Recorded in study area.
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	E	V	Rocky areas in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices (Strahan 1998).	Unlikely. Suitable habitat absent.
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	V	—	Preferred habitat is Dry Open forest with a sparse open understorey, however, has been located in heath, swamps and rainforest and wet sclerophyll forest (NPWS 1999l).	Potential. Suitable habitat present.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
<i>Phascolarctos cinereus</i>	Koala	V	—	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70% (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred <i>Eucalyptus</i> species are: <i>Eucalyptus tereticornis</i> , <i>E. punctata</i> , <i>E. cypellocarpa</i> , <i>E. viminalis</i>	Potential. Suitable habitat present.
<i>Potorous tridactylus</i>	Long-nosed Potoroo	V	—	Associated with dry coastal heath and dry and wet sclerophyll forests (Strahan 1998) with dense cover for shelter and adjacent more open areas for foraging (Menkhorst & Knight 2004).	Potential. Suitable habitat present.
<i>Potorous tridactylus tridactylus</i>	Long-nosed Potoroo (SE Mainland Population)	—	V		
<i>Pseudomys oralis</i>	Hastings River Mouse		E	Open forest or woodland with a grassy sedge rush or heath understorey that is about 10-75cm above the ground (NPWS 2003a). Shelter areas such as rock piles, hollow logs, yabby burrows or cavities in the butts of large old trees are also required to be present (NPWS 2003a). Preferred habitat is in minor drainage lines, swamps, seepages, grassy flats with good soil moisture (at least seasonally) (NPWS 2003a).	Potential. Suitable habitat present.
BATS					
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; NPWS 2005p). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998; NPWS 2005p).	Potential. Suitable foraging habitat present.
<i>Chalinolobus nigrogriseus</i>	Hoary Wattled Bat	V	—	The preferred habitat of this species appears to be variable, with dry open forest, woodland, vine thickets, coastal scrub, sand dunes, grasslands and floodplains recorded (Churchill 1998). This species often forages along watercourses, swampy areas and over farm dams. In NSW, this species has been recorded in Spotted Gum (<i>Corymbia maculata</i>), Grey Box (<i>Eucalyptus moluccana</i>) and Northern Ironbark (<i>E. siderophloia</i>) and woodland characterised by Scribbly Gums (<i>E. signata</i>) and Pink	Potential. Suitable habitat present.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				Bloodwood (<i>C. intermedia</i>) and sites dominated by the Blackbutt (<i>E. pilularis</i>) (Churchill 1998). Roost sites have been identified as tree hollows, rock crevices and the roofs of buildings (Churchill 1998).	
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	—	This species is associated with forested areas with higher rainfall (Parnaby 1998), and has been located from the highlands to the coast, appearing to be less common at low altitudes, and tending to favour the cool moist forests of the ranges (Phillips 1998). While the Eastern False Pipistrelle roosts primarily in tree trunk hollows, individuals have also be found in caves and abandoned buildings (Klippel 1992).	Potential. Suitable habitat present.
<i>Kerivoula papuensis</i>	Golden-tipped Bat	V	—	The most favoured habitat for this species is moist closed forests often with a rainforest influence, however, some captures have been made in dry forests some distance from any rainforest (Lunney & Barker 1986; Parnaby & Mills 1994). It has been suggested that the amount of vines and complex tree layers allows for increased numbers of spiders and webs and such areas are sought by the Golden-tipped Bat (Schulz & Eyre 2000). This species is often caught over streams within rainforest are known to frequently roost within the pendulous nests of Yellow-throated and Large-billed Scrub Wrens and Brown Gerygone in such areas. (Schulz & Eyre 2000).	Potential. Suitable habitat present.
<i>Miniopterus australis</i>	Little Bent-wing Bat	V	—	Prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, <i>Melaleuca</i> swamps and coastal forests (Churchill 1998). This species shelter in a range of structures including culverts, drains, mines and caves (Environment Australia 2000). Relatively large areas of dense vegetation of either wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (NPWS 2005q). Breeding occurs in caves, usually in association with <i>M. schreibersii</i> (Environment Australia 2000, NPWS 2005q).	Recorded in study area.
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bent-wing Bat	V	—	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and	Recorded in study area.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				open grassland (Churchill 1998). It forages above and below the tree canopy on small insects (AMBS 1995, Dwyer 1995, Dwyer 1981). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000, Dwyer 1995).	
<i>Mormopterus norfolkensis</i>	East Coast Freetail Bat	V	—	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges (Environment Australia 2000; Allison & Hoyer 1998). Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoyer 1998).	Potential. Suitable habitat present.
<i>Myotis adversus</i>	Large-footed Myotis	V	—	Will occupy most habitat types such as mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland, as long as they are close to water (Churchill 1998). While roosting is most commonly associated with caves, this species has been observed to roost in tree hollows, amongst vegetation, in clumps of <i>Pandanus</i> , under bridges, in mines, tunnels and stormwater drains (Churchill 1998). However the species apparently has specific roost requirements, and only a small percentage of available caves, mines, tunnels and culverts are used (Richards 1998).	Recorded in study area.
<i>Nyctophilus bifax</i>	Eastern Long-eared Bat	V	—	This species prefers wetter habitats, ranging from rainforest and monsoon forest to riverine forests of paperbark, but may be found in open woodland, tall open forest and dry sclerophyll woodland (Churchill 1998). These forest bats have been recorded roosting under peeling bark, among epiphytes, in tree hollows and in foliage (Churchill 1998). Individuals are likely to change roost sites nightly (NPWS 2005r).	Potential. Suitable habitat present.
<i>Pteropus alecto</i>	Black Flying-Fox	V	—	Mangroves, paperbark forests and occasionally patches of rainforest are most commonly utilised for camp sites (Strahan 1998; Churchill 1998).	Potential. Suitable habitat present.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				They have been found to occupy a range of habitats of tropical and sub-tropical forests and woodlands (Churchill 1998). Preferred food includes blossoms (such as eucalypts, paperbarks and turpentine), also introduced fruits and blossoms (Strahan 1998).	
<i>Pteropus poliocephalus</i>	Grey-headed Flying-Fox	V	V	Inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1998). Camps are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998).	Recorded in study area.
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail-bat	V	—	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies. Roosts in tree hollows; may also use caves; has also been recorded in a tree hollow in a paddock (Environment Australia 2000) and in abandoned sugar glider nests (Churchill 1998). The Yellow-bellied Sheathtail-bat is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000).	Potential. Suitable habitat present.
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	—	Associated with moist gullies in mature coastal forest, or rainforest, east of the Great Dividing Range (Churchill 1998), tending to be more frequently located in more productive forests (Hoye & Richards 1998). Within denser vegetation types use is made of natural and man made openings such as roads, creeks and small rivers, where it hawks backwards and forwards for prey (Hoye & Richards 1998).	Recorded in study area.
<i>Syconycteris australis</i>	Eastern Blossom-bat	V	—	The combination of heathland and coastal rainforest is essential for this species (Churchill 1998). Breeding and sheltering habitats are in subtropical and littoral rainforests and a diverse range of nectar producing plant communities are required year round; it will occasionally eat some rainforest fruits (Churchill 1998; Environment Australia 2000).	Recorded in study area.
<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V	—	Inhabit tropical mixed woodland and wet sclerophyll forest on the coast and the dividing range but extend into the drier forest of the western	Potential. Suitable habitat present.

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V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				slopes and inland areas” (Churchill 1998). “Has been found roosting in sandstone overhand caves, boulder piles, mine tunnels and occasionally in buildings” (Churchill 1998).	
INVERTEBRATES					
<i>Petalura gigantea</i>	Giant Dragonfly	E	—	Swamps, streamlines and seepages in mainly natural condition with short to moderate vegetation and a relatively deep soil base (Trueman 2005). Larvae permanently burrow into soil and so do not survive in permanent ponds or other open water (Trueman 2005).	Unlikely. Suitable habitat absent.
<i>Phyllodes imperalis</i> (Southern subspecies)	A moth	E	E	Lower montane rainforests from QLD to NSW, where larvae appear to be dependent on the vine <i>Carronia multiseptata</i> (NSW Scientific Committee 2004). Breeding habitat is considered to be restricted to undisturbed old growth subtropical rainforest below 600m altitude (NSW Scientific Committee 2004)	Unlikely. Suitable habitat absent.
MIGRATORY SPECIES LISTED UNDER EPBC ACT					
<i>Gallinago hardwickii</i>	Latham’s Snipe	—	M	A variety of permanent and ephemeral wetlands, preferring open fresh water wetlands with nearby cover (Marchant & Higgins 1993). Occupies a variety of vegetation around wetlands (Marchant & Higgins 1993) including wetland grasses and open wooded swamps (Simpson & Day 1999).	Unlikely. Suitable habitat absent.
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	—	M	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins 1993).	Recorded in study area.
<i>Hirundapus caudacutus</i>	White-throated Needletail	—	M	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Marchant & Higgins 1993; Simpson & Day 1999). Has been observed	Recorded in study area.

Table 3-2: Assessment of Occurrence of Threatened Fauna Species

V – Vulnerable E – Endangered M – Migratory

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Occurrence
		TSC Act	EPBC Act		
				roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Marchant & Higgins 1993).	
<i>Monarcha melanopsis</i>	Black-faced Monarch	—	M	Rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al. 1984).	Potential. Suitable habitat present.
<i>Monarcha trivirgatus</i>	Spectacled Monarch	—	M	Wet forests, mangroves (Simpson & Day 1999).	Recorded in study area.
<i>Myiagra cyanoleuca</i>	Satin Flycatcher	—	M	Associated with drier eucalypt forests, absent from rainforests (Blakers et al. 1984), open forests, often at height (Simpson & Day 1999).	Potential. Suitable habitat present.
<i>Rhipidura rufifrons</i>	Rufous Fantail	—	M	Wet forests, less often open forests (Simpson & Day 1999)	Recorded in study area.
<i>Rostratula benghalensis</i>	Painted Snipe	—	M	Shallow fresh water for breeding (Blakers et al. 1984) forages in marshes with moderate cover (Simpson & Day 1999).	Unlikely. Suitable habitat absent.

E = Endangered

E2 = Endangered population

V = Vulnerable

M = Migratory

Disclaimer: Data extracted from the Atlas of NSW Wildlife are only indicative and cannot be considered a comprehensive inventory. In recognising this, a literature review complemented by appropriate field survey has been undertaken that targets a larger number of species than is listed in Table 3-2.

3.3.1 Threatened Species Listed under Fisheries Management Act 1994

Watercourses within the study area, such as creeklines, provide potential habitat for fish. Table 2-1 details the aquatic species, populations and ecological communities listed as 'threatened' under the *Fisheries Management Act 1994* (FM Act), together with their distribution and/or habitat associations.

Table 3-3: Aquatic Species, Populations & Ecological Communities listed as Threatened on FM Act 1994

Common Name	Scientific Name	Distribution/Habitat Association ¹
<i>Schedule 4: Endangered species, populations and ecological communities and species presumed extinct</i>		
Eastern Freshwater Cod	<i>Maccullochella ikei</i>	Clarence and Richmond river systems in north-eastern NSW.
Green Sawfish	<i>Pristis zijsron</i>	Estuaries and shallow coastal waters around south-east Asia and northern Australia.
Grey Nurse Shark	<i>Carcharias taurus</i>	Deep gutters (15-40m) around rocky outcrops, bomboras and reefs along the entire coast.
Murray Hardyhead	<i>Craterocephalus fluviatilis</i>	Inland rivers and streams in southern NSW and northern Victoria.
Oxleyan Pygmy Perch	<i>Nannoperca oxleyana</i>	Small streams and lakes in coastal heath in south-eastern Queensland and north-eastern NSW.
River Snail	<i>Notopala sublineata</i>	Flowing water in inland areas.
Southern Bluefin Tuna	<i>Thunnus maccoyii</i>	Marine
Trout Cod	<i>Maccullochella macquariensis</i>	Inland rivers and streams in southern NSW and northern Victoria.
Western population of Purple Spotted Gudgeon (<i>Mogurnda adspersa</i>)		Inland areas (the Murray-Darling).
Western population of Olive Perchlet (<i>Ambassis agassizii</i>)		Inland areas (the Murray-Darling). In inland areas, found only at a few sites in the Darling drainage.
Aquatic ecological community in the natural drainage system of the lower Murray River catchment.		
Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River.		
Bennetts seaweed	<i>Vanvoorstia bennettiana</i>	Historical records (dated 1855 and 1886) for two localities in Port Jackson, Sydney Harbour. Only known from these two localities. Surveys of the entire NSW coastline have revealed no records since 1886. Species now presumed extinct.
<i>Schedule 5: Vulnerable species</i>		
Adams emerald dragonfly	<i>Archaeophya adamsi</i>	Small creeks with gravel or sandy bottoms, in narrow, shaded riffle zones with moss and rich riparian vegetation in the greater Sydney region.
Black cod	<i>Epinephelus daemeli</i>	Marine habitats in the warm temperate and subtropical parts of the south-western Pacific.
Buchanans fairy shrimp	<i>Branchinella buchananensis</i>	Waters of temporary (intermittently inundated) salt lakes, which have salinities between freshwater and seawater. Known only from Lake Buchanan in southwest Queensland, and Gidgee and Burkanoko Lakes in the north-west of NSW.
Great white shark	<i>Carcharodon carcharias</i>	Occur in marine habitats throughout the world.

Table 3-3: Aquatic Species, Populations & Ecological Communities listed as Threatened on FM Act 1994

Common Name	Scientific Name	Distribution/Habitat Association ¹
Macquarie perch	<i>Macquaria australasica</i>	Cooler parts of inland rivers and streams. Murray-Darling Basin (particularly upstream reaches) and parts of south-eastern coastal NSW, including the Hawkesbury and Shoalhaven catchments.
Southern pygmy perch	<i>Nannoperca australis</i>	Vegetated areas in small streams, lakes, billabongs and other types of wetlands. Once widely distributed throughout the Murrumbidgee and Murray River systems.
Silver perch	<i>Bidyanus bidyanus</i>	Murray-Darling river system.

¹: Source of distribution/habitat information – DPI (2005)

Only two of the species or communities listed in Table 3 – 3 have a distribution encompassing or close to the Sapphire to Woolgoolga area. These are the Oxleyan Pygmy Perch and Eastern Freshwater Cod. Oxleyan Pygmy Perch are found almost exclusively in swamps, streams and lakes in coastal lowland ‘wallum’ (banksia dominated heath) ecosystems, characterised by waterbodies with low salinity and conductivity, and high organic content and acidity. The creeks and watercourses crossed by proposed route do not include any areas of this habitat type, and as such the Oxleyan Pygmy Perch and its habitat will not be affected by the project.

The Sapphire to Woolgoolga area is just outside the presumed historical distribution of the Eastern Cod and well outside the current known distribution of naturally occurring Eastern Cod. This species was once abundant in both the Clarence and Richmond river systems downstream of tablelands waterfalls, but is now considered to be extinct in the Richmond River system, and very rare or absent in the major tributaries of the Clarence River System. Since the 1960s only small numbers of Eastern Cod have been recorded from the Nymboida, Guy Fawkes, Boyd, and Mann Rivers where some pristine habitat still exists.

The preferred habitat of the Eastern Cod is clear, flowing streams with rocky beds and deep holes with plenty of boulders or large woody debris (snags). This habitat is not present within the study area, which is also outside the known distribution of this species. As such, the Eastern Cod and its habitat will not be affected by the project.

3.4 Key Habitats and Corridors

The NPWS Key Habitats and Corridors Project (NPWS 1999v) defines Regional and Sub-Regional Corridors as those that provide linkage corridors for species assemblages, and are intended to maintain ecological processes such as migration, dispersal, predation and pollination. These processes are required for the long term viability and interaction of an ecosystem.

Key Habitats and Corridors identified by NPWS as occurring within, or in the vicinity of, the study area include:

- Moonee Regional Corridor, which serves as a link between Moonee Beach NR and Avocado Heights;
- Wedding Bells - Moonee Beach Regional Corridor which serves as a link between Moonee Beach NR and Skinners Creek;
- Moonee Beach NR - Orara East Subregional Corridor, which serves as a link between the Moonee Coastal Corridor and Sugar Mill Creek;
- Moonee Beach NR - Sapphire Regional Corridor, which links Moonee Beach NR and Hills Beach; and
- Woolgoolga Coast Regional Corridor, which is a link between Woolgoolga Lake and Hearn Lake

In addition, a subregional corridor serves as a link between Moonee Beach NR and the Pacific Highway.

4. Overview of Impacts

This section provides an overview of the type of impacts that roads and road construction may have on fauna and their habitats and mitigation measures that can be employed to minimise these impacts. A specific impact assessment, including impacts on threatened species, populations and communities, is presented in the Environmental Assessment Report.

4.1 Fauna

The highway upgrade could potentially impact native fauna in several ways, including:

- Wildlife injury and mortality through collisions with vehicles.
- Removal, modification and fragmentation of habitat.
- Creation of barriers to movement and genetic dispersal and exchange.
- Effects on animal behaviour due to noise and lights
- Risk of contamination and siltation of waterways

Most of the proposed upgrade is along an existing section of the Pacific Highway, hence many, if not all of the above impacts are likely to be already operating within this part of the study area. However, widening the footprint of the existing highway is likely to increase the cumulative effect of these impacts, by removing an extensive area of habitat, and by increasing the barrier effect posed by the existing highway. A discussion of some of the anticipated impacts of the road upgrade is provided in the following sections.

4.1.1 Fragmentation of Habitats

Fragmentation of a contiguous habitat, that is the division of a single area of bushland into two or more areas, has the potential to disrupt wildlife movement corridors, sever linkages between areas of habitat, increase edge to interior ratios and decrease the amount of habitat available to threatened fauna.

Habitat contiguity is important for a number of threatened species for several reasons:

- Certain species require large, continuous areas of habitat;
- The larger the area of habitat, the larger the potential carrying capacity for populations of threatened species, and accordingly the decreased likelihood of localised extinction due to inability to recolonise a disturbed area; and
- The lower number and/or level of threats such as road kill, predation or competition from animals associated with edge environments.

Important wildlife linkages occur throughout the study area, and have been recognised in various studies by DEC and CHCC. NPWS/CHCC (1999) has identified Koala movement corridors, and regional and sub-regional movement corridors have been identified from the NPWS Key Habitats and Corridors Project.

4.1.2 Loss of Tree Hollow Resource

Hollow bearing trees are a critical habitat feature for a number of threatened species (Gibbons & Lindenmayer 2002), providing breeding and/or sheltering habitat. Gibbons and Lindenmayer (2002) found that hollow bearing trees were more common in older stands, gullies, vegetation not logged and on flat terrain. Habitats with high productivity were also noted to support a higher number of hollow bearing trees.

In the North Coast Bioregion, in a study of forests broadly similar to those in the study area, Andrews et al. (1994) found the abundance of large tree hollows (possibly greater than 30cm diameter at entrance) did not increase with the increase in productivity. Forests characterised by *Eucalyptus saligna*, *E. microcorys*, *E. acmenoides*, *E. grandis*, being species associated with more productive areas, had less hollow bearing trees than forests characterised by *Eucalyptus punctata*, *E. acmenoides*, and *Corymbia maculata* (Table 2.9). This may indicate that other factors, namely those mentioned above, are a better predictor of tree hollows than the community type.

Within the study area, the greatest density of tree hollows occur in ring-barked stags in Wedding Bells State Forest. Hence, the greatest loss of tree hollow resource for local populations of hollow-dependent fauna will result from the section of highway traversing the State Forest. Yellow-bellied Glider, Squirrel Glider and Glossy Black-cockatoo in the northern section of the study area in particular are likely to be impacted by the loss of arboreal resources such as tree hollows

4.2 Loss of Foraging Resources

A number of threatened species require winter flowering species to supply food year-round, or to coincide with migratory movements. As such, the presence or absence of winter flowering species is considered a limiting factor for a number of threatened species.

Within the study area, several winter-flowering tree species provide an important food resource for fauna, such as the Squirrel Glider. Nomadic and migratory species such as the Grey-headed Flying Fox, Regent Honeyeater and Swift Parrot, are also dependent on winter-flowering trees, with their seasonal movements occurring in response to the flowering cycles of such species. Winter-flowering trees occur within the Swamp Sclerophyll Forest and Moist Open Forest communities which are found throughout the study area.

4.3 Mitigation and Amelioration Measures

Mitigation and amelioration measures may include but not be limited to:

- Reducing construction zones to keep vegetation clearance and disturbance to a minimum;
- Minimising the road footprint to avoid significant habitat areas, such as concentrations of hollow-bearing trees, where possible;
- Incorporating fauna underpasses and/or overpasses into the road design;
- Minimising the disturbance to bat roost sites, such as culverts and bridges;
- Development of dual purpose drainage structures that can act as 'default' fauna underpasses;
- Directional/exclusion fencing;
- Landscaping and revegetation;
- Site rehabilitation;
- Compensatory habitat; and
- Traffic control and driver education (measures to reduce risk of road kill).

Most of the measures listed above are typically employed in highway planning to reduce ecological impact.

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Appendix A

Habitat Proformas

Detailed Site Description	
Name(s) of observers	
Plot number / unique identifier	
Date & time	

Locality description to assist relocation <i>(eg, distances from road, track or distinctive landmark, giving walking distance and direction. Include property name or reserve name if known)</i>

Precise Location		
Method	6 digit easting (AMG)	7 digit northing (AMG)
Topographic Map Reading		
GPS		
Accuracy (GPS)	∇	∇

Physical Features				
Altitude (range)				
Aspect (range) (using compass bearing)				
Landform type				
Geology (rock outcrops)				
Soil Texture	clay	loam	sand	organic
Disturbance History				
Trampling				
Logging				
Grazing				
Fire				
Clearing				
Rubbish Dumping				
Soil Disturbance				
Nutrient Enrichment				
Altered Hydrology				
Other				
Land tenure				

FAUNA					
Terrestrial FAUNA					
<i>Hollow density estimated per 400m² (ranges: 0 = absent; 1-2 = occasional; 2-5 moderate; 5- 10; >10 abundant)</i>					
Item	Location of hollow				
	On trunk	Broken trunk or split	Large branch	Medium branch	Small branch
Tree hollows > 30 cm diameter	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant		
Tree hollows 10 – 30 cm diameter	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	
Tree hollows <10 cm diameter	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant
Stag trees	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant				
Hollow logs	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant				
Caves	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant				
Termite Mounds	⊖ Absent ⊖ Rare ⊖ Occasional ⊖ Moderate ⊖ Abundant				
Rock Outcrops	% Cover				
Leaf litter	% Cover				

Abundance, size and breeding condition of any fauna plant food resources						
<i>Survey area 400m² (Diversity = described in ranges of 0-5, 6-10, 11-15, etc)</i>						
Vegetation Layer	% Projective Foliage Cover	Diversity	Age Structure			
Canopy and emergent			Juvenile	Semi-mature	Mature	Over-mature
			Dominant	Sub Dominant	Trace	Absent
Shrubs and young trees			Juvenile	Semi-mature	Mature	Over-mature
			Dominant	Sub Dominant	Trace	Absent
Ground layer (<1m)			Juvenile	Semi-mature	Mature	Over-mature
			Dominant	Sub Dominant	Trace	Absent

Community 1			
General location: Upper - Mid - Lower Slopes; Mesic (swamp or rainfall) or Xeric;			
Canopy species			
PFC %			
Shrub species			
PFC %			
Ground layer species			
PFC %			
Community 2			
Canopy species			
PFC %			
Shrub species			
PFC %			
Ground layer species			
PFC %			
Community 3			
Canopy species			
PFC %			
Shrub species			
PFC %			
Ground layer species			
PFC %			
Community 4			
Canopy species			
PFC %			
Shrub species			
PFC %			
Ground layer species			
PFC %			

AQUATIC FAUNA HABITATS						
Type	Stream (Ephemeral or Perennial) / Soak / Waterbody (Ephemeral or Perennial)					
Flow Rate	Rapids Riffles Ponding					
Dimensions of Waterbody						
Substrate Type	Gravel / Sand / Silt / Rock (_ _ _ _ _) / Rubble / Concrete /					
Shading (%)						
Disturbances						
Predatory Species						
Snags						
Aquatic flora species						
Riparian vegetation	%Cover	Complexity:	High	Medium	Low	Absent
Aquatic vegetation	% Cover	Complexity:	High	Medium	Low	Absent
Aquatic fauna species observed						

Appendix B

Fauna Species List

Table 1: Fauna Species Observed During Survey

E = Endangered V = Vulnerable M = Migratory O = Listed Overfly

Group	Family	Scientific Name	Common Name	Conservation Status	
				TSC Act	EPBC Act
Amphibians	HYLIDAE	<i>Litoria fallax</i>	Eastern Dwarf Tree Frog	–	–
Amphibians	HYLIDAE	<i>Litoria peronii</i>	Peron's Tree Frog	–	–
Amphibians	HYLIDAE	<i>Litoria phyllochroa</i>	Leaf Green Tree Frog	–	–
Amphibians	MYOBATRACHIDAE	<i>Crinea signifera</i>	Common Eastern Froglet	–	–
Amphibians	MYOBATRACHIDAE	<i>Limnodynastes peronii</i>	Striped Marsh Frog	–	–
Amphibians	MYOBATRACHIDAE	<i>Mixophyes fasciolatus</i>	Giant Barred Frog	–	–
Amphibians	MYOBATRACHIDAE	<i>Pseudophryne coriacea</i>	Red-backed Toadlet	–	–
Birds	ACCIPITRIDAE	<i>Accipiter novaehollandiae</i>	Grey Goshawk	–	–
Birds	ACCIPITRIDAE	<i>Elanus axillaris</i>	Black-shouldered Kite	–	–
Birds	ACCIPITRIDAE	<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	–	M
Birds	ACCIPITRIDAE	<i>Haliastur sphenurus</i>	Whistling Kite	–	–
Birds	ACCIPITRIDAE	<i>Pandion haliaetus</i>	Osprey	V	–
Birds	ACEDINIDAE	<i>Todiramphus sanctus</i>	Sacred Kingfisher	–	–
Birds	AEGOTHELIDAE	<i>Aegotheles cristatus</i>	Australian Owlet-nightjar	–	–
Birds	ALCEDINIDAE	<i>Alcedo azurea</i>	Azure Kingfisher	–	–
Birds	ALCEDINIDAE	<i>Dacelo novaeguineae</i>	Laughing Kookaburra	–	–
Birds	ANATIDAE	<i>Anas superciliosa</i>	Pacific Black Duck	–	–
Birds	ANATIDAE	<i>Aythya australis</i>	Hardhead (White-eyed) Duck	–	–

Birds	ANATIDAE	<i>Biziura lobatus</i>	Musk Duck	-	-
Birds	ANATIDAE	<i>Chenonetta jubata</i>	Australian Wood Duck	-	-
Birds	ANHINGIDAE	<i>Anhinga melanogaster</i>	Darter	-	-
Birds	APODIDAE	<i>Hirundapus caudacutus</i>	White-throated Needletail	-	M
Birds	ARDEIDAE	<i>Ardea ibis</i>	Cattle Egret	-	O
Birds	ARDEIDAE	<i>Ardea pacifica</i>	White-necked (Pacific) Heron	-	-
Birds	ARDEIDAE	<i>Egretta novaehollandiae</i>	White-faced Heron	-	-
Birds	ARTAMIDAE	<i>Artamus leucorhynchus</i>	White-breasted Woodswallow	-	-
Birds	ARTAMIDAE	<i>Cracticus nigrogularis</i>	Pied Butcherbird	-	-
Birds	ARTAMIDAE	<i>Cracticus torquatus</i>	Grey Butcherbird	-	-
Birds	ARTAMIDAE	<i>Gymnorhina tibicen</i>	Australian Magpie	-	-
Birds	ARTAMIDAE	<i>Strepera graculina</i>	Pied Currawong	-	-
Birds	CACATUIDAE	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	-	-
Birds	CACATUIDAE	<i>Cacatua roseicapilla</i>	Galah	-	-
Birds	CACATUIDAE	<i>Calyptorhynchus fumereus</i>	Yellow-tailed Black Cockatoo	-	-
Birds	CACATUIDAE	<i>Calyptorhynchus lathami</i>	Glossy Black Cockatoo	V	-
Birds	CAMPEPHAGIDAE	<i>Coracina lineata</i>	Barred Cuckoo-shrike	V	-
Birds	CAMPEPHAGIDAE	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	-	-
Birds	CAMPEPHAGIDAE	<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike	-	-
Birds	CAMPEPHAGIDAE	<i>Coracina tenuirostris</i>	Cicadabird	-	-
Birds	CHARADRIIDAE	<i>Vanellus miles</i>	Masked Lapwing	-	-
Birds	CLIMACTERIDAE	<i>Cormobates leucophaeus</i>	White-throated Treecreeper	-	-
Birds	COLUMBIDAE	<i>Geopelia humeralis</i>	Bar-shouldered Dove	-	-

Birds	COLUMBIDAE	<i>Leucosarcia melanoleuca</i>	Wonga Pigeon	-	-
Birds	COLUMBIDAE	<i>Ocyphaps lophotes</i>	Crested Pigeon	-	-
Birds	CORVIDAE	<i>Corvus mellori</i>	Little Raven	-	-
Birds	CORVIDAE	<i>Corvus orru</i>	Torresian Crow	-	-
Birds	CUCULIDAE	<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo	-	-
Birds	CUCULIDAE	<i>Centropus phasianinus</i>	Pheasant Coucal	-	-
Birds	CUCULIDAE	<i>Eudynamys scolopacea</i>	Common Koel	-	-
Birds	CUCULIDAE	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	-	-
Birds	DICAEIDAE	<i>Dicaeum hirundinaceum</i>	Mistletoebird	-	-
Birds	DICRURIDAE	<i>Dicrurus bracteatus</i>	Spangled Drongo	-	-
Birds	DICRURIDAE	<i>Grallina cyanoleuca</i>	Magpie-lark	-	-
Birds	DICRURIDAE	<i>Monarcha trivirgatus</i>	Spectacled Monarch	-	M
Birds	DICRURIDAE	<i>Myiagra rubecula</i>	Leaden Flycatcher	-	-
Birds	DICRURIDAE	<i>Rhipidura fuliginosa</i>	Grey Fantail	-	-
Birds	DICRURIDAE	<i>Rhipidura leucophrys</i>	Willie Wagtail	-	-
Birds	DICRURIDAE	<i>Rhipidura rufifrons</i>	Rufous Fantail	-	M
Birds	HIRUNDINIDAE	<i>Hirundo neoxena</i>	Welcome Swallow	-	-
Birds	MALURIDAE	<i>Malurus cyaneus</i>	Superb Blue Fairy-wren	-	-
Birds	MALURIDAE	<i>Malurus lamberti</i>	Variigated Fairy-wren	-	-
Birds	MELIPAGIDAE	<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill	-	-
Birds	MELIPAGIDAE	<i>Anthochaera carunculata</i>	Red Wattlebird	-	-
Birds	MELIPAGIDAE	<i>Anthochaera chrysoptera</i>	Little Wattlebird	-	-
Birds	MELIPAGIDAE	<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater	-	-

Birds	MELIPAGIDAE	<i>Lichenostomus fuscus</i>	Fuscous Honeyeater	–	–
Birds	MELIPAGIDAE	<i>Lichenostomus leucotis</i>	White-eared Honeyeater	–	–
Birds	MELIPAGIDAE	<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater	–	–
Birds	MELIPAGIDAE	<i>Manorina melanocephala</i>	Noisy Miner	–	–
Birds	MELIPAGIDAE	<i>Meliphaga lewinii</i>	Lewin's Honeyeater	–	–
Birds	MELIPAGIDAE	<i>Melithreptus lunatus</i>	White-naped Honeyeater	–	–
Birds	MELIPAGIDAE	<i>Myzomela sanguinolenta</i>	Scarlet Honeyeater	–	–
Birds	MELIPAGIDAE	<i>Philemon corniculatus</i>	Noisy Friarbird	–	–
Birds	MELIPAGIDAE	<i>Phylidonyris nigra</i>	White-cheeked Honeyeater	–	–
Birds	MELIPHAGIDAE	<i>Entomyzon cyanotis</i>	Blue-faced Honeyeater	–	–
Birds	MENURIDAE	<i>Menura novaehollandiae</i>	Superb Lyrebird	–	–
Birds	NEOSITTIDAE	<i>Daphoenositta chrysoptera</i>	Varied Sittella	–	–
Birds	PACHYCEPHALIDAE	<i>Colluricincla harmonica</i>	Grey Shrike-thrush	–	–
Birds	PACHYCEPHALIDAE	<i>Pachycephala rufiventris</i>	Rufous Whistler	–	–
Birds	PACHYCEPHALIDAE	<i>Pachycephala pectoralis</i>	Golden Whistler	–	–
Birds	PARDALOTIDAE	<i>Acanthiza lineata</i>	Striated Thornbill	–	–
Birds	PARDALOTIDAE	<i>Acanthiza pusilla</i>	Brown Thornbill	–	–
Birds	PARDALOTIDAE	<i>Gerygone olivacea</i>	White-throated Gerygone	–	–
Birds	PARDALOTIDAE	<i>Pardalotus punctatus</i>	Spotted Pardalote	–	–
Birds	PARDALOTIDAE	<i>Pardalotus striatus</i>	Striated Pardalote	–	–
Birds	PARDALOTIDAE	<i>Sericornis frontalis</i>	White-browed Scrubwren	–	–
Birds	PLOCEIDAE	<i>Neochima temporalis</i>	Red-browed Finch	–	–
Birds	PETROICIDAE	<i>Eopsaltria australis</i>	Eastern Yellow Robin	–	–

Birds	PHALACROCORACIDAE	<i>Phalacrocorax carbo</i>	Great Cormorant	–	–
Birds	PHALACROCORACIDAE	<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant	–	–
Birds	PODARGIDAE	<i>Podargus strigoides</i>	Tawny Frogmouth	–	–
Birds	PODICIPEDIDAE	<i>Tachybaptus novaehollandiae</i>	Australasian Grebe	–	–
Birds	PSITTACIDAE	<i>Alisterus scapularis</i>	Australian King Parrot	–	–
Birds	PSITTACIDAE	<i>Glossopsitta concinna</i>	Musk Lorikeet	–	–
Birds	PSITTACIDAE	<i>Platycercus elegans</i>	Crimson Rosella	–	–
Birds	PSITTACIDAE	<i>Platycercus eximius</i>	Eastern Rosella	–	–
Birds	PSITTACIDAE	<i>Trichoglossus chlorolepidotus</i>	Scaly-breasted Lorikeet	–	–
Birds	PSITTACIDAE	<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	–	–
Birds	PSOPHODIDAE	<i>Psophodes olivaceus</i>	Eastern Whipbird	–	–
Birds	PTILONORHYNCHIDAE	<i>Ptilonorhynchus violaceus</i>	Satin Bowerbird	–	–
Birds	RALLIDAE	<i>Fulica atra</i>	Eurasian Coot	–	–
Birds	RALLIDAE	<i>Porphyrio porphyrio</i>	Purple Swamphen	–	–
Birds	STRIGIDAE	<i>Ninox novaeseelandiae</i>	Southern Boobook	–	–
Birds	STRIGIDAE	<i>Ninox strenua</i>	Powerful Owl	V	–
Birds	THRESKIORNITHIDAE	<i>Threskiornis molucca</i>	Australian White Ibis	–	–
Birds	ZOSTEROPIDAE	<i>Zosterops lateralis</i>	Silvereeye	–	–
Mammals	BURRAMYIDAE	<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	–
Mammals	CANIDAE	<i>Canis lupus familiaris</i> *	Dog*	–	–
Mammals	CANIDAE	<i>Vulpes vulpes</i> *	Fox*	–	–
Mammals	DASYURIDAE	<i>Antechinus stuartii</i>	Brown Antechinus	–	–
Mammals	DASYURIDAE	<i>Antechinus</i> sp	Antechinus sp	–	–

Mammals	FELIDAE	<i>Felis catus*</i>	Cat*	–	–
Mammals	MACROPODIDAE	<i>Macropus giganteus</i>	Eastern Grey Kangaroo	–	–
Mammals	MACROPODIDAE	<i>Macropus rufogriseus</i>	Red-necked Wallaby	–	–
Mammals	MACROPODIDAE	<i>Wallabia bicolor</i>	Swamp Wallaby	–	–
Mammals	MACROPODIDAE		Wallaby sp	–	–
Mammals	MOLOSSIDAE	<i>Nyctinomus australis</i>	White-striped Freetail-Bat	–	–
Mammals	MURIDAE	<i>Rattus fuscipes</i>	Bush Rat	–	–
Mammals	MURIDAE	<i>Rattus rattus*</i>	Black Rat*	–	–
Mammals	PERAMELIDAE	<i>Isoodon macrourus</i>	Northern Brown Bandicoot	–	–
Mammals	PERAMELIDAE	<i>Perameles nasuta</i>	Long-nosed Bandicoot	–	–
Mammals	PERAMELIDAE		Bandicoot sp.	–	–
Mammals	PETAURIDAE	<i>Petaurus australis</i>	Yellow-bellied Glider	V	–
Mammals	PETAURIDAE	<i>Petaurus breviceps</i>	Sugar Glider	–	–
Mammals	PETAURIDAE	<i>Petaurus norfolcensis</i>	Squirrel Glider	V	–
Mammals	PHALANGERIDAE	<i>Trichosurus vulpecula</i>	Common Brushtail Possum	–	–
Mammals	PSEUDOCHEIRIDAE	<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum	–	–
Mammals	PTEROPODIDAE	<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	V
Mammals	PTEROPODIDAE	<i>Syconycteris australis</i>	Common Blossom Bat	V	–
Mammals	RHINOLOPHIDAE	<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe-bat	–	–
Mammals	TARSIPEDIDAE	<i>Acrobates pygmaeus</i>	Feathertail Glider	–	–
Mammals	TACHYGLOSSIDAE	<i>Tachyglossus aculeatus</i>	Short- beaked Echidna	–	–
Mammals	VESPERTILIONIDAE	<i>Chalinolobus gouldi</i>	Gould's Wattled Bat	–	–
Mammals	VESPERTILIONIDAE	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	–	–

Mammals	VESPERTILIONIDAE	<i>Miniopterus australis</i>	Little Bent-wing Bat	V	–
Mammals	VESPERTILIONIDAE	<i>Miniopterus schreibersii</i>	Large Bent-wing Bat	V	–
Mammals	VESPERTILIONIDAE	<i>Myotis adversus</i>	Southern Myotis	V	–
Mammals	VESPERTILIONIDAE	<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat	–	–
Mammals	VESPERTILIONIDAE	<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	–
Mammals	VESPERTILIONIDAE	<i>Scotorepens</i> sp.1	Broad-nosed Bat	–	–
Mammals	VESPERTILIONIDAE	<i>Scotorepens orion</i>	Eastern Broad-nosed Bat	–	–
Mammals	VESPERTILIONIDAE	<i>Vespadelus pumilus</i>	Eastern Forest Bat	–	–
Mammals	VESPERTILIONIDAE	<i>Vespadelus regulus</i>	Southern-Forest Bat	–	–
Mammals	VESPERTILIONIDAE	<i>Vespadelus vulturnus</i>	Little Forest Bat	–	–
Mammals	VOMBATIDAE	<i>Vombatus ursinus</i>	Wombat	–	–
Mammals		<i>Bos taurus</i> *	Cattle*	–	–
Reptiles	AGAMIDAE	<i>Physignathus lesueurii</i>	Eastern Water Dragon	–	–
Reptiles	BOIDAE	<i>Morelia spilota</i>	Diamond Python	–	–
Reptiles	ELAPIDAE	<i>Cacophis squamulosus</i>	Golden Crowned Snake	–	–
Reptiles	ELAPIDAE	<i>Hemiaspis signata</i>	Black-bellied Swamp Snake	–	–
Reptiles	ELAPIDAE	<i>Rhinolophus nigrescens</i>	Eastern Small-eyed Snake	–	–
Reptiles	ELAPIDAE	<i>Vermicella annulata</i>	Bandy-Bandy	–	–
Reptiles	SCINCIDAE	<i>Calyptotis ruficauda</i>		–	–
Reptiles	SCINCIDAE	<i>Ctenotus taeniolatus</i>	Copper-tailed Skink	–	–
Reptiles	SCINCIDAE	<i>Lampropholis delicata</i>	Grass Skink	–	–
Reptiles	SCINCIDAE	<i>Saiphos equalis</i>	Three-toed Skink	–	–
Reptiles	VARANIDAE	<i>Varanus varius</i>	Lace Monitor	–	–

EPBC Act	Environmental Protection and Biodiversity Conservation Act
TSC Act	Threatened Species Conservation Act
V	Listed as Vulnerable
M	Listed as Migratory
O	Listed Overfly Marine Area
*	Introduced Species

4. State Environmental Planning Policy 44 – Koala habitat protection

4.1 Potential Koala Habitat Assessment

The identification of an area of land as potential koala habitat is determined by the presence of Schedule 2 koala feed tree species, as listed under State Environmental Planning Policy (SEPP) 44 - Koala Habitat Protection. Potential koala habitat is defined as areas where the tree species listed under Schedule 2 (Table 4.1) constitute at least 15% of the total number of trees in the upper or lower strata of the tree component. An area of land to which the policy applies must be at least one hectare in area (and may include adjoining land in the same ownership).

Table 4.1: SEPP 44 Schedule 2 Primary Browse Trees

Scientific Name	Common Name
<i>Eucalyptus albens</i>	White Box
<i>Eucalyptus camaldulensis</i>	River Red Gum
<i>Eucalyptus haemastoma</i>	Broad-leaved Scribbly Gum
<i>Eucalyptus microcorys</i>	Tallowood
<i>Eucalyptus populnea</i>	Bimble Box
<i>Eucalyptus punctata</i>	Grey Gum
<i>Eucalyptus robusta</i>	Swamp Mahogany
<i>Eucalyptus signata</i>	Scribbly Gum
<i>Eucalyptus tereticornis</i>	Forest Red Gum
<i>Eucalyptus viminalis</i>	Ribbon Gum

Forest Red Gum (*Eucalyptus tereticornis*) was the most commonly observed Schedule 2 species observed within the Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association in the study area. Tallowood (*Eucalyptus microcorys*) were scattered within the Blackbutt Coastal Hills Moist Open Forest vegetation association and a small number of Swamp Mahogany (*Eucalyptus robusta*) were recorded within the northeast portion of the Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association.

Forest Red Gum made up greater than 15% of the total number of trees within some areas of Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association within the study area and as such qualify as Potential Koala Habitat under SEPP 44, as indicated on Figure 3.2.

4.2 Core Koala Habitat Assessment

Core Koala Habitat is defined as “an area of land with a resident population of Koalas, as evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a Koala population” (Source: State Environment Planning Policy No. 44 - Koala Habitat Protection). Information to determine if a resident Koala population occurs in the study area was obtained by direct survey of the site and review of relevant published information and records.

4.2.1 Literature Review and Data Base Searches

A review of the Atlas for Wildlife (DEC, 2007) indicates there are four Koala records within 10km of the study area. It is likely that the Koala population in the Wedding Bells State Forest area is of low

density. Parts of the study area may possibly be utilised by the locally occurring low density Koala population, though no evidence of this use was observed.

4.2.2 Direct Survey Methods and Results

Direct survey of Koala included spotlighting, call playback, and searches for scats at the base of Schedule 2 Primary Browse Trees in areas of Potential Koala Habitat. Call play back was undertaken in early Spring (March), a period when Koala are generally considered to be active and respond to territorial calls from a dominant male Koala.

The Koala was not detected in the study area by either secondary evidence, spotlighting or call play back.

4.2.3 Conclusion

According to the definition provided in SEPP 44 – Koala Habitat Protection, there are two identified attributes that indicate Core Koala Habitat, which are described in relation to the study area as follows:

- 1) “Breeding females (that is, females with young)”. No individuals or evidence of Koala, including breeding females, was observed during diurnal surveys including scat and scratch searches.
- 2) “Recent sightings and historical records of a Koala population”. Review of the available literature indicates there are four Koala records within 10km of the study area. It is likely that the Koala population in the Wedding Bells State Forest area is of low density. Parts of the study area may possibly be utilised by the locally occurring low density Koala population, though no evidence of this use was observed.

Few records of Koala exist within 10 km and the absence of evidence of recent Koala usage (scats, scratches and direct observation) within the study area, suggests that the site does not qualify as Core Koala Habitat or an area subject to frequent Koala usage.

5. Potential impacts

5.1 General impacts

Likely and potential impacts associated with the construction and operation of the Proposal at Arararra Interchange would include:

- Loss of native vegetation, including areas of endangered ecological community
- Removal, modification and fragmentation of habitat
- Wildlife injury and mortality through collisions with vehicles
- Wildlife injury and mortality during vegetation clearance
- Stress placed on fauna displaced into adjoining habitats through competition with existing resident fauna for habitat resources
- Creation of physical barriers to fauna movement
- Risk of contamination and siltation of waterways

Key threatening processes are things that threaten, or could threaten, the survival or evolutionary development of species, populations or ecological communities. The Proposal would contribute to two key threatening processes listed under the NSW *Threatened Species Conservation Act 1995*. These are:

- Clearing of native vegetation
- Removal of dead wood and dead trees

A preliminary determination for the listing of the loss of hollow-bearing trees as a Key Threatening Process has been made by the NSW Scientific Committee. Should the loss of hollow-bearing trees be determined as a Key Threatening Process, the proposed removal of 20 hollow-bearing trees would contribute to this process.

This section includes a discussion of the potential impacts of the proposal. The significance of any potential impact of the Arararra Interchange on threatened species, populations and/or endangered ecological communities has not been assessed as part of this report. Additionally, detailed mitigation measures have not been discussed as part of this report but are incorporated into the Environmental Assessment document covering the entire Sapphire to Woolgoolga Pacific Highway Upgrade.

5.2 Potential flora impacts

5.2.1 Vegetation communities

The area of each vegetation community that would be removed or disturbed by the Proposal is presented in Table 5.1 below. This is a conservative estimate, based on the direct footprint of the concept design (including batters and cuttings) plus an additional five metres, to incorporate areas that could be disturbed during construction.

Table 5.1 Extent of vegetation removal by vegetation type found within Arrawarra Interchange study area

Broad vegetation type	Community	Endangered ecological community (TSC Act)	Extent of loss
COASTAL HILLS MOIST OPEN FOREST	Blackbutt	-	7.4 ha
COASTAL FLOOD-PLAIN FOREST	Broad-leaved Paperbark	<i>Swamp Sclerophyll Forest on Coastal Floodplain of the NSW North Coast, Sydney Basin and South east corner Bioregions.</i>	3.1 ha
COASTAL FLOOD-PLAIN FOREST	Swamp Oak	<i>Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South east corner Bioregions.</i>	<0.01 ha
OTHER	Blackbutt Plantation	-	1.3 ha
Total			11.8 ha

The Proposal would result in the removal of approximately 11.8 ha of native vegetation. The Blackbutt Coastal Hills Moist Open Forest community would incur the greatest loss, being approximately 7.4 ha.

5.2.2 Endangered ecological communities

Two endangered ecological communities listed under the *Threatened Species Conservation Act 1995* were recorded within the study area. Approximately 3.1 ha of Swamp Sclerophyll Forest would be removed as a result of the proposal. Most of the Swamp Sclerophyll Forest to be removed within the study area has a history of disturbance (ie land clearing, fragmentation), particularly to the east of the Pacific Highway and the northern-most area to be removed (see Figure 3.1). However, Swamp Sclerophyll Forest to be removed in the southwest of the study area is in good condition and the proposal is likely to result in edge effects extending outside of the area of direct removal. A small area (6 m²) of Swamp Oak Floodplain Forest would also be removed as a result of the proposal.

Impacts on endangered ecological communities could be minimised by implementing strict silt and weed control on vegetated edges and by minimising the road footprint.

5.2.3 Threatened flora species

No threatened flora species were identified during surveys. However, suitable habitat exists for the Swamp Orchid (*Phaius australis*) within the Arrawarra Interchange study area. This area was surveyed outside of the flowering period for this species when it is most easily detected. Based on the suitability of habitat, it is considered possible that this species is present in the Swamp Sclerophyll Forest areas of the Arrawarra Interchange. Prior to construction, surveys to identify this species should be undertaken during the flowering period of September to October within the footprint of the Arrawarra Interchange. Approximately 4000 m² of potential habitat for the Swamp Orchid would be removed as a result of the proposal. Additionally, a further 4000 m² of potential habitat may be modified through indirect edge effects resulting from the proposal. Further surveys would enable the presence or absence of this species to be confirmed and the potential impact quantified.

5.3 Potential fauna impacts

Fauna species have the potential to be affected during both the construction phase, through habitat loss and modification, and in the operation phase, through increased threat of road kill and increased barriers to movement within the local area. These potential impacts are further discussed below.

5.3.1 Habitat removal

The broad habitat types present within the study area include moist open forest, floodplain forest and watercourses. These habitats provide fauna resources such as hollow bearing trees, fallen timber and leaf litter, dense understorey vegetation, grassy understorey vegetation, winter flowering flora species, creeks and drainage lines.

Twenty hollow-bearing trees would be removed as a result of the proposed Arrawarra Interchange. Hollow-bearing trees within the study area may provide refuge and/or breeding habitat for a range of hollow dependant threatened species, such as:

- Glossy Black-Cockatoo
- Powerful Owl
- Masked Owl
- Squirrel Glider
- Yellow-bellied Glider
- Brush-tailed Phascogale
- Hoary Wattled Bat
- Eastern False Pipistrelle
- East Coast Freetail Bat
- Eastern Long-eared Bat
- Greater Broad-nosed Bat

Table 5.2 below presents a summary of the likely impacts of the proposed Arrawarra Interchange on threatened species and EEC's within the study area.

Winter-flowering species such as Broad-leaved Paperbark, Forest Red Gum and Tallowwood occur within the moist open forest and swamp sclerophyll forest communities and removal of these habitats would reduce the availability of important seasonal food sources for fauna species within the local area. The proposed Arrawarra Interchange would result in the loss of approximately 11.8 ha of these communities.

A series of culverts and one bridge (Arrawarra Creek) will be replaced as a result of the proposal. Culverts and bridges within the study area may provide roosting/breeding habitat for the following threatened microchiropteran bat species:

- Large-footed Myotis
- Little Bent-wing Bat
- Large Bent-wing Bat
- Eastern Cave Bat

Whilst culvert and bridge habitat will be replaced by new structures, it is unknown whether the new structures will be suitable for roosting and/or breeding. Demolition and construction of bridges and culverts should be undertaken outside of the microbat maternity season (November) and winter months when bat species are likely to be less active.

5.3.2 Habitat fragmentation and edge effects

Habitat fragmentation is the division of a single (contiguous) area of bushland into two or more areas. This has the potential to disrupt wildlife movement corridors, increase edge to interior ratios and decrease the amount of available habitat for threatened fauna. Habitat contiguity is important as some threatened species require large areas of intact habitat. The larger the area of habitat the greater the potential carrying capacity and the lower the level of threats such as road kill, predation and competition from animals associated with edge environments.

Fragmentation due to road construction may create isolated areas of native vegetation, which become too small to support viable populations of native flora and fauna and where populations may become genetically depressed. The removal of vegetation as a result of the proposal is likely to increase habitat fragmentation impacts on fauna species by widening the distance between vegetation remnants.

Edge effects resulting from the proposed Arrawarra Interchange would have the greatest impact within Blackbutt forest and Swamp Sclerophyll Forest on the west of the existing Pacific Highway.

5.3.3 Fauna movement barriers and mortality

Roads can impact on fauna through direct mortality resulting from vehicle collision and through the creation of barriers that prevent or restrict fauna movement. Fauna movement barriers may isolate fauna populations or they may prevent or limit fauna access to seasonally abundant resources, such as vegetation communities dominated by winter flowering species.

The existing Pacific Highway is a 25 m wide, linear clearing within the study area and is likely to be already acting as a movement barrier to some less mobile fauna species. In addition, powerline easements and local roads 10-20 m wide may also present a barrier to movement for some fauna species.

Arboreal mammals such as Sugar Gliders, Squirrel Gliders and Yellow-bellied Gliders can potentially glide over a physical barrier such as the existing highway, depending on the proximity of adjacent canopy trees. However, reported estimates of glide distances and trajectory suggests that the threatened Squirrel Glider and Yellow-bellied Glider are capable of gliding up to 50 m and 90 m, respectively, and depending on glide point height and other environmental parameters (van der Ree 2006; Daly 2005; NPWS 2003; Quin 1995). The habitat of the Yellow-bellied Glider and Squirrel Glider is likely to become further fragmented by the proposed dual carriageway highway.

During the initial stages of construction, the clearing of vegetation may result in injury or death to resident fauna. Species at risk include nocturnal species such as microbats, possums and gliders which shelter during the day, and ground dwelling species such as snakes, lizards, amphibians, and small mammals which may not be able to move fast enough or cover large enough distances to avoid clearing activities. Mobile fauna species that are less active or inactive during cooler seasons, such as microbats, may suffer increased mortality resulting from vegetation clearing activities during these seasons. Vegetation clearing during breeding seasons may place additional stress on fauna species and may result in mortality of young and/or adults. There is also the risk of displaced fauna succumbing to predation, or stress induced by competing with existing resident populations for resources, particularly shelter / refuge habitat.

Vehicle collision is likely to be the major cause of fauna mortality during the operation phase of the proposed Arrawarra Interchange. Species groups at risk include medium to large terrestrial mammals, diurnal birds, nocturnal birds, amphibians and reptiles.

Threatened amphibian species such as Green-thighed Frog, Wallum Sedge Frog and Wallum Froglet may experience higher mortality rates as a result of the operation of the proposed Arrawarra Interchange. Goldingay and Taylor (2006) report on high levels of frog mortality, particularly of Wallum Sedge Frog, Wallum Froglet and the Northern Banjo Frog (*Limnodynastes terraereginae*) on a coastal road in north-east NSW. No amphibian roadkill surveys have been undertaken within the study area or along the remainder of the Sapphire to Woolgoolga upgrade route. Frogs within the study area may use existing culverts to cross under the highway during light rainfall events. However, during heavier rainfall, high water levels are unlikely to facilitate frog movement through culverts and frogs may cross the wet bitumen surface. The construction of the proposed Arrawarra Interchange will increase the amount of road surface and may increase the amount of frog mortality resulting from vehicle collision. Current best-practice frog exclusion fencing methods and specially designed culverts should be considered adjacent to Swamp Sclerophyll Forest and other low-lying vegetation communities within

both the Arrawarra Interchange study area and the remainder of the Sapphire to Woolgoolga upgrade route.

6. Conclusion

The proposed Arararra Interchange is likely to directly and indirectly impact upon threatened fauna species, two endangered ecological communities and potentially one threatened flora species. Potential impacts associated with the proposed Arararra Interchange include both foraging and breeding habitat loss, habitat fragmentation, direct mortality, increased action of listed Key Threatening Processes and edge effects. The magnitude of potential impacts on threatened species, populations and endangered ecological communities is likely to increase when considering the entire Sapphire to Woolgoolga Pacific Highway Upgrade. Detailed measures to mitigate potential impacts of the proposal have not been discussed in this report but are included in the Environmental Assessment document addressing the entire Sapphire to Woolgoolga Pacific Highway Upgrade.

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Appendix A

Threatened species likelihood of occurrence assessment

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
FROGS					
<i>Crinia tinnula</i>	Wallum Froglet	V	—	Wallum swamps and associated low land meandering watercourses on coastal plains (Ehmann 1997). Occurs in elevations up to around 50m and is closely related to freshwater habitats in the coastal zone (NPWS 2005a). Found most commonly in wallum wetlands characterised by low nutrients, highly acidic, tanin-stained waters that are typically dominated by paperbarks and tea-trees. Also found in sedgeland and wet heathland (NPWS 2005a)	Recorded. Further records occur north of Corindi Beach and at Hearn's Lake
<i>Litoria aurea</i>	Green and Golden Bell Frog	E	V	This species has been observed utilising a variety of natural and man-made waterbodies (Pyke & White 1996) such as coastal swamps, marshes, dune swales, lagoons, lakes, other estuary wetlands, riverine floodplain wetlands and billabongs, stormwater detention basins, farm dams, bunded areas, drains, ditches and any other structure capable of storing water (DEC 2005a). Fast flowing streams are not utilised for breeding purposes by this species (Mahony 1999). Preferable habitat for this species includes attributes such as shallow, still or slow flowing, permanent and/or widely fluctuating water bodies that are unpolluted and without heavy shading (DEC 2005a). Large permanent swamps and ponds exhibiting well-established fringing vegetation (especially bulrushes— <i>Typha</i> sp. and spikerushes— <i>Eleocharis</i> sp.) adjacent to open grassland areas for foraging are preferable (Ehmann 1997; Robinson 1993). Ponds that are typically inhabited tend to be free from predatory fish such as Mosquito Fish (<i>Gambusia holbrooki</i>) (NPWS 1999m). Recorded north of Red Rock (BioNet, 2007).	Unlikely. No suitable habitat present (no still, ephemeral or permanent ponds lined with <i>Typha</i> sp. and other well established fringing vegetation).

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Litoria brevipalmata</i>	Green Thighed Frog	V	—	Wet sclerophyll forest along the northern coast of NSW to Ourimbah (Anstis 2002). Also in a variety of habitats including dry to wet sclerophyll forest, rainforests and shrubland with a healthy understorey (NPWS 2005b). Breeding aggregations occur in still water habitats such as grassy temporary to semi-permanent ponds and flooded ditches in late spring and summer (Cogger 2000; Anstis 2002; NPWS 2005b). Recorded to the west of Emerald Beach, approximately 10 km to the south of the Arrawarra Interchange (Lewis Ecological Surveys, 2006).	Likely. Suitable habitat present and local records to the west of Emerald Beach. Additionally, Lewis Ecological Surveys (2006) identified drainage lines and depressions within the study area as containing potential habitat for the Green-thighed Frog.
<i>Litoria olongburensis</i>	Wallum Sedge Frog	V	V	Wallum, woodlands and sedgeland on coastal swamps dominated by <i>Melalueca quinquinervia</i> with an understorey of the sedge <i>Leprionia articulata</i> are typical habitat (NPWS 2005c). Suitable wallum swamps are characterised by low nutrients, highly acidic, tannin-stained waters occurring on Pleistocene coastal sand deposits (NPWS 2005c).	Likely. Suitable habitat present in wallum areas such as Swamp Sclerophyll Forest and sedgeland.
<i>Mixophyes balbus</i>	Stuttering Frog	E	V	A variety of forest habitats from rainforest through wet and moist sclerophyll forest to riparian habitat in dry sclerophyll forest (NPWS 2005t) that are generally characterised by deep leaf litter or thick cover from understorey vegetation (Ehmann 1997). Breeding habitats are streams and occasionally springs. Not known from streams disturbed by humans (Ehmann 1997) or still water environments (NSW Scientific Committee 2002b). Recorded in Conglomerate State Forest.	Unlikely. Marginal habitat present within upper reaches of Little Arrawarra Creek. However, creeks within the study area are highly disturbed, precluding the species from the area.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Mixophyes iteratus</i>	Giant Barred Frog	E	E	Found on forested slopes of the escarpment and adjacent ranges in riparian vegetation, subtropical and dry rainforest, wet sclerophyll forests and swamp sclerophyll forest (NPWS 2005d; Ehmann 1997). This species is associated with flowing streams with high water quality, though habitats may contain weed species (Ehmann 1997). This species is not known from riparian vegetation disturbed by humans (NSW Scientific Committee 1999). During breeding eggs are kicked up onto an overhanging bank or the streams edge (NPWS 2005d).	Unlikely. Marginal habitat present within upper reaches of Little Arrawarra Creek. However, creeks within the study area are highly disturbed, precluding the species from the area.
REPTILES					
<i>Coeranoscincus reticulatus</i>	Three-toed Snake-tooth Skink	V	V	The Three-toed Snake-tooth Skink occurs in the coast and ranges from the Macleay valley in NSW to south-eastern Queensland (DEC, 2005n). It is very uncommon south of Grafton (DEC, 2005n). It occupies rainforest and occasionally moist eucalypt forest, on loamy or sandy soils (DEC, 2005n). The Three-toed Snake-tooth Skink lives in loose soil, leaf litter and rotting logs, and feeds on earthworms and beetle grubs (DEC, 2005n).	Unlikely. Marginal habitat present within Swamp Sclerophyll Forest. However, not detected during surveys, it is considered to be very uncommon south of Grafton and there are no local records within 40 km of study area.
<i>Emydura signata</i> <i>Emydura macquarii</i>	Bellinger River Emydura	V	V	The Bellinger River Emydura is restricted to the upper Bellinger River above Thora. It prefers long, deep pools in broad reaches of the upper Bellinger River.	Unlikely. Extremely restricted distribution well outside of the study area and no suitable habitat present

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Hoplocephalus stephensii</i>	Stephen's Banded Snake	V	—	Found in a variety of habitats from rainforest through wet and moist sclerophyll forests to dry sclerophyll forests (NPWS 2005e). However it is most commonly found in wet to moist forests with rocky outcrops, cliffs or ridges and tends to favour ecotones between wet and dry forests (NPWS 2005e). It most frequently uses gaps in the peeling bark of large senescent or dead trees for daytime shelter (NPWS 2005e). However it can use hollow trunks, limbs, epiphytes, vine thickets, rock crevices or rock slabs (NPWS 2005e).	Unlikely. No suitable habitat present (no rocky outcrops, cliffs or ridges)
<i>Underwoodisaurus sphyrurus</i>	Border Thick-tailed Gecko	V	V	Found only on the tablelands and slopes of northern NSW and southern Queensland, reaching south to Tamworth and west to Moree (DEC, 2005m). Most common in the granite country of the New England Tablelands (DEC, 2005m). Rocky hills with dry open eucalypt forest or woodland (DEC, 2005m). Favours forest and woodland areas with boulders, rock slabs, fallen timber and deep leaf litter (DEC, 2005m).	Unlikely. No suitable habitat present (no rocky hills within study area, rock slabs or boulders)
DIURNAL BIRDS					
<i>Burhinus grallarius</i>	Bush Stone-curlew	E	—	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Pittwater Council 2000; Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed in lightly disturbed.	Unlikely. Marginal open forest habitat present. However, study area has experience a high level of logging disturbance which is likely to preclude the species.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Calidris alba</i>	Sanderling	V	—	Occur in coastal areas on low beaches, near reefs and inlets along tidal mudflats and bare open coastal lagoons (NPWS 1999a). Rarely seen in near-coastal wetlands such as lagoons, hypersaline lakes, saltponds and samphire flats (NPWS 1999a)	Unlikely. No suitable habitat present (no coastal areas or near-coastal wetlands).
<i>Calidris tenuirostris</i>	Great Knot	V	—	Sheltered coastal habitats containing large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons (NPWS 1999q). Often recorded on sandy beaches with mudflats nearby, sandy spits and inlets, or exposed reefs or rock platforms (Morris 1989; Higgins & Davies 1996).	Unlikely. No suitable habitat present (no coastal areas).
<i>Calyptorhynchus lathamii</i>	Glossy Black-Cockatoo	V	—	Associated with a variety of forest types containing Allocasuarina species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000; NPWS 1997; NPWS 1999b). Intact drier forest types with less rugged landscapes are preferred (NPWS 1999b). Nests in large trees with large hollows (Environment Australia 2000).	Recorded. Numerous additional records within 10 km of study area.
<i>Charadrius leschenaultii</i>	Greater Sand Plover	V	—	Entirely coastal in NSW, foraging on intertidal sand and mudflats in estuaries, roosting during high tide on sandy beaches or rocky shores (NPWS 1999c)	Unlikely. No suitable habitat present (no coastal areas).
<i>Coracina lineata</i>	Barred Cuckoo-shrike	V	—	It is associated with subtropical, dry and littoral rainforests and is restricted to below 500m elevation (NPWS 2005f).	Unlikely. Marginal habitat present within northwest Swamp Sclerophyll Forest and margins. However, not detected during surveys.
<i>Dromaius novaehollandiae</i> NSW North Coast Bioregion and Port Stephens LGA Population	Emu	E2	—	Occupies a range of mainly open habitats including plains, grasslands, woodlands, shrubs and occasionally forest (NSW Scientific Committee 2002a). Not found in rainforest (Simpson & Day 1999). Recorded less than six kilometres to the north, just south of Red Rock (BioNet, 2007).	Likely. Local records and marginal open forest habitat present.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Hoplocephalus stephensii</i>	Stephen's Banded Snake	V	—	Found in a variety of habitats from rainforest through wet and moist sclerophyll forests to dry sclerophyll forests (NPWS 2005e). However it is most commonly found in wet to moist forests with rocky outcrops, cliffs or ridges and tends to favour ecotones between wet and dry forests (NPWS 2005e). It most frequently uses gaps in the peeling bark of large senescent or dead trees for daytime shelter (NPWS 2005e). However it can use hollow trunks, limbs, epiphytes, vine thickets, rock crevices or rock slabs (NPWS 2005e).	Unlikely. No suitable habitat present (no rocky outcrops, cliffs or ridges)
<i>Underwoodisaurus sphyrurus</i>	Border Thick-tailed Gecko	V	V	Found only on the tablelands and slopes of northern NSW and southern Queensland, reaching south to Tamworth and west to Moree (DEC, 2005m). Most common in the granite country of the New England Tablelands (DEC, 2005m). Rocky hills with dry open eucalypt forest or woodland (DEC, 2005m). Favours forest and woodland areas with boulders, rock slabs, fallen timber and deep leaf litter (DEC, 2005m).	Unlikely. No suitable habitat present (no rocky hills within study area, rock slabs or boulders)
DIURNAL BIRDS					
<i>Burhinus grallarius</i>	Bush Stone-curlew	E	—	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Pittwater Council 2000; Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed in lightly disturbed.	Unlikely. Marginal open forest habitat present. However, study area has experience a high level of logging disturbance which is likely to preclude the species.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V	—	A coastal species that inhabits rock coastlines, coral cays, reefs and occasionally sandy beaches and Marchant & Higgins 1993; Simpson & Day 1999).	Unlikely. No suitable habitat present (no coastal areas).
<i>Haematopus longirostris</i>	Pied Oystercatcher	V	—	Roosts and forages on sandy beaches, sand banks, mudflats and estuaries (Marchant & Higgins 1993, Simpson & Day 1999).	Unlikely. No suitable habitat present (no coastal areas).
<i>Irediparra gallinacea</i>	Comb-crested Jacana	V	—	Freshwater wetlands, such as lagoons, billabongs, swamps, lakes and reservoirs, generally with abundant floating aquatic vegetation (Marchant and Higgins 1999).	Unlikely. No suitable habitat present (no freshwater wetlands with abundant floating aquatic vegetation).
<i>Ixobrychus flavicollis</i>	Black Bittern	V	—	Occurs in both terrestrial and estuarine wetlands generally in areas of permanent water and dense vegetation (NPWS 1999g). In areas with permanent water it may occur in flooded grassland, forest, woodland, rainforest and mangroves (NPWS 1999g)	Unlikely. No suitable habitat present (no wetlands with permanent water and abundant floating aquatic vegetation within study area or flooded areas adjacent to wetlands).
<i>Lathamus discolor</i>	Swift Parrot	E	E	Breeds in Tasmania between September and January. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts (Blakers et al. 1984; Schodde and Tidemann 1986; Forshaw and Cooper 1981). Hence, in this region, autumn and winter flowering eucalypts are important for this species. Favoured feed trees include winter flowering species such as Swamp Mahogany (<i>Eucalyptus robusta</i>), Spotted Gum (<i>Corymbia maculata</i>), Red Bloodwood (<i>C. gummifera</i>), Mugga Ironbark (<i>E. sideroxylon</i>), and White Box (<i>E. albens</i>) (DEC 2005h).	Unlikely. Preferred winter flowering forage species were scarce within the study area.

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Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Limosa limosa</i>	Black-tailed Godwit	V	—	Primarily found along the coast on sandspits, lagoons and mudflats (NPWS 1999s). The species has also been found to occur inland on mudflats or shallow receding waters of portions of large muddy swamps or lakes (Pizzey and Knight 1997; Higgins & Davies 1996).	Unlikely. No suitable habitat present (no coastal areas).
<i>Lophoictinia isura</i>	Square-tailed Kite	V	—	In coastal areas associated tropical and temperate forests and woodlands on fertile soils with an abundance of passerine birds (Marchant & Higgins 1993, NPWS 1999h). May be recorded inland along timbered watercourses (NPWS 1999h). In NSW it is commonly associated with ridge or gully forests dominated by Woollybutt (<i>Eucalyptus logiflora</i>), Spotted Gum (<i>E. maculata</i>), or Peppermint Gum (<i>E. elata</i> , <i>E. smithii</i>) (NPWS 1999h). Recorded within one kilometre of the study area (DEC, 2007).	Likely. Suitable habitat present and recent local records.
<i>Monarcha leucotis</i>	White-eared Monarch	V	—	Associated with lowland subtropical rainforest edges and remnants; littoral and floodplain rainforest, swamp sclerophyll with mesomorphic mid storey, coastal wet sclerophyll (Environment Australia 2000; NPWS 2005i). It is thought to avoid moving into small remnants; preferring to move through areas of continuous forest cover (Environment Australia 2000). Recorded approximately five kilometres to the southwest of the study area within Wedding Bells State Forest (BioNet, 2007).	Likely. Suitable Swamp Sclerophyll Forest habitat present.

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Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Pandion haliaetus</i>	Osprey	V	—	Associated with waterbodies including coastal waters, inlets, lakes, estuaries, beaches, offshore islands and sometimes along inland rivers (Schodde and Tidemann 1986; Clancy 1991; Olsen 1995). Osprey may nest on the ground, on sea cliffs or in trees (Olsen 1995). Osprey generally prefer emergent trees, often dead or partly dead with a broken off crown (Olsen 1995). Numerous local records (BioNet, 2007, DEC, 2007).	Likely. Likely to fly over study area and marginal nesting/roosting habitat present.
<i>Pezoporus wallicus wallicus</i>	Ground Parrot (eastern subspecies)	V	—	Predominantly restricted to coastal heath and sedgeland, generally below one metre in height, that provide a high density of cover and food foraging resources (Blakers et al. 1984; Simpson & Day 1999). Recorded two kilometres to the north of the study area (DEC, 2007)	Unlikely. No suitable habitat present (no coastal heath or suitable sedgelands).
<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subspecies)	V	—	Open woodlands dominated by mature eucalypts with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs (NSW Scientific Committee 2001d). This species avoids very wet areas (Blakers et al. 1984). Recorded prior to 1990, approximately 10 km to the north of the study area (BioNet, 2007).	Unlikely. No suitable habitat present (no woodland)
<i>Ptilinopus magnificus</i>	Wompoo Fruit-Dove	V	—	Associated with large, undisturbed patches of tall tropical or subtropical rainforest, at all altitudes, preferably with a diversity of fruit (Marchant and Higgins 1999; NPWS 2005k). Occasionally located in patches of monsoon rainforest, closed gallery forest, wet sclerophyll forest, tall open forest, open woodland or vine thickets near rainforest (Marchant and Higgins 1999; NPWS 2005k).	Unlikely. No suitable habitat present (low occurrence and diversity of fruiting rainforest species recorded within study area).

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Ptilinopus regina</i>	Rose-crowned Fruit-Dove	V	—	Tall tropical and subtropical, evergreen or semi-deciduous rainforests, especially with a dense growth of vines trees (Marchant and Higgins 1999). Also located in closed wet sclerophyll forest, gallery forests or sclerophyll woodlands with abundant fruiting trees, near or next to rainforest (NPWS 2005). Is thought to prefer large areas of vegetation, but has been located in patches and occasionally in parks and gardens with fruiting trees (Marchant and Higgins 1999).	Unlikely. No suitable habitat present (low occurrence and diversity of fruiting rainforest species recorded within study area).
<i>Ptilinopus superbus</i>	Superb Fruit-Dove	V	—	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms (DEC 2005j). It may also forage in eucalypt or acacia woodland where there are fruit-bearing trees (<i>ibid.</i>). Part of the population is migratory or nomadic (<i>ibid.</i>). At least some of the population, particularly young birds, moves south through Sydney, especially in autumn (<i>ibid.</i>). Breeding takes place from September to January (<i>ibid.</i>). Will feed in adjacent mangroves or eucalypt forests (Blakers et al. 1984).	Unlikely. No suitable habitat present (low occurrence and diversity of fruiting rainforest species recorded within study area).
<i>Rostratula benghalensis australis</i>	Painted Snipe (Australian subspecies)	E	E	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (DEC 2005k). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (<i>ibid.</i>). Breeding is often in response to local conditions; generally occurs from September to December (DEC 2005k). Roosts during the day in dense vegetation (NSW Scientific Committee 2004a). Forages nocturnally on mud-flats and in shallow water (DEC 2005k). Feeds on worms, molluscs, insects and some plant-matter (<i>ibid.</i>).	Unlikely. No suitable habitat present (no wetlands, mudflats or shallow water). Additionally no records within 50 km (BioNet, 2007; DEC, 2007).

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Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Sterna albifrons</i>	Little Tern	E	—	Almost exclusively coastal, preferring sheltered areas (NPWS 1999o), however may occur several kilometres inland in harbours, inlets and rivers (Smith 1990). Australian birds breed on sandy beaches and sand spits (Simpson & Day 1999).	Unlikely. No suitable habitat present (no coastal areas, harbours, inlets or rivers).
<i>Sterna fuscata</i>	Sooty Tern	V	—	Forages offshore, usually only observed onshore in breeding season or when storms force them to shelter (NPWS 1999p)	Unlikely. No suitable habitat present (no coastal areas).
<i>Stictonetta naevosa</i>	Freckled Duck	V	—	Associated with a variety of plankton-rich wetlands, such as heavily vegetated, large open lakes and their shores, creeks, farm dams, sewerage ponds and floodwaters (NPWS 1999v).	Unlikely. No suitable habitat present (no wetlands).
<i>Todiramphus chloris</i>	Collared Kingfisher	V	—	In NSW it is most commonly observed in the Tweed River estuary, where it breeds (DEC, 2005i). It appears to be an irregular visitor further south (DEC, 2005i). Collared Kingfishers are virtually restricted to mangroves and other estuarine habitats and mainly occur about the mouths of the larger coastal rivers (DEC, 2005i). Nests are usually in a hollow in a mangrove tree or drilled into termite nests in a large eucalypt or paperbark adjacent to mangroves (DEC, 2005i).	Unlikely. No suitable habitat present (no estuarine areas or mangroves within study area or adjacent).

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Turnix melanogaster</i>	Black-breasted Button-quail	E	V	Dry rainforests, vine scrub or lantana thickets (Marchant & Higgins 1993). In NSW the species inhabits dry or subtropical forests which contain Brigalow, Belah, Bottletrees, Hoop Pine, Lantana, Ironbark, Wattle, Spotted Gum, Wallaby Grass or Rhodes Grass (Bennett 1985; Hughes & Hughes 1991). Observations in Lantana thickets and hoop pine plantations indicate this species may be able to utilise human modified environments (Blakers et al. 1984). Nearest record is west of Coffs Harbour, more than 30 km from the study area near Dorrigo (BioNet, 2007).	Unlikely. Marginal habitat present on edges of Swamp Sclerophyll Forest in northwest of study area. However, no records within 30 km and not detected during survey.
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E	E, M	Associated with temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts, and riparian forests of River Oak (<i>Casuarina cunninghamiana</i>) (Garnett 1993). Areas containing Swamp Mahogany (<i>Eucalyptus robusta</i>) in coastal areas have been observed to be utilised (NPWS 1997). The Regent Honeyeater primarily feeds on nectar from box and ironbark eucalypts and occasionally from banksias and mistletoes (NPWS 1995). As such it is reliant on locally abundant nectar sources with different flowering times to provide reliable supply of nectar (Environment Australia 2000).	Likely. Suitable foraging habitat present.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
NOCTURNAL BIRDS					
<i>Ninox strenua</i>	Powerful Owl	V	—	Powerful Owls are associated with a wide range of wet and dry forest types with a high density of prey, such as arboreal mammals, large birds and flying foxes (Environment Australia 2000, Debus & Chafer 1994). Large trees with hollows at least 0.5m deep are required for shelter and breeding (Environment Australia 2000). Recorded less than one kilometre to the south of the study area (Connell Wagner, 2005).	Likely. Suitable habitat present and recorded nearby.
<i>Tyto novaehollandiae</i>	Masked Owl	V	—	Associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland (NPWS 2005m) and especially the ecotone between wet and dry forest, and non forest habitat (Environment Australia 2000). Known to utilise forest margins and isolated stands of trees within agricultural land (Hyem 1979) and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained (Kavanagh & Peake 1993). Recorded approximately five kilometres to the west of the study area (BioNet, 2007).	Likely. Suitable habitat present and local records.
<i>Tyto tenebricosa</i>	Sooty Owl	V	—	Sooty Owls are associated with tall wet old growth forest on fertile soil with a dense understorey and emergent tall Eucalyptus species (Environment Australia 2000, Debus 1994). Pairs roost in the daytime amongst dense vegetation, in tree hollows and sometimes in caves. The Sooty Owl is typically associated with an abundant and diverse supply of prey items and a selection of large tree hollows (Debus 1994, Garnett 1993, Hyem 1979).	Unlikely. No suitable habitat present (no tall wet old growth forest on fertile soil).

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arararra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
MAMMALS (EXCLUDING BATS)					
<i>Aepyprymnus rufescens</i>	Rufous Bettong	V	—	Prefer forests with a grassy to sparse understorey including coastal forest, tall wet sclerophyll forest and dry forests west of GDR (NPWS 2005n). It is most commonly found on sites derived from sedimentary rock and in north eastern NSW in forests characterised by Spotted Gum (<i>Corymbia maculata</i> and <i>C. henryi</i>) (NPWS 2005n). It has been known to feed on introduced pasture species (NPWS 2005n). Recorded 10 km to the north and south and more than 20 km to the west of the study area (BioNet, 2007).	Likely. Marginal habitat present in open forest habitats.
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	—	Found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath (Menkhorst & Knight 2004). Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit (Turner & Ward 1995). The presence of Banksia sp. and Leptospermum sp. are an important habitat feature (NPWS 2005v). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old birds nests and in the branch forks of tea-trees (Turner & Ward 1995).	Unlikely. Marginal habitat present. However, important forage species (<i>Banksia</i> sp. and <i>Leptospermum</i> sp.) are absent or occur in low abundance within the study area.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arararra Interchange study area

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Dasyurus maculatus</i> <i>Dasyurus maculatus maculatus</i>	Spotted-tailed Quoll Spotted-tailed Quoll (SE Mainland Population)	V —	— E	The Spotted-tailed Quoll inhabits a range of forest communities including wet and dry sclerophyll forests, coastal heathlands and rainforests (Mansergh 1984; NPWS 1999j), more frequently recorded near the ecotones of closed and open forest. This species requires habitat features such as maternal den sites, an abundance of food (birds and small mammals) and large areas of relatively intact vegetation to forage in (NPWS 1999j). Maternal den sites are logs with cryptic entrances; rock outcrops; windrows; burrows (Environment Australia 2000). Recorded less than two kilometres to the southwest of the study area in 1986 (BioNet, 2007).	Likely. Suitable habitat present within open forest habitats.
<i>Petaurus australis</i>	Yellow-bellied Glider	V	—	This species is restricted to tall mature forests, preferring productive tall open sclerophyll forests with a mosaic of tree species including some that flower in winter (Environment Australia 2000, Braithwaite 1984, Davey 1984, Kavanagh 1984; NPWS 1999k). Large hollows within mature trees are required for shelter, nesting and breeding (Henry and Craig 1984; NPWS 1999k).	Recorded. Other local records exist less than one kilometre to the south of the study area (Connell Wagner, 2005).
<i>Petaurus norfolcensis</i>	Squirrel Glider	V	—	Associated with dry hardwood forest and woodlands (Menkhorst et al. 1988; Quin 1995). Habitats typically include gum barked and high nectar producing species, including winter flower species (Menkhorst et al. 1988). The presence of hollow bearing eucalypts is a critical habitat value (Quin 1995). Recorded approximately one kilometre to the east of the study area near Arararra (BioNet, 2007).	Likely. Suitable habitat present. However, not recorded during the survey. Likely to occur at low densities.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arwarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	E	V	Rocky areas in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices (Strahan 1995).	Unlikely. No suitable habitat present (no rocky areas).
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	V	—	Preferred habitat is Dry Open forest with a sparse open understorey, however, has been located in heath, swamps and rainforest and wet sclerophyll forest (NPWS 1999). Recorded approximately 10 km to the north and 15 km to the south of the study area (BioNet, 2007).	Likely. Suitable habitat present within open forest habitat.
<i>Phascolarctos cinereus</i>	Koala	V	—	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70% (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred Eucalyptus species are: Eucalyptus tereticornis, E. punctata, E. cypellocarpa, E. viminalis	Likely. Potential Koala habitat present (Forest Red Gum – <i>Eucalyptus tereticornis</i>). Likely to occur at low densities.
<i>Planigale maculata</i>	Common Planigale	V	—	Subtropical to dry rainforest, dry sclerophyll forest, heathland and grassland up to 400m elevation (NPWS 2005o; Strahan 1998). Habitat selection is dependant on surface cover (NPWS 2005o). Recorded in 1994 less than one kilometre to the south of the study area (BioNet, 2007). Recorded within 2 km of the study area.	Likely. Suitable habitat present. Not recorded during targeted survey; however, the species is difficult to capture and may have been undetected within the study area.
<i>Potorous tridactylus</i> <i>Potorous tridactylus tridactylus</i>	Long-nosed Potoroo Long-nosed Potoroo (SE Mainland Population)	V —	— V	Associated with dry coastal heath and dry and wet sclerophyll forests (Strahan 1998) with dense cover for shelter and adjacent more open areas for foraging (Menkhorst & Knight 2004). Recorded along the Pacific Highway near Emerald Beach, less than 10 km to the south of the current study area	Likely. Suitable habitat present and recent local records.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Pseudomys gracilicaudatus</i>	Eastern Chestnut Mouse	V		Grassy forests woodlands and wet heaths; prefers early post fire serial stage; in areas where foxes scarce or absent; seeds and stems important. Sheltering grass nest on surface of ground or burrow network (Environment Australia 2000). Recorded over 20 km to the north within Yuraygir National Park (BioNet, 2007).	Unlikely. Marginal habitat present. However, not recorded during targeted survey.
<i>Pseudomys oralis</i>	Hastings River Mouse	E	E	An open canopy and shrub layer appear to be the major predictive habitat features of this species (Read & Tweedie 1996). Open forest or woodland with a grassy sedge rush or heath understorey that is about 10-75cm above the ground (NPWS 1999w). Ground cover may vary from almost no cover to a dense, rank cover of grasses, herbs and sedges (DEH 2006a). Sedges, particularly <i>Carex</i> , <i>Juncus</i> and <i>Cyperus</i> spp. are common to most sites (DEH 2006a). This habitat occurs beside creeks (permanent and ephemeral) and soakages, but is also found on ridges and grassy Plains (DEH 2006a). Shelter areas such as rock piles, hollow logs, yabby burrows or cavities in the butts of large old trees are also required to be present (NPWS, 1999w). Recorded more than 30 km to the west of the study area (BioNet, 2007).	Unlikely. Marginal habitat present. However, not recorded during targeted survey.

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
MAMMALS (BATS)					
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; NPWS 2005p). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998; NPWS 2005p). Closest record is approximately 20 km to the west of the study area within Conglomerate State Forest (BioNet, 2007).	Unlikely. No suitable roosting/breeding habitat present (no cave habitats, no rock outcrops or cliff faces within study area)
<i>Chalinolobus nigrogriseus</i>	Hoary Wattled Bat	V	—	The preferred habitat of this species appears to be variable, with dry open forest, woodland, vine thickets, coastal scrub, sand dunes, grasslands and floodplains recorded (Churchill 1998). This species often forages along watercourses, swampy areas and over farm dams. In NSW, this species has been recorded in Spotted Gum (<i>Corymbia maculata</i>), Grey Box (<i>Eucalyptus moluccana</i>) and Northern Ironbark (<i>E. siderophloia</i>) and woodland characterised by Scribbly Gums (<i>E. signata</i>) and Pink Bloodwood (<i>C. intermedia</i>) and sites dominated by the Blackbutt (<i>E. pilularis</i>) (Churchill 1998). Roost sites have been identified as tree hollows, rock crevices and the roofs of buildings (Churchill 1998). Closest record is five kilometres to the north, just south of Red Rock (BioNet, 2007).	Likely. Suitable habitat present and local record.

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Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	—	Prefers moist habitats with trees taller than 20m (DEC 2005f). Roosts in tree hollows but has also been found roosting in buildings or under loose bark (DEC 2005f). Closest records are five kilometres to the north of the study area, just south of Red Rock and west of the study area within Conglomerate State Forest (BioNet, 2007).	Likely. Marginal habitat present and local records.
<i>Kerivoula papuensis</i>	Golden-tipped Bat	V	—	The most favoured habitat for this species is moist closed forests often with a rainforest influence, however, some captures have been made in dry forests some distance from any rainforest (Lunney et. al. 1986; Parnaby and Mills, 1994). It has been suggested that the amount of vines and complex tree layers allows for increased numbers of spiders and webs and such areas are sought by the Golden-tipped Bat (Schulz & Eyre 2000). This species is often caught over streams within rainforest and are known to frequently roost within the pendulous nests of Yellow-throated and Large-billed Scrub Wrens and Brown Gerygone in such areas (Schulz & Eyre 2000). Recorded approximately five kilometres to the south of the study area, west of Woolgoolga (BioNet, 2007).	Likely. Marginal habitat present and local records.

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Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Miniopterus australis</i>	Little Bent-wing Bat	V	—	Prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, Melaleuca swamps and coastal forests (Churchill 1998). This species shelter in a range of structures including culverts, drains, mines and caves (Environment Australia 2000). Relatively large areas of dense vegetation of either wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (NPWS 2005q). Breeding occurs in caves, usually in association with <i>M. schreibersii</i> (Environment Australia 2000, NPWS 2005q).	Recorded.
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bent-wing Bat	V	—	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland (Churchill 1998). It forages above and below the tree canopy on small insects (AMBS 1995, Dwyer 1995, Dwyer 1981). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000, Dwyer 1995).	Recorded.
<i>Mormopterus norfolkensis</i>	East Coast Freetail Bat	V	—	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges (Environment Australia 2000; Allison & Hoye 1998). Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoye 1998).	Recorded.

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Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Myotis adversus</i>	Large-footed Myotis	V	—	Will occupy most habitat types such as mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland, as long as they are close to water (Churchill 1998). While roosting is most commonly associated with caves, this species has been observed to roost in tree hollows, amongst vegetation, in clumps of Pandanus, under bridges, in mines, tunnels and stormwater drains (Churchill 1998). However the species apparently has specific roost requirements, and only a small percentage of available caves, mines, tunnels and culverts are used (Richards 1998).	Likely. Suitable foraging habitat along creek within the study area and in dams adjacent to the study area.
<i>Nyctophilus bifax</i>	Eastern Long-eared Bat	V	—	This species prefers wetter habitats, ranging from rainforest and monsoon forest to riverine forests of paperbark, but may be found in open woodland, tall open forest and dry sclerophyll woodland (Churchill 1998). These forest bats have been recorded roosting under peeling bark, among epiphytes, in tree hollows and in foliage (Churchill 1998). Individuals are likely to change roost sites nightly (NPWS 2005r).	Likely. Suitable habitat present, although, not within core distribution.
<i>Pteropus alecto</i>	Black Flying-Fox	V	—	Mangroves, paperbark forests and occasionally patches of rainforest are most commonly utilised for camp sites (Strahan 1998; Churchill 1998). They have been found to occupy a range of habitats of tropical and sub-tropical forests and woodlands (Churchill 1998). Preferred food includes blossoms (such as eucalypts, paperbarks and turpentines), also introduced fruits and blossoms (Strahan 1998).	Likely. Suitable foraging habitat present

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		TSC Act	EPBC Act		
<i>Pteropus poliocephalus</i>	Grey-headed Flying-Fox	V	V	Inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1998). Camps are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998).	Recorded.
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V	—	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies (SFNSW 1995). Roosts in tree hollows; may also use caves; has also been recorded in a tree hollow in a paddock (Environment Australia 2000) and in abandoned sugar glider nests (Churchill 1998). The Yellow-bellied Sheath-tail-bat is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000).	Likely. Suitable habitat present.
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	—	Associated with moist gullies in mature coastal forest, or rainforest, east of the Great Dividing Range (Churchill, 1998), tending to be more frequently located in more productive forests (Hoye & Richards 1998). Within denser vegetation types use is made of natural and man made openings such as roads, creeks and small rivers, where it hawks backwards and forwards for prey (Hoye & Richards 1998).	Recorded.

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		TSC Act	EPBC Act		
<i>Syconycteris australis</i>	Common Blossom-bat	V	—	The combination of heathland and coastal rainforest is essential for this species (Churchill 1998). Breeding and sheltering habitats are in subtropical and littoral rainforests and a diverse range of nectar producing plant communities are required year round; it will occasionally eat some rainforest fruits (Churchill 1998; Environment Australia 2000).	Unlikely. No suitable habitat present (no heathland or coastal rainforest).
<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V	—	Inhabit tropical mixed woodland and wet sclerophyll forest on the coast and the dividing range but extend into the drier forest of the western slopes and inland areas (Churchill 1998). Has been found roosting in sandstone overhand caves, boulder piles, mine tunnels and occasionally in buildings (Churchill 1998).	Likely. Suitable habitat present. However, closest records are more than 40 km to the north and south of study area (BioNet, 2007).
INVERTEBRATES					
<i>Petalura gigantea</i>	Giant Dragonfly	E	—	Swamps, streamlines and seepages in mainly natural condition with short to moderate vegetation and a relatively deep soil base (Trueman 2005). Larvae permanently burrow into soil and so do not survive in permanent ponds or other open water (Trueman 2005).	Unlikely. Marginal habitat present within Swamp Sclerophyll Forest. However, the high level of disturbance is likely to have precluded the species.
MIGRATORY TERRESTRIAL SPECIES LISTED UNDER EPBC ACT					
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	—	M	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins 1993).	Likely. Species is likely to fly over the study area. However, no suitable foraging or breeding habitat present.

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Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Hirundapus caudacutus</i>	White-throated Needletail	—	M	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Marchant & Higgins 1993; Simpson & Day 1999). Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Marchant & Higgins 1993).	Likely. Species is likely to fly and forage over the study area.
<i>Merops ornatus</i>	Rainbow Bee-eater	—	M	Resident in coastal and subcoastal northern Australia; regular breeding migrant in southern Australia, arriving September to October, departing February to March, some occasionally present April to May (Pizzey and Doyle 1988). Occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil: sand-ridges, riverbanks, road-cuttings, sand-pits, occasionally coastal cliffs (<i>ibid</i>). Nest is a chamber at the end of a burrow, up to 1.6 m long, tunnelled in flat or sloping ground, sandy back or cutting (<i>ibid</i>).	Likely. Suitable habitat present.
<i>Monarcha melanopsis</i>	Black-faced Monarch	—	M	Rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al. 1984).	Likely. Marginal habitat present
<i>Monarcha trivirgatus</i>	Spectacled Monarch	—	M	Wet forests, mangroves (Simpson and Day 1999).	Likely. Marginal habitat present
<i>Myiagra cyanoleuca</i>	Satin Flycatcher	—	M	Associated with drier eucalypt forests, absent from rainforests (Blakers et al. 1984), open forests, often at height (Simpson & Day 1999).	Likely. Suitable habitat present
<i>Rhipidura rufifrons</i>	Rufous Fantail	—	M	Wet forests, less often open forests (Simpson & Day 1999)	Likely. Suitable habitat present
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E	E, M	SEE DIURNAL BIRDS ABOVE	SEE DIURNAL BIRDS ABOVE

Table A: Assessment of Likelihood of Occurrence of Threatened Fauna Species within the Arrawarra Interchange study area

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<p>Disclaimer: Data extracted from the Atlas of NSW Wildlife, BioNet and DEH Protected Matters Report are only indicative and cannot be considered a comprehensive inventory. In recognising this, a literature review complemented by appropriate field survey has been undertaken that targets a larger number of species than is listed in this table. 'Migratory marine species' and 'listed marine species' listed on the EPBC Act (and listed on the DEH protected matters report) have not been included in this table, since they are considered unlikely to occur within the study area due to the absence of marine habitat.</p>					

E = Endangered

E2 = Endangered population

V = Vulnerable

M = Migratory

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Acacia chrysotricha</i>	Newry Golden Wattle	E	—	An understorey species on rainforest edges and in wet or dry eucalypt forest in steep narrow gullies on quartzite soils (DEC, 2005bk). The round, yellow flower heads are present from July-August (DEC, 2005bk). Recorded less than five kilometres to the south near Safety Beach (BioNet 2007).	Unlikely. No suitable habitat present (no rainforest edges or steep gullies in wet or dry eucalypt forest).
<i>Acronychia littoralis</i>	Scented Acronychia	E	E	It is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW (DEC, 2005bm). It grows in littoral rainforest on sand (DEC, 2005bm). Recorded approximately five kilometres to the north, just south of Red Rock (DEC, 2007).	Unlikely. No suitable habitat present (no littoral rainforest).

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Allocasuarina defungens</i>	Dwarf Heath She-oak	E	E	Found only in NSW from the Nabic area, north-west of Forster, to Byron Bay on the NSW north coast (DEC 2005bg). <i>A. defungens</i> is a straggly oak about 2m high with blue-green foliage found in heath on sand (sometimes clay and sandstone soils), and swamp sclerophyll forest margins (DEC 2005bg). The species also extends onto exposed nearby-coastal hills or headlands adjacent to sandplains (DEC 2005bg). Recorded approximately 7 km to the north of the study area (BioNet 2007).	Unlikely. Suitable habitat present in Swamp Sclerophyll Forest. However, not detected during surveys.
<i>Amorphospermum whitei</i>	Rusty Plum	V	E	Typical habitat consists of gully rainforest or wet sclerophyll with a well-developed rainforest understorey growing on medium fertility soils formed on metasediment or rhyolite (Floyd 1989). The altitudinal range of this species is from near sea level to 600 m (Floyd 1989). Recorded around two kilometres to the southwest (DEC, 2007) and at numerous locations around Woolgoolga (Ecos Environmental Pty Ltd, 2005).	Unlikely. The southern ecotone of the northwest swamp sclerophyll forest offers some very marginal habitat. However, disturbance history (ie logging) is likely to have precluded this species from occurring and the species was not detected during surveys.
<i>Angophora robur</i>	Large-fruited Angophora	V	V	Dry open forest in sandy or skeletal soils on sandstone, or occasionally granite, with frequent outcrops of rock (DEC, 2005bl). Recorded more than 10 km to the west of the study site (BioNet, 2007).	Unlikely. No suitable habitat present (soil type unsuitable and no rock outcrops).

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Arthraxon hispidus</i>	Hairy Jointgrass	V	V	Moisture and shade-loving grass, found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps (DEC, 2005cb). Recorded south of Coffs Harbour, more than 20 km south of the study area.	Unlikely. Marginal habitat present in Swamp Sclerophyll Forest. However, not detected during surveys and logging disturbance is likely to have precluded the species.
<i>Asperula asthenes</i>	Trailing Woodruff	V	V	It is found in scattered locations from Bulahdelah north to near Kempsey, with several records from the Port Stephens/Wallis Lakes area. Damp sites often along river banks (Harden 1994). Recorded approximately 30 km to the west within Kangaroo River State Forest (BioNet, 2007).	Unlikely. Marginal habitat present within low areas of Swamp Sclerophyll Forest in northwest study area and along the banks of Little Arrawarra Creek. However, recorded more than 30 km away and not detected during surveys.
<i>Boronia umbellata</i>	Orara Boronia	V	V	Found at only a few locations between Glenreagh and Lower Bucca, north of Coffs Harbour, but it is locally common in the restricted area where it occurs (DEC, 2005bn). It grows as an understory shrub in and around gullies in wet open forest (DEC, 2005bn). It appears to regenerate well after disturbance, but it is not known whether prolonged or repeated disturbance affects long-term persistence (DEC, 2005bn). Recorded approximately five kilometres to the west of the study area in Conglomerate State Forest (BioNet, 2007).	Unlikely. Marginal habitat present in Swamp Sclerophyll Forest. However, not detected during surveys.

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Callistemon linearifolius</i>	Netted Bottlebrush	V	—	Grows in dry sclerophyll forest on the coast and adjacent ranges (DEC 2005af). <i>C. linearifolius</i> has been recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW (DEC 2005af). Recorded approximately 10 km to the west of the study area (BioNet, 2007).	Unlikely. Suitable dry sclerophyll forest habitat present. However, not detected during surveys.
<i>Chamaesyce psammogeton</i>	Sand Spurge	E	—	<i>C. psammogeton</i> is a prostrate perennial herb, which grows on foredunes and exposed sites on headlands often with Spinifex (DEC 2005ab). Flowers in Summer.	Unlikely. No suitable habitat present (no foredunes or headlands).
<i>Cynanchum elegans</i>		E	E	Climber or twiner with a variable form (NPWS 2002ab). It occurs in dry rainforest gullies, scrub and scree slopes. It prefers the ecotone between dry subtropical rainforest and sclerophyll woodland/forest. However has been found in littoral rainforest; <i>Leptospermum laevigatum</i> – <i>Banksia integrifolia</i> subsp <i>integrifolia</i> coastal scrub; <i>Eucalyptus tereticornis</i> aligned open forest/ woodland; <i>E. maculata</i> aligned open forest/woodland; and <i>Melaleuca armillaris</i> scrub to open scrub (NPWS 2002ab). Flowers between August and May, peaking in November (NPWS 2002ab).	Unlikely. The southern ecotone of the northwest swamp sclerophyll forest offers some very marginal habitat. However, not detected during survey.

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Eleocharis tetraquetra</i>	Square-stemmed Spike Rush	E	–	Thought to be extinct in NSW until it was rediscovered in 1997 at Boambee near Coffs Harbour (DEC, 2005ca). It has since been found in other north coast localities near Grafton and Murwillumbah (DEC, 2005ca). Found in damp locations on stream edges and in and on the margins of freshwater swamps (DEC, 2005ca). Recorded near Coffs Harbour, more than 20 km to the south (DEC, 2007).	Unlikely. Suitable habitat present in the northwest of the study area. However, not detected during survey.
<i>Eucalyptus tetrapleura</i>	Square-fruited Ironbark	V	V	Restricted to the coastal lowlands and foothills of northern NSW around Casino and Grafton (DEC, 2005bo). Dry or moist eucalypt forest on moderately fertile soil, often in low areas with poor drainage (DEC, 2005bo). Recorded approximately 10 km to northwest of study area (DEC, 2007).	Unlikely. Suitable eucalypt forest habitat present in the study area. However, not detected during survey.
<i>Grammitis stenophylla</i>	Narrow-leaf Finger Fern	E	–	In NSW it has been found on the south, central and north coasts and as far west as Mount Kaputar National Park near Narrabrai (DEC, 2005bp). Moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest (DEC, 2005bp). Recorded approximately 10 km to west of study area (BioNet, 2007).	Unlikely. Suitable habitat present in the northwest of the study area and marginal habitat adjacent to Little Arrawarra Creek. However, not detected during survey.
<i>Hicksbeachia pinnatifolia</i>	Red Boppel Nut	V	V	Subtropical rainforest, moist eucalypt forest and Brush Box forest (DEC, 2005bq). Recorded approximately five kilometres to the south of the study area (DEC, 2007).	Unlikely. The southern ecotone of the northwest swamp sclerophyll forest offers some very marginal habitat. However, not detected during survey.

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Lindsaea incisa</i>	Slender Screw Fern	E	—	In NSW it is known only from a few locations between Woombah and just south of Coffs Harbour (DEC, 2005br). Dry eucalypt forest on sandstone and moist shrubby eucalypt forest on metasediments (DEC, 2005br). It is usually found in waterlogged or poorly drained sites along creeks, where ferns, sedges and shrubs grow thickly (DEC, 2005br). Recorded approximately 10 km to the west of the study area (BioNet, 2007).	Unlikely. Marginal habitat present near Little Arrawarra Creek and in the northwest of the study area. However, not detected during survey.
<i>Macadamia tetraphylla</i>	Rough-shelled Bush Nut	V	V	Confined chiefly to the Richmond and Tweed Rivers in north-east NSW, extending just across the border into QLD (DEC, 2005bs). Found in subtropical rainforest, usually near the coast (DEC, 2005bs). Recorded less than two kilometres to the southwest of the study area (DEC, 2007). Ecos Environmental Pty (2005) consider local specimens to have been introduced to the area.	Unlikely. No suitable habitat present (no subtropical rainforest).

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Marsdenia longiloba</i>	Slender Marsdenia	E	V	Subtropical and warm temperate rainforest, lowland moist eucalypt forest adjoining rainforest and, sometimes, in areas with rock outcrops (DEC, 2005bt). Moist open forest with a fern-grass understorey and occasional small rainforest trees, often on hillslopes adjacent to gully rainforest (Ecos Environmental Pty Ltd, 2005). It appears to prefer soils of medium fertility formed on substrates such as metasediment (Ecos Environmental Pty Ltd, 2005). Recorded around three kilometres to the south of the study area, just west of Woolgoolga (DEC, 2007; Ecos Environmental Pty Ltd, 2005).	Unlikely. The southern ecotone of the northwest swamp sclerophyll forest offers some very marginal habitat. However, not detected during survey.
<i>Maundia triglochinoxides</i>		V	-	Restricted to coastal NSW and extending into southern Queensland. The current southern limit is Wyong; former sites around Sydney are now extinct (DEC 2005bh). <i>Maundia triglochinoxides</i> is an aquatic herbaceous plant found in swamps or shallow fresh water on heavy clay on the north and central NSW coast. Recorded 15 km to the north within Yuraygir National Park (BioNet, 2007).	Unlikely. Marginal habitat present in Little Arrawarra Creek and in the northwest of the study area. However, not detected during survey.
<i>Melichrus hirsutus</i>	Hairy Melichrus	E	E	Restricted to a few locations near Grafton in north-east NSW (DEC, 2005ce). Dry eucalypt forest with a shrubby understorey on sandy infertile soils with rock outcrops (DEC, 2005ce). Recorded 20 km to west and north of study area (DEC, 2007).	Unlikely. No suitable habitat present (no sandy soils with rock outcrops).

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species					
Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Parsonsia dorrigoensis</i>		V	E	Scattered populations in the north coast region between Kendall and Woolgoolga (DEC, 2005bu). Found in subtropical and warm-temperature rainforest, on rainforest margins, and in moist eucalypt forest up to 800 m, on brown clay soils (DEC, 2005bu). Flowers in summer (DEC, 2005bu). Recorded 10 km to the west of the study area within Conglomerate State Forest (DEC, 2007).	Unlikely. The southern ecotone of the northwest swamp sclerophyll forest and margins offer some very marginal habitat. However, not detected during survey.
<i>Phaius australis</i>	Swamp Orchid	E	E	Swampy grassland or swampy forest including rainforest, eucalypt or paperbark forest, mostly in coastal areas (DEC, 2005bv). Flowers September to October (DEC, 2005bv). Recorded approximately two kilometres to the south near Safety Beach (DEC, 2007).	Likely. Suitable habitat present in Swamp Sclerophyll Forest. Survey was conducted outside of flowering period and was unlikely to detect species.

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Quassia</i> sp.1	'Mooney Creek' Quassia	E	E	The habitat of the Moonee Quassia at Moonee and other coastal sites is wet sclerophyll forest, typically comprising canopy species such as <i>Eucalyptus microcorys</i> (Tallowwood), <i>Lophostemon confertus</i> (Brushbox), <i>Syncarpia glomulifera</i> (Turpentine), and <i>Allocasuarina torulosa</i> (Forest Oak) (DEC, 2005bw). This wet forest habitat usually supports a varying density and diversity of rainforest understorey species (DEC, 2005bw). The habitat of populations in the Grafton district consists of tall dry Eucalypt forests of <i>Eucalyptus planchoniana</i> (Needlebark Stringybark) / <i>Eucalyptus pyrocarpa</i> (Large-fruited Blackbutt) above a well developed shrub layer (DEC, 2005bw). It occurs with populations of the threatened plants <i>Boronia umbellata</i> , <i>Parsonsia dorrigoensis</i> and <i>Amorphospermum whitei</i> . Populations of <i>Eucalyptus rummeryi</i> , <i>Austrobuxus swainii</i> and <i>Marsdenia liisae</i> have also been recorded in the same area as the Moonee Quassia at Conglomerate State Forest (DEC, 2005bw). Recorded approximately seven kilometres to the southwest of the study area (DEC, 2007).	Unlikely. Marginal habitat present in Swamp Sclerophyll Forest and margins. However, not detected during survey.

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Sarcochilus fitzgeraldii</i>	Ravine Orchid	V	V	North-east NSW, north of the Macleay River, to Maleny in south-east Queensland (DEC, 2005cd). The Ravine Orchid grows mainly on rocks, amongst organic matter, in cool, moist, shady ravines, gorges and on cliff faces in dense subtropical rainforest at altitudes between 500 and 700 m (DEC, 2005cd). Occasional clumps are found on the bases of fibrous-barked trees and it flowers between Spring and Summer (DEC, 2005cd). Recorded 10 km to the west of Sapphire turnoff (DEC, 2007).	Unlikely. No suitable habitat present (no ravines, cliff faces or rocky areas).
<i>Senna acclinis</i>	Rainforest Cassia	E	—	Grows in or on the edges of subtropical and dry rainforest (DEC, 2005bx). Recorded approximately seven kilometres to the south of the study area (DEC, 2007).	Unlikely. Marginal habitat present adjacent to Little Arrawarra Creek and margins of Swamp Sclerophyll Forest. However, not detected during survey.
<i>Thesium australe</i>	Austral Toadflax	V	V	Occurs in grassland or grassy woodland (DEC 2005ar). Often found in damp sites in association with Kangaroo Grass (<i>Themeda australis</i>) DEC 2005ar). Recorded within Moonee Beach Nature Reserve, approximately 10 km to the south of the study area	Unlikely. No suitable habitat present (no grassland or grassy woodland). Not detected during survey.

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Tylophora woollsii</i>	Cryptic Forest Twiner	E	E	It is found from the NSW north coast and New England Tablelands to southern Queensland, but is very rare within that range (DEC, 2005cc). Known on the Tablelands from the Bald Rock and Boonoo Boonoo areas north of Tenterfield (DEC, 2005cc). Grows in moist eucalypt forest, moist sites in dry eucalypt forest and rainforest margins (DEC, 2005cc). Flowering occurs in summer and autumn, usually between January and March but sometimes as late as November (DEC, 2005cc). Recorded south of Coffs Harbour and 30 km to the west of Woolgoolga (DEC, 2007)	Unlikely. Marginal habitat present within Swamp Sclerophyll Forest and margins. However, not detected during survey and records more than 20 km away.
<i>Typhonium</i> sp. aff. <i>brownii</i>	Stinky Lily	E	—	Only known from four locations in the ranges west of Coffs Harbour and Woolgoolga: Kangaroo River, Bruxner Park, Bindarri National Park and Upper Corindi (DEC, 2005bz). Occurs on reasonably fertile soils, in moist eucalypt forest and the moist eucalypt forest-subtropical rainforest interface (DEC, 2005bz). It is best detected during Summer (DEC, 2005bz). Recorded approximately two kilometres to the south, just west of Woolgoolga (DEC, 2007).	Unlikely. Marginal habitat present within Swamp Sclerophyll Forest and margins. However, the study area has relatively poor soils and a high level of logging disturbance likely to preclude the species.

Table B: Assessment of Likelihood of Occurrence of Threatened Flora Species

Scientific Name	Common Name	Conservation Significance		Habitat Associations	Likelihood of Occurrence
		TSC Act	EPBC Act		
<i>Zieria prostrata</i>	Headland Zieria	E	E	Restricted to four coastal headlands in the Coffs Harbour area of north-east NSW (DEC, 2005by). Low grassy heath on exposed sites and wind-pruned open to sparse shrubland on more sheltered aspects (DEC, 2005by). Recorded approximately five kilometres to the south, near Safety Beach (BioNet, 2007).	Unlikely. No suitable habitat present (no headlands or exposed sites with heath).
<p>Disclaimer: Data extracted from the Atlas of NSW Wildlife and EPBC Act Protected Matters Report are only indicative and cannot be considered a comprehensive inventory. In recognising this, a literature review complemented by appropriate field survey has been undertaken that targets a larger number of species than is listed in this table.</p>					

Appendix B

Flora species list

Scientific Name	Common Name	TSCA	EPBC	Blackbutt Forest E Block	Swamp Sclerophyll Forest SW Block	Swamp Sclerophyll Forest Central W Block	Swamp Sclerophyll Forest NW Block	Blackbutt Forest NW Block + Central W Block	Freshwater Wetland NW Block
<i>Acacia binervia</i>	Coast Myall	-	-					+	
<i>Acacia falcata</i>	Sickle Wattle	-	-	+					
<i>Acacia fimbriata</i>	Fringed Wattle	-	-	+		+		+	
<i>Acacia irrorata</i>	Green Wattle	-	-					+	
<i>Acacia longifolia</i>	Sydney Golden Wattle	-	-	+					
<i>Acacia myrtifolia</i>	Red Stem Wattle	-	-					+	
<i>Acmella grandiflora</i>	-	-	-				+		
<i>Ageratum conyzoides*</i>	Goatweed	-	-						+
<i>Allocasuarina littoralis</i>	Black She-oak	-	-	+		+	+		
<i>Allocasuarina torulosa</i>	Forest Oak	-	-	+				+	
<i>Alphitonia excelsa</i>	Red Ash	-	-	+			+	+	
<i>Amyema congener</i>	Mistletoe	-	-	+					
<i>Aristida vagans</i>	Threeawn Speargrass	-	-	+					
<i>Asplenium flabellifolium</i>	Necklace Fern	-	-			+			
<i>Axonopus affinis*</i>	-	-	-		+	+			+
<i>Baccharis halimifolia</i>	Groundsel Bush	-	-			+	+		+
<i>Baumea articulata</i>	Jointed Twig-rush	-	-						+

Scientific Name	Common Name	TSCA	EPBC	Blackbutt Forest E Block	Swamp Sclerophyll Forest SW Block	Swamp Sclerophyll Forest Central W Block	Swamp Sclerophyll Forest NW Block	Blackbutt Forest NW Block + Central W Block	Freshwater Wetland NW Block
<i>Baumea juncea</i>	-	-	-				+		
<i>Baumea rubiginosa</i>	Soft Twig-rush	-	-						+
<i>Billardiera scandens</i>	Apple Dumplings	-	-					+	
<i>Breynia oblongifolia</i>	Coffee Bush	-	-	+		+	+	+	
<i>Callistemon salignus</i>	Willow Bottlebrush	-	-		+		+	+	
<i>Cassytha pubescens</i>	Devil's Twine	-	-	+	+	+	+		
<i>Chrysanthemoides monilifera ssp. rotundata</i> *	Bitou Bush	-	-	+					
<i>Corymbia intermedia</i>	Pink Bloodwood	-	-	+			+	+	
<i>Cymbopogon refractus</i>	Barbwire Grass	-	-	+				+	
<i>Cyperus haspan</i>	-	-	-						+
<i>Daviesia ulicifolia</i>	Gorse Bitter Pea	-	-					+	
<i>Desmodium rhytidophyllum</i>	-	-	-	+				+	
<i>Dianella caerulea</i>	Flax Lily	-	-	+		+			
<i>Dichondra repens</i>	Kidney Weed	-	-			+		+	+
<i>Dillwynia retorta</i>	Eggs and Bacon	-	-			+			
<i>Dodonaea triquetra</i>	Hop Bush	-	-					+	

Scientific Name	Common Name	TSCA	EPBC	Blackbutt Forest E Block	Swamp Sclerophyll Forest SW Block	Swamp Sclerophyll Forest Central W Block	Swamp Sclerophyll Forest NW Block	Blackbutt Forest NW Block + Central W Block	Freshwater Wetland NW Block
<i>Echinopogon ovatus</i>	Forest Hedgehog Grass	-	-				+		
<i>Eclipta platyglossa</i>	-	-	-				+		
<i>Elaeocarpus obovatus</i>	Hard Quandong	-	-					+	
<i>Eleocharis phillippinensis</i>	-	-	-						+
<i>Eleocharis sphacelata</i>	Tall Spike-rush	-	-				+		+
<i>Entolasia marginata</i>	Bordered Panic	-	-			+	+	+	
<i>Entolasia stricta</i>	Wiry Panic	-	-	+		+	+	+	
<i>Epacris pulchella</i>	NSW Coral Heath	-	-					+	
<i>Eragrostis brownii</i>	Brown's Lovegrass	-	-			+		+	
<i>Eucalyptus globboidea</i>	White Stringybark	-	-	+					
<i>Eucalyptus microcorys</i>	Tallowwood	-	-	+				+	
<i>Eucalyptus paniculata</i>	Grey Ironbark	-	-	+				+	
<i>Eucalyptus pilularis</i>	Blackbutt	-	-	+				+	
<i>Eucalyptus resinifera</i>	Red Mahogany	-	-	+		+		+	
<i>Eucalyptus robusta</i>	Swamp Mahogany	-	-				+		
<i>Eucalyptus tereticornis</i>	Forest Red Gum	-	-		+	+	+		

Scientific Name	Common Name	TSCA	EPBC	Blackbutt Forest E Block	Swamp Sclerophyll Forest SW Block	Swamp Sclerophyll Forest Central W Block	Swamp Sclerophyll Forest NW Block	Blackbutt Forest NW Block + Central W Block	Freshwater Wetland NW Block
<i>Eustrephus latifolius</i>	Wombat Berry	-	-	+			+		
<i>Exocarpos cupressiformis</i>	Native Cherry	-	-	+					
<i>Fimbristylis dichotoma</i>	Common Fringe-rush	-	-						+
<i>Fuirena ciliaris</i>	-	-	-						+
<i>Gahnia aspera</i>	Saw Sedge	-	-				+	+	
<i>Gahnia clarkei</i>	Tall Saw-sedge	-	-				+		
<i>Glochidion ferdinandi</i>	Cheese Tree	-	-	+	+	+	+		
<i>Glycine micropylla</i>	Twining Glycine	-	-	+				+	
<i>Gonocarpus chinensis</i>	-	-	-				+		
<i>Gonocarpus micranthus</i>	-	-	-	+		+			
<i>Goodenia heterophylla</i>	-	-	-					+	
<i>Goodenia paniculata</i>	-	-	-						+
<i>Goodenia rotundifolia</i>	-	-	-	+					
<i>Hakea dactyloides</i>	Broad-leaved Hakea	-	-	+					
<i>Hakea sericea</i>	Silky Hakea	-	-				+		
<i>Hardenbergia violacea</i>	False Sarsparilla	-	-	+					

Scientific Name	Common Name	TSCA	EPBC	Blackbutt Forest E Block	Swamp Sclerophyll Forest SW Block	Swamp Sclerophyll Forest Central W Block	Swamp Sclerophyll Forest NW Block	Blackbutt Forest NW Block + Central W Block	Freshwater Wetland NW Block
<i>Hibbertia aspera</i>	Rough Guinea Flower	-	-				+		
<i>Hibbertia diffusa</i>	-	-	-	+		+	+	+	
<i>Hydrocotyle peduncularis</i>	-	-	-						+
<i>Hygrophila angustifolia</i>	-	-	-				+		
<i>Hypolepis muelleri</i>	Harsh Ground Fern	-	-				+		
<i>Imperata cylindrica</i>	Blady Grass	-	-	+		+	+	+	
<i>Ipomoea cairica</i> *	Blue Morning Glory	-	-	+					
<i>Isolepis</i> sp.	Rush sp.	-	-						+
<i>Juncus prismatocarpus</i>	-	-	-						+
<i>Kennedia rubicunda</i>	Dusky Coral Pea	-	-					+	
<i>Lantana camara</i> *	Lantana	-	-				+	+	
<i>Lepidium</i> sp.	Peppercress sp	-	-						+
<i>Lepidosperma laterale</i>	Variable Sword-sedge	-	-	+					
<i>Leptospermum juniperinum</i>	Prickly Tea-tree	-	-	+				+	
<i>Leucopogon juniperinus</i>	Prickly Beard-heath	-	-	+		+		+	
<i>Lomandra longifolia</i>	Spiky-headed Mat-rush	-	-	+		+	+	+	

Scientific Name	Common Name	TSCA	EPBC	Blackbutt Forest E Block	Swamp Sclerophyll Forest SW Block	Swamp Sclerophyll Forest Central W Block	Swamp Sclerophyll Forest NW Block	Blackbutt Forest NW Block + Central W Block	Freshwater Wetland NW Block
<i>Lomandra micrantha</i>	-	-	-	+				+	
<i>Lophostemon suaveolens</i>	Swamp Box	-	-	+	+	+	+		+
<i>Melaleuca linariifolia</i>	Snow in Summer	-	-	+					
<i>Melaleuca quinquinervia</i>	Broad-leaved Paperbark	-	-		+	+	+		+
<i>Myrsine howittiana</i>	Brush Muttonwood	-	-				+		
<i>Oplismenus aemulus</i>	Basket Grass	-	-	+					
<i>Ozothamnus diosmifolius</i>	Ball Everlasting	-	-	+				+	
<i>Parsonsia straminea</i>	Common Silkpod	-	-			+	+	+	
<i>Paspalum dilatatum</i> *	Paspalum	-	-				+	+	+
<i>Patersonia sericea</i>	Wild Iris	-	-					+	
<i>Persoonia lanceolata</i>	Lance-leaved Geebung	-	-			+			
<i>Persoonia lanceolata</i>	Lance Leaf Geebung	-	-	+				+	
<i>Philydrum lanuginosum</i>	Woolly Frogmouth	-	-				+		+
<i>Pimelea linifolia</i>	Slender Rice Flower	-	-			+	+		
<i>Polymeria calycina</i>	Bindweed	-	-	+		+	+	+	
<i>Pratia purpurascens</i>	Whiteroot	-	-	+				+	

Scientific Name	Common Name	TSCA	EPBC	Blackbutt Forest E Block	Swamp Sclerophyll Forest SW Block	Swamp Sclerophyll Forest Central W Block	Swamp Sclerophyll Forest NW Block	Blackbutt Forest NW Block + Central W Block	Freshwater Wetland NW Block
<i>Pseuderanthemum variabile</i>	Pastel Flower	-	-	+					
<i>Pteridium esculentum</i>	Bracken	-	-	+				+	
<i>Pultenaea retusa</i>	-	-	-	+	+	+	+		
<i>Scaevola ramosissima</i>	Purple Fan Flower	-	-			+	+		
<i>Schoenus sp.</i>	Rush sp	-	-						+
<i>Schoenus brevifolius</i>		-	-						+
<i>Setaria pumila</i>	Pale Pigeon Grass	-	-						+
<i>Smilax glycyphylla</i>	Sarsaparilla	-	-			+			
<i>Sporobolus africanus</i>	Parramatta Grass	-	-					+	
<i>Stephania japonica</i>	Snake Vine	-	-					+	
<i>Syncarpia glomulifera</i>	Turpentine	-	-					+	
<i>Themeda australis</i>	Kangaroo Grass	-	-	+		+		+	
<i>Thysanotus juncifolius</i>	Fringed Lily	-	-			+			
<i>Verbena bonariensis</i> *	Purpletop	-	-	+					
<i>Villarsia exaltata</i>	Yellow Marsh Flower	-	-				+		+
<i>Viola hederacea</i>	Native Violet	-	-			+			

Appendix C

Fauna species list

Group	Family	Scientific Name	Common Name	TSCA	EPBC
Amphibians	HYLIDAE	<i>Litoria fallax</i>	Eastern Dwarf Tree Frog	-	-
Amphibians	MYOBATRACHIDAE	<i>Crinia tinnula</i>	Wallum Froglet	V	-
Amphibians	MYOBATRACHIDAE	<i>Limnodynastes peronii</i>	Striped Marsh Frog	-	-
Amphibians	MYOBATRACHIDAE	<i>Pseudophryne coriacea</i>	Red-backed Toadlet	-	-
Birds	ACCIPITRIDAE	<i>Haliastur sphenurus</i>	Whistling Kite	-	-
Birds	ARDEIDAE	<i>Ardea alba</i>	Great Egret	-	-
Birds	ARDEIDAE	<i>Egretta novaehollandiae</i>	White-faced Heron	-	-
Birds	ARTAMIDAE	<i>Cracticus torquatus</i>	Grey Butcherbird	-	-
Birds	ARTAMIDAE	<i>Strepera graculina</i>	Pied Currawong	-	-
Birds	CACATUIDAE	<i>Calyptorhynchus fumereus</i>	Yellow-tailed Black Cockatoo	-	-
Birds	CACATUIDAE	<i>Calyptorhynchus lathami</i>	Glossy Black Cockatoo	V	-
Birds	CAMPEPHAGIDAE	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	-	-
Birds	CLIMACTERIDAE	<i>Cormobates leucophaeus</i>	White-throated Treecreeper	-	-
Birds	CORVIDAE	<i>Corvus coronoides</i>	Australian Raven	-	-
Birds	CUCULIDAE	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	-	-
Birds	DICRURIDAE	<i>Rhipidura fuliginosa</i>	Grey Fantail	-	-
Birds	LARIDAE	<i>Larus novaehollandiae</i>	Silver Gull	-	-
Birds	MELIPAGIDAE	<i>Anthochaera chrysoptera</i>	Little Wattlebird	-	-
Birds	MELIPAGIDAE	<i>Manorina melanocephala</i>	Noisy Miner	-	-
Birds	MELIPAGIDAE	<i>Meliphaga lewinii</i>	Lewin's Honeyeater	-	-
Birds	MELIPAGIDAE	<i>Myzomela sanguinolenta</i>	Scarlet Honeyeater	-	-
Birds	MELIPAGIDAE	<i>Philemon corniculatus</i>	Noisy Friarbird	-	-
Birds	ORIOLOIDAE	<i>Sphecotheres viridis</i>	Figbird	-	-

Group	Family	Scientific Name	Common Name	TSCA	EPBC
Birds	PACHYCEPHALIDAE	<i>Colluricincla megarhyncha</i>	Little Shrike-thrush	-	-
Birds	PELICANIDAE	<i>Pelecanus conspicillatus</i>	Australian Pelican	-	-
Birds	PETROIICIDAE	<i>Microeca fascinans</i>	Jacky Winter	-	-
Birds	PLOCEIDAE	<i>Neochima temporalis</i>	Red-browed Finch	-	-
Birds	PODARGIDAE	<i>Podargus strigoides</i>	Tawny Frogmouth	-	-
Birds	PSITTACIDAE	<i>Alisterus scapularis</i>	Australian King Parrot	-	-
Birds	PSITTACIDAE	<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	-	-
Birds	PSOPHODIDAE	<i>Psophodes olivaceus</i>	Eastern Whipbird	-	-
Birds	PTILONORHYNCHIDAE	<i>Ptilonorhynchus violaceus</i>	Satin Bowerbird	-	-
Birds	SYLVIIDAE	<i>Acrocephalus stentoreus</i>	Clamorous Reed-Warbler	-	-
Mammals	CANIDAE	<i>Canis lupus familiaris</i> *	Dog	-	-
Mammals	DASYURIDAE	<i>Antechinus stuartii</i>	Brown Antechinus	-	-
Mammals	EQUIDAE	<i>Equus caballus</i> *	Horse	-	-
Mammals	LEPORIDAE	<i>Oryctolagus cuniculus</i> *	Rabbit	-	-
Mammals	MACROPODIDAE	<i>Macropus giganteus</i>	Eastern Grey Kangaroo	-	-
Mammals	MOLOSSIDAE	<i>Mormopterus norfolkensis</i>	East Coast Freetail Bat	V	-
Mammals	MOLOSSIDAE	<i>Mormopterus</i> sp 2	Freetail Bat	-	-
Mammals	MURIDAE	<i>Hydromys chrysogaster</i>	Water Rat	-	-
Mammals	MURIDAE	<i>Rattus fuscipes</i>	Bush Rat	-	-
Mammals	MURIDAE	<i>Rattus lutreolus</i>	Swamp Rat	-	-
Mammals	MURIDAE	<i>Rattus rattus</i> *	Black Rat	-	-
Mammals	PETAURIDAE	<i>Petaurus australis</i>	Yellow-bellied Glider	V	-

Group	Family	Scientific Name	Common Name	TSCA	EPBC
Mammals	PETAURIDAE	<i>Petaurus breviceps</i>	Sugar Glider	-	-
Mammals	PHALANGERIDAE	<i>Trichosurus vulpecula</i>	Common Brushtail Possum	-	-
Mammals	PTEROPODIDAE	<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	V
Mammals	RHINOLOPHIDAE	<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe-bat	-	-
Mammals	VESPERTILIONIDAE	<i>Chalinolobus gouldi</i>	Gould's Wattled Bat	-	-
Mammals	VESPERTILIONIDAE	<i>Nyctophilus</i> sp.	Long-eared Bat	-	-
Mammals	VESPERTILIONIDAE	<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V	-
Mammals	VESPERTILIONIDAE	<i>Vespadelus pumilus</i>	Eastern Forest Bat	-	-
Mammals	VESPERTILIONIDAE	<i>Miniopterus australis</i>	Little Bent-wing Bat	V	-
Mammals	VESPERTILIONIDAE	<i>Miniopterus schreibersii</i>	Large Bent-wing Bat	V	-
Reptiles	SCINCIDAE	<i>Lampropholis amricula</i>	Friendly Sunskink	-	-
Reptiles	SCINCIDAE	<i>Lampropholis delicata</i>	Garden Sun Skink	-	-

7 Working Paper

Arrawarra Interchange Flora and Fauna Assessment

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**Flora and Fauna Report
Arrawarra Interchange Pacific Highway
Upgrade - Sapphire to Woolgoolga
Roads and Traffic Authority**

8 August 2007
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1. Introduction

1.1 Background to the Study and Proposal

Connell Wagner Pty Ltd was engaged by the NSW Roads and Traffic Authority (RTA) to undertake ecological investigations for the proposed Arrawarra Interchange, to the north of Woolgoolga on the north coast of NSW. The Arrawarra Interchange is to form a part of the RTA's proposed Pacific Highway upgrade between Sapphire and Woolgoolga.

The proposed interchange and rest area consists of entry and exit ramps, truck and car parking areas, amenities blocks and shelters and tables. The interchange and rest area would be located immediately south of the existing Arrawarra turnoff on the eastern side of the existing highway.

As the Arrawarra Interchange was not part of the original project design, flora and fauna surveys undertaken in 2005 for the project did not cover this area. This report documents the findings of flora and fauna surveys undertaken during March 2007 and discusses potential impacts of the proposal.

1.2 Study Objectives

The objectives of the flora and fauna assessment were to:

- Describe the plant communities and faunal habitats within the study area
- Document the animal and plant species recorded within the study area, highlighting any species listed on the *Threatened Species Conservation Act 1995* (TSC Act) and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Investigate potential flora and fauna links extending from the study area to adjacent natural areas
- Undertake an assessment of Koala habitat, including connectivity with other areas of potential or known koala habitat according to SEPP 44 - Koala Habitat Protection
- Map the location of any significant species or ecological communities identified in relation to the study area
- Outline likely impacts of the proposed Arrawarra Interchange project

2. Methodology

Ecological survey methods that were undertaken as part of the Arrawarra Interchange ecological study included literature review, flora/vegetation surveys and several fauna survey techniques that are described below. All field investigations were undertaken between 20 and 24 March 2007. Weather conditions experienced during the field investigation were recorded and are detailed in the results section.

2.1 Literature and Database Review

A review of relevant information sources and previous investigations in the area was undertaken. The literature review included the following sources:

- DEC Wildlife Atlas for TSC Act listed threatened fauna and flora records in the local area
- Bionet database for TSC Act listed threatened fauna and flora records in the local area
- EPBC Act Protected Matters search for items listed under the EPBC Act in the local area
- Ecotone (2005) – Preliminary Terrestrial Flora and Fauna Assessment for GHD on behalf of the RTA
- Connell Wagner (2001) – Supplementary REF for the Halfway Creek duplication section of the Pacific Highway for the RTA
- Connell Wagner (2005) – Flora and Fauna investigations for Sapphire to Woolgoolga section of the Pacific Highway
- Ecos Environmental Pty (2005) *Vegetation Survey Of The Preferred Route For The Upgrade Of The Pacific Highway Between Sapphire To Woolgoolga*, Connell Wagner
- Department of Environment and Conservation (2004) *Threatened Biodiversity Survey and Assessment: guidelines for developments and activities, working draft*, DEC
- Relevant recovery plans and species information sources

2.2 Flora Survey

Flora surveys were undertaken during the field investigation period between 20 and 24 March 2007. The aim of the flora survey was to:

- identify and describe the plant communities occurring within the study area
- compile a list of plant species occurring in the study area
- assess the suitability of habitat for threatened plant species
- conduct targeted searches for threatened species

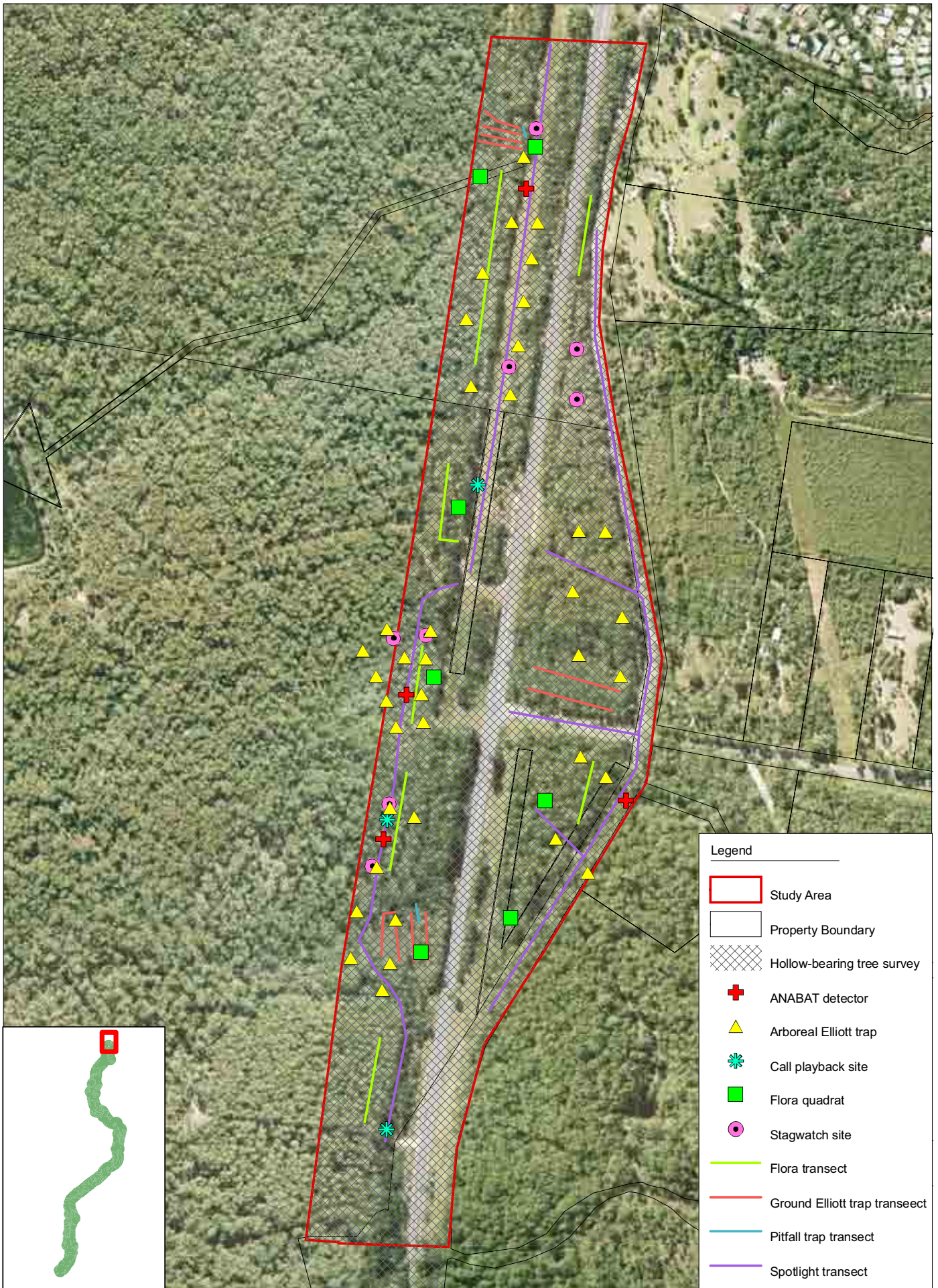
2.2.1 Walking Transects

Flora survey sites are illustrated in Figure 2.1. Seven walking transects were conducted within the study area and involved traverses on foot and recording plant species that occurred within one metre of the transect. This method allowed for the location of specific vegetation communities and their boundaries, which were later mapped via GPS and ArcGIS. During the walking transects, targeted searches for threatened flora were undertaken in suitable habitat.

2.2.2 Quadrat Sampling

Sampling quadrats enabled quantitative examination of species distribution and abundance across the study area. Seven quadrats (20m x 20m) were strategically positioned and located with GPS to sample an adequate representation of the native vegetation communities within the study area. The location of each quadrat is shown in Figure 2.1. The plant species within each quadrat were recorded, along with an approximate abundance of each species. Other information recorded during quadrat sampling included:

- **Structural attributes** - The dominant species, height and percentage foliage cover of each stratum layer
- **Physical attributes** - The landform, elevation, slope, aspect and soil type



- Legend**
- Study Area
 - Property Boundary
 - Hollow-bearing tree survey
 - + ANABAT detector
 - ▲ Arboreal Elliott trap
 - ✱ Call playback site
 - Flora quadrat
 - Stagwatch site
 - Flora transect
 - Ground Elliott trap transect
 - Pitfall trap transect
 - Spotlight transect

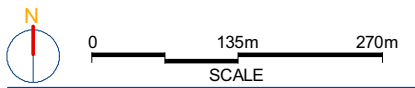
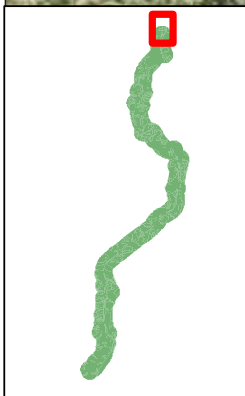


Figure 2.1
Methodology

All species in each quadrat and walking transect were recorded and identified as far as practicable to a species or subspecies level. Those species not able to be identified in the field were keyed out using the Flora of New South Wales (Harden 1993, 2000, 2002a and 2002b) and other reference material, or sent to the Royal Botanic Gardens Sydney Herbarium for identification.

2.3 Fauna Survey

Fauna surveys within the study area were undertaken during the field investigation period between 20 and 24 March 2007. The aims of the fauna survey were to:

- Assess the habitats in the study area and their suitability for threatened species
- Obtain a representative sample of the fauna assemblage in the study area via more detailed fauna survey methodologies

The fauna survey involved direct and indirect techniques, including habitat assessment, diurnal bird survey, arboreal and terrestrial trapping, spotlighting, call playback, opportunistic observations and searches for secondary evidence as discussed in the following sections. Fauna survey sites are illustrated in Figure 2.1.

2.3.1 Habitat Assessment

Data collected for compilation of site descriptions included habitat attributes, such as:

- Structural and floristic characteristics of the vegetation, such as species mix, type and development of vegetation
- Degree and extent of disturbance, eg fire, clearing, sand mining and weed invasion;
- Soil type and suitability
- Presence of water or aquatic habitat
- Size and abundance of hollows and fallen timber
- Availability of shelter, such as rocks, hollows, logs and dense undergrowth
- Wildlife corridors, refuge and proximate and contiguous habitat types
- Forage resources, such as nectar/pollen, gum, sap, mistletoe and seed
- Presence of preferred forage species

The information obtained during the habitat assessment allowed for determination of habitat suitability for threatened species.

2.3.2 Diurnal Bird Census

The recording of bird species within the study area was undertaken using the following methods:

- Three 30 minute diurnal census based on the species-time approach were undertaken within the study area.
- Opportunistic observations made while undertaking other activities in the study area.
- Searches for evidence of the presence of birds, such as whitewash and regurgitation pellets of owls.

Each diurnal bird census was conducted for a minimum of 30 minutes and ceased when no additional species were identified within a subsequent five minute period. Diurnal bird species occurring within the study area were recorded during early morning and afternoon census periods based on the species-time approach. A total of three person hours of diurnal bird census was undertaken within the study area.

2.3.3 Terrestrial Trapping

Elliot A trapping

Ten ground trapping transects comprising two lines of 11 traps and eight lines of 10 Elliot A traps were set over four nights in the study area in areas of suitable habitat (Figure 2.1). Each trap was baited with

a mixture of rolled oats, peanut butter and honey. Traps were checked early in the morning, with captured individuals identified and released at the point of capture.

Elliot A trapping targeted the threatened Common Planigale (*Planigale maculata*) and Eastern Chestnut Mouse (*Pseudomys gracilicaudatus*). A total of 408 ground trap nights were undertaken in the study area.

Pitfall Trapping

Two pitfall trap lines, consisting of five pits connected by drift fence, were positioned in suitable habitat within the study area (Figure 2.1). Each pit consisted of a 20L bucket inserted into an appropriately sized hole with the top rim of the bucket at or just below ground level. Buckets contained floating material and vegetation debris to provide a refuge for trapped animals. Drift fence was supported by wooden pegs and was approximately 30cm high with the lower 5 cm buried into the soil. Traps were checked early each morning and on dusk and animals released following identification. Pits were open for four nights, constituting a total of 40 trap nights.

Pitfall trapping targeted the threatened Common Planigale, Eastern Chestnut Mouse and Wallum Froglet (*Crinia tinnula*).

2.3.4 Arboreal trapping

Eight Elliot B type arboreal trapping transects comprising six transects of five traps and two transects of four traps were set over four nights within the study area where suitable arboreal habitat occurred (Figure 2.1). Traps were mounted on trees with a Diameter at Breast Height (DBH) greater than 30cm, approximately two metres above the ground and baited with a mixture of rolled oats, peanut butter and honey. The tree trunk was sprayed liberally with a honey-water mix around the trap each afternoon to attract arboreal mammal species. Traps were checked early in the morning, with captured individuals identified and released at the point of capture. A total of 152 trap nights were undertaken in the study area. The primary species targeted were the threatened Squirrel Glider (*Petaurus norfolcensis*) and Brush-tailed Phascogale (*Phascogale tapoatafa*).

2.3.5 Spotlighting and stag watching

Nocturnal spotlighting was undertaken on foot with 55 Watt spotlights for 3 person hours each night for four nights between 20 and 23 March 2007. Spotlighting was carried out in all vegetation associations (Figure 2.1) and targeted arboreal and terrestrial mammal species, nocturnal birds (including owls), amphibians and reptiles that may be active during the night, as well as roosting diurnal birds. Species were either identified visually or by call. A total of 12 person hours of spotlighting was undertaken within the study area during the field survey.

Stagwatching of hollow-bearing trees was undertaken for 30 minutes following dusk on all four evenings of the survey. Given the distribution of hollow-bearing trees across the study area (refer to Figure 3.2), a different tree was surveyed on each night. A total of three person hours of stagwatching was undertaken within the study area during the field survey, with eight hollow-bearing trees watched.

2.3.6 Call playback

Call playback, quiet listening and spotlighting on and after dusk were conducted for a total of two person hours over three nights between 20 and 22 March 2007. A 15W amplifier was used to broadcast calls for approximately five minutes for each target species, followed by a five minute listening and spotlighting period. Species targeted during call playback were the Powerful Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*), Barking Owl (*Ninox connivens*), Koala (*Phascolarctos cinereus*) and Yellow-bellied Glider (*Petaurus australis*). Call playback sites are indicated in Figure 2.1.

2.3.7 Ultrasonic echolocation detection

Ultrasonic bat echolocation calls were recorded using an ANABAT II bat detector connected to a digital (ZCAIM) recording device. The unit was left over night in suitable flyways during suitable weather conditions (refer Figure 2.1). A total of four complete nights of bat call recording was undertaken during the survey. Bat call analysis was undertaken by Ray Williams (of Ecotone Ecological Consultants), a recognised expert in bat call analysis.

2.3.8 Amphibian survey

Given only limited rainfall was experienced during the survey period, targeted amphibian surveys were not undertaken. However, opportunistic observations during other field methods were recorded during both nocturnal and diurnal periods. The study area has previously been surveyed for amphibians by Lewis Ecological Surveys during optimum climatic and seasonal conditions, with the results of these surveys presented in the Frog Working Paper.

2.3.9 Secondary evidence

Secondary evidence included evidence obtained opportunistically during other survey activities, such as animal traces, such as scats, tracks and foraging evidence.

3. Results

3.1 Weather conditions

Table 3.1 below indicates the weather conditions experienced at the Coffs Harbour weather station, approximately 40 km to the south of the study area. While there may be some variation in conditions experienced in the study area and at Coffs Harbour, the results below are generally considered to be representative of weather conditions during the field survey.

Table 3.1 Climatic conditions experienced at Coffs Harbour during field survey period (BOM, 2007)

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	Evaporation (mm)	Sunshine (hours)	Direction of maximum wind gust	Speed of maximum wind gust (km/h)
18/03/2007	22.5	24.5	4.2	5.2	0	SE	37
19/03/2007	19.6	26.4	6	10.4	4.9	NNE	26
20/03/2007	21.3	29.6	0	1.4	10.3	NNE	50
21/03/2007	20.6	29.9	0	6	10	NNE	43
22/03/2007	21.1	27.5	0	4.8	6.1	NE	28
23/03/2007	18.5	27.6	0	4	10.8	NE	28
24/03/2007	19.3	29.3	0	4	10.8	NNE	54

3.2 Flora

3.2.1 Vegetation association

The study area was found to contain the following four vegetation associations as indicated in Figure 3.1:

- Blackbutt Coastal Hills Moist Open Forest
- Broad-leaved Paperbark Swamp Sclerophyll Forest
- Blackbutt Forestry Plantation
- Swamp Oak Swamp Sclerophyll Forest

Vegetation associations have been classified according to the method adopted by Ecos Environmental Pty (2005) in the Flora Working Paper to ensure consistency and are discussed in more detail below. A list of flora species recorded is provided in Appendix B.

Blackbutt Coastal Hills Moist Open Forest

The Blackbutt Coastal Hills Moist Open Forest vegetation association was recorded in the more elevated locations within the study area (Figure 3.1). The canopy was dominated by Blackbutt (*Eucalyptus pilularis*), with Grey Ironbark (*E. paniculata*), Red Mahogany (*E. resinifera*) and Pink Bloodwood (*Corymbia intermedia*) also occurring. Occasional Tallowood (*E. microcorys*) were also present within the canopy. The midstorey included Black Oak (*Allocasuarina littoralis*), Forest Oak (*A. torulosa*), Swamp Box (*Lophostemon suaveolens*), Red Ash (*Alphitonia excelsa*), Turpentine (*Syncarpia glomulifera*), young eucalypts and scattered Snow in Summer (*Melaleuca linariifolia*).

The shrub layer was characterised by Broad-leaved Hakea (*Hakea dactyloides*), Coffee Bush (*Breynia oblongifolia*), Hop Bush (*Dodonaea triquetra*), Lantana (*Lantana camara*), Lance-leaved Geebung (*Persoonia lanceolata*) and Prickly Beard Heath (*Leucopogon juniperinus*).

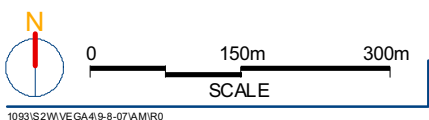
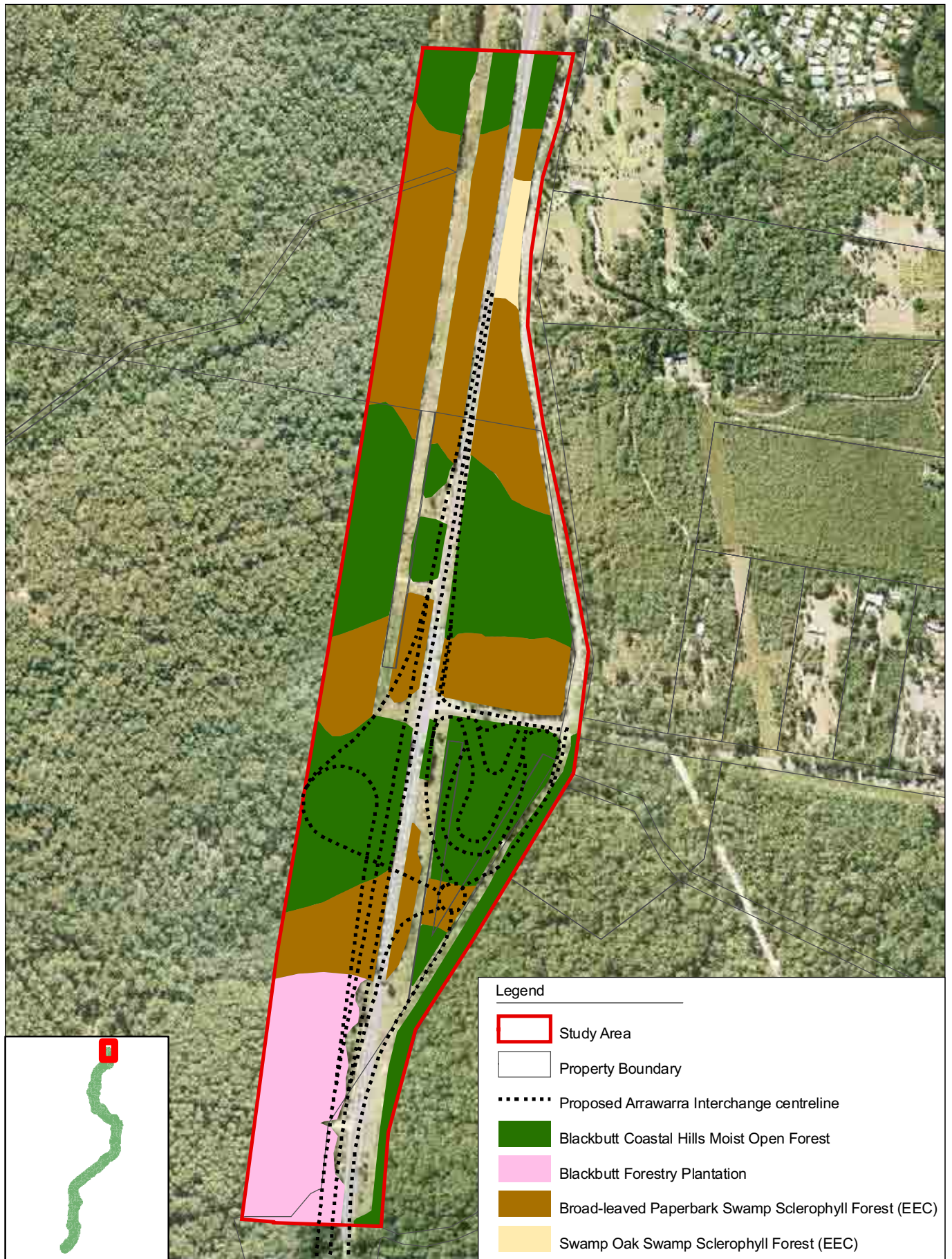


Figure 3.1

Vegetation communities

The ground cover included Blady Grass (*Imperata cylindrica*), Kangaroo Grass (*Themeda australis*), Bordered Panic (*Entolasia marginata*), Wiry Panic (*Entolasia stricta*), Guinea Flower (*Hibbertia diffusa*) and Paspalum (*Paspalum dilatatum*). Vines recorded within this vegetation association included Dusky Coral Pea (*Kennedia rubicunda*), Apple Dumplings (*Billardiera scandens*), Bindweed (*Polymnia calycina*), Snake Vine (*Stephania japonica*) and Common Silkpod (*Parsonsia straminea*).

Broad-leaved Paperbark Swamp Sclerophyll Forest

The Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association occurred in low-lying areas within the study area (Figure 3.1). The canopy was dominated by Broad-leaved Paperbark (*Melaleuca quinquinervia*) with Forest Red Gum (*Eucalyptus tereticornis*) and Swamp Box also occurring. Much less frequently Red Mahogany, Swamp Mahogany (*E. robusta*) and Pink Bloodwood were also recorded as canopy species. The midstorey included Swamp Box, Black Oak, Cheese Tree (*Glochidion ferdinandi*) and Swamp Box.

The shrub layer consisted of Groundsel Bush (*Baccharis halimifolia*), Lance-leaved Geebung and Coffee Bush. The ground layer was typically dominated by Spiky-headed Mat-rush (*Lomandra longifolia*), with Slender Rice Flower (*Pimelea linifolia*), Wiry Panic, Bordered Panic and Blady Grass. Vines recorded include Common Silkpod, Bindweed and Devil's Twine (*Cassytha pubescens*).

Blackbutt Forestry Plantation

The Blackbutt Forestry Plantation vegetation association was located in the southwest of the study area, just north of Little Arrawarra Creek (Figure 3.1). The Blackbutt Forestry Plantation vegetation association has a monoculture canopy of Blackbutt with no mid or shrub understorey. The groundcover consists of Blady Grass and Prickly Beard Heath remnant of the Blackbutt Coastal Hills Moist Open Forest vegetation association that was likely to have been cleared for the plantation.

Swamp Oak Swamp Sclerophyll Forest

The Swamp Oak Swamp Sclerophyll Forest vegetation association was recorded in the northeast of the study site in disturbed or previously cleared areas in the road reserve adjacent to Broad-leaved Paperbark Swamp Sclerophyll forest (Figure 3.1). The Swamp Oak Swamp Sclerophyll Forest vegetation association is likely to be dominated by Swamp Oak rather than Paperbark, because Swamp Oak (*Casuarina glauca*) is a better coloniser of cleared and disturbed ground. The dense canopy of Swamp Oak precludes many shrub species and little groundcover remains

3.2.2 Threatened species

Several threatened flora species have been recorded within 10 km of the study area. An assessment of the likelihood of occurrence of threatened flora species is presented in Appendix A. Whilst no threatened flora species were detected during surveys, one threatened species the Swamp Orchid (*Phaius australis*) is considered likely to occur based on the presence of suitable habitat. Surveys were conducted outside of the species flowering period of September to October when it is most detectable.

3.2.3 Endangered Ecological Communities

The Broad-leaved Paperbark Swamp Sclerophyll Forest and Swamp Oak Swamp Sclerophyll Forest vegetation associations (Figure 3.1) are considered to qualify as Swamp Sclerophyll Forest on Coastal Floodplain in the North Coast Bioregion, an Endangered Ecological Community (EEC), listed on the TSC Act. No EECs listed on the EPBC Act were recorded within the study area.

3.2.4 Disturbance History

The study area is fragmented by powerline easements, the Pacific Highway, local roads (old Pacific Highway) in the east and forestry access trails in the west. The main sources of disturbance within the study area are forestry operations (including logging, frequent hazard reduction burns, access trails and plantation establishment) and the road network (including both historical and current Pacific Highway alignments).

3.3 Fauna

Results of the fauna survey are discussed below, including the threatened species recorded. Fauna species recorded within the study area are listed in Appendix C.

3.3.1 Habitat Assessment

Aquatic Habitat

Aquatic habitat within the study area consists of:

- Arrawarra Creek in the south of the study area
- Arrawarra Gully, a small ephemeral watercourse in the north of the study area
- Swamp Sclerophyll Forest within the study area (short-term ephemeral aquatic habitat)

Arrawarra Creek runs east to west across the southern boundary of the study area and is located just north of Little Arrawarra Creek. Within the study area Arrawarra Creek is heavily degraded and has experienced a high level of weed invasion. The Blackbutt Forestry Plantation is directly adjacent to Arrawarra Creek and few eucalypts with large DBH within the riparian zone of the creek indicates heavy historical logging of the creek.

Arrawarra Gully is a small ephemeral watercourse that runs east to west across the northern portion of the study area through an area of Broad-leaved Paperbark Swamp Sclerophyll Forest. The watercourse has a defined channel approximately two to three metres wide and less than one metre deep, in the far west of the study area. The channel opens up into swamp forest where it forms more of a soak than a defined channel. Within the study area, the drainage line is intersected by:

- the old Pacific Highway in the east of the study area
- the current Pacific Highway
- a powerline easement, approximately 25-30 m wide, located on the west of the Pacific Highway
- a forestry access track in the west

During wet conditions, vehicular movement on both the forestry access track and powerline easement disturb the soil and is likely to increase turbidity within the watercourse. Where the drainage line crosses the powerline easement, an open sedgeland has formed due to removal of swamp forest canopy and mid-storey. This ephemeral drainage line and ditches are likely to provide habitat for the Green-thighed Frog (*Litoria brevipalmata*) a threatened frog species, recorded to the south of Woolgoolga during previous investigations (Lewis Ecological Surveys, 2006) and for Wallum Froglet (*Crinia tinnula*) recorded during this survey.

Swamp Sclerophyll Forest within the study area provides short-term ephemeral aquatic habitat during heavy rain events. The aquatic habitat provided by the Swamp Sclerophyll Forest would consist of temporary shallow sheets of water in lower areas and small pools. Swamp Sclerophyll Forest with abundant sedges in lower areas are likely to provide breeding habitat for the Wallum Froglet.

Terrestrial Habitat

Terrestrial habitats that offer refuge and forage resources for ground dwelling fauna, such as small to medium sized mammals, reptiles and frogs, within the study area include groundcover, logs and fallen timber.

Logs and Fallen Timber

The study area contains medium to large-sized logs scattered throughout the study area that are likely to provide habitat for reptiles and small to medium sized mammals. The frequent fire history of the study area has resulted in most of the logs and fallen timber having been partly burnt, which may homogenise the available resources. Large sized logs occurred more frequently within the Blackbutt Coastal Hills Moist Open Forest and the Broad-leaved Paperbark Swamp Sclerophyll Forest

vegetation associations, with the Blackbutt Forestry Plantation containing only small to medium-sized logs, probably as a result of thinning practices.

Ground Cover, Shrubs and Leaf Litter

Ground cover, shrubs and leaf litter densities vary across the study area. The Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association offers reasonable shrub and ground cover in some areas, such as in the northwest, but is generally quite open with the groundcover dominated by scattered Spiky-headed Mat Rush (*Lomandra longifolia*). The Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association is likely to offer some shelter for small mammals and reptiles.

The Blackbutt Coastal Hills Moist Open Forest vegetation association has a generally open shrub and ground layer that provides some small pockets of shelter for small mammals and reptiles.

Leaf litter cover within the study area was generally reasonable with approximately 10 cm of litter in most locations.

Forage Resources

The study area provides nectar and pollen resources across all seasons, including Autumn and Winter flowering myrtaceous trees that are likely to provide important forage for nectarivore fauna (Table 3.2).

Table 3.2: Flowering species likely to be used as forage resources by nectarivores within the study area

Species	Common Name	Abundance and Vegetation Association	Flowering Season
<i>Callistemon salignus</i>	Willow Bottlebrush	Occasional shrubs across study area	Spring
<i>Eucalyptus microcorys</i>	Tallowwood	Uncommon in Blackbutt Moist Coastal Forest vegetation association	Winter - Spring
<i>E. globboidea</i>	White Stringybark	Uncommon in Blackbutt Moist Coastal Forest vegetation association	Autumn
<i>E. paniculata</i>	Grey Ironbark	Uncommon in Blackbutt Moist Coastal Forest vegetation association	Winter - Spring
<i>E. pilularis</i>	Blackbutt	Dominant in Blackbutt Moist Coastal Forest vegetation association	Spring - Summer
<i>E. resinifera</i>	Red Mahogany	Reasonably common in Blackbutt Moist Coastal Forest vegetation association	Spring - Summer
<i>E. robusta</i>	Swamp Mahogany	Uncommon with a few trees in northwest Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association.	Winter

Species	Common Name	Abundance and Vegetation Association	Flowering Season
<i>E. tereticornis</i>	Forest Red Gum	Reasonably common in Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association	Winter
<i>Corymbia intermedia</i>	Pink Bloodwood	Reasonably common in Blackbutt Moist Coastal Forest vegetation association	Summer
<i>Melaleuca linariifolia</i>	Snow in Summer	Uncommon in Blackbutt Moist Coastal Forest vegetation association	Spring - Summer
<i>Melaleuca quinquenervia</i>	Broad-leaved Paperbark	Dominant in the Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association.	Autumn - Winter
<i>Leptospermum juniperinum</i>	Prickly Tea-tree	Scattered in Blackbutt Moist Coastal Forest vegetation association	Spring

The Blackbutt Moist Coastal Forest vegetation association is likely to be an important foraging resource for nectarivores in Spring and Summer when the Blackbutt is flowering. Conversely the Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association is likely to offer Winter foraging resources when the Broad-leaved Paperbark and Forest Red Gum are flowering.

Winter flowering trees and shrubs provide an important forage resource for nectarivore and insectivore fauna (ie Squirrel Glider), as reliably flowering plants and insects are often limited during the Winter season. In particular, Swamp Mahogany and Forest Red Gum are considered important forage resources, as they are reportedly reliable flowerers (Law *et al.* 2000), unlike some other Winter flowering eucalypts that can have inconsistent and variable flowering depending on climatic and other environmental factors.

Allocasuarina species (Black Oak and Forest Oak) were relatively common in the Blackbutt Moist Coastal Forest vegetation association within the study area and are likely to provide an important forage resource for the locally recorded Glossy Black Cockatoo.

Grass and sedge abundance across the study area was generally moderate, occurring in both the Blackbutt Moist Coastal Forest and Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation associations. While this offers somewhat marginal seed resources for threatened granivore fauna species, the high level of disturbance history generally limits the availability of this resource to native fauna species - as reflected in the ground trapping results.

Arboreal Habitat

Tree Hollows

Hollow bearing trees were relatively common in the study area, with 114 recorded (Figure 3.2). Hollows were observed most commonly in stags (dead trees), Swamp Box being the most common live tree with hollows. Less often hollows were recorded in Forest Red Gums, Broad-leaved Paperbark, Blackbutt, Pink Bloodwood, Narrow-leaved White Stringybark and Tallowwoods. A number of the stags showed evidence of ringbarking, a common forestry practice. Hollows ranged from small cracks in trunks and branches to large hollows in trunks and large branches. It is likely that hollows recorded

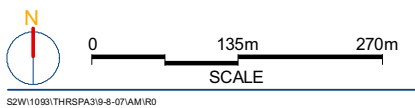
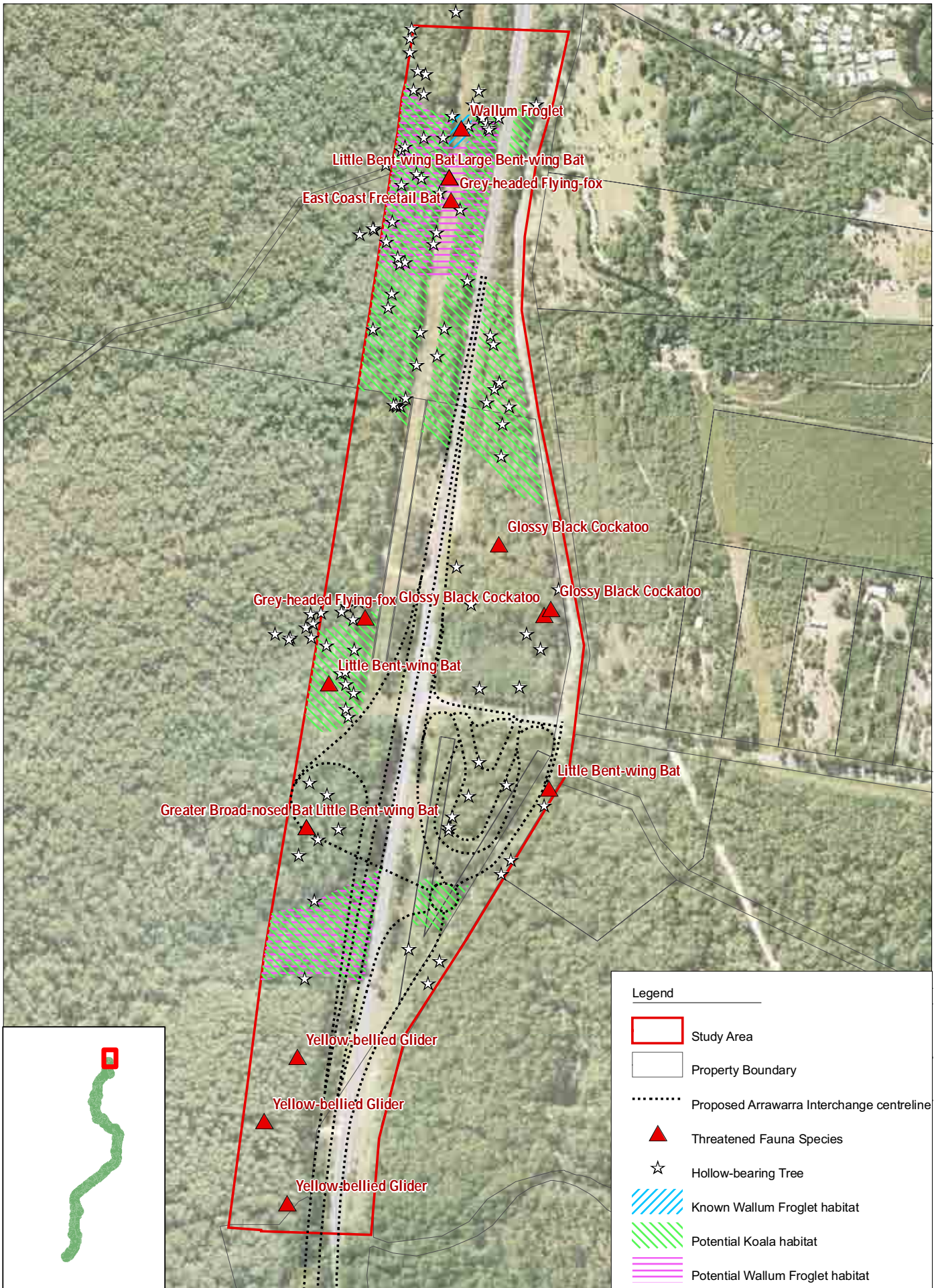


Figure 3.2
Threatened species, habitat and hollow-bearing trees

within the study area are suitable for a wide range of hollow-dependent mammal and bird species, many of which are threatened.

Microchiropteran Bat Foraging Habitat

The structure of vegetation associations in the study area offer foraging resources suitable for over-canopy foraging such as aerial intercept foraging and sub-canopy foraging, suitable for more agile species foraging in the relatively open understorey habitat. The aquatic habitat associated with the Arrawarra creek in the south of the study area offers marginal foraging habitat for the Large-footed Myotis (*Myotis adversus*).

Overall the habitat within the study area is considered to be suitable for the following threatened microchiropteran bat species:

- Hoary Wattled Bat (*Chalinolobus nigrogriseus*)
- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)
- Little Bent-wing Bat (*Miniopterus australis*)
- East Coast Freetail Bat (*Mormopterus norfolcensis*)
- Yellow-bellied Sheath-tail Bat (*Saccolaimus flaviventris*)
- Eastern Cave Bat (*Vespadelus traughtoni*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Large-footed Myotis (*Myotis adversus*).

Wildlife Corridors

Key Habitats and Corridors

Scotts (2003) presents information on key habitats and regional corridor interconnectivity on the north coast of New South Wales, and identifies the study area and adjacent areas of Wedding Bells State Forest as Key Habitat. Scott (2003) also identifies the study area as forming part of a Regional Corridor, intended to link large areas of Key Habitat.

3.3.2 Diurnal Bird Census

A total of 29 bird species were recorded in the study area during field surveys (refer to Appendix C), including a pair of Glossy Black Cockatoos, a Vulnerable species listed on the TSC Act. The Glossy Black Cockatoos recorded within the study area were observed foraging within the Blackbutt Coastal Hills Moist Open Forest vegetation association in the eastern part of the study area.

3.3.3 Terrestrial Trapping

Elliott A Trapping

A total of four species were recorded during terrestrial Elliott A trapping. These were Swamp Rat (*Rattus lutreolus*), Brown Antechinus (*Antechinus stuartii*), one Water Rat (*Hydromys chrysogaster*) and the introduced Black Rat (*R. rattus*). The female Water Rat was captured within the northeast Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association adjacent to a small pond within an ephemeral drainage line. The Brown Antechinus and Swamp Rat were captured within each of the survey blocks (Figure 2.1). Black Rat was recorded within the northwest and southwest survey blocks.

Pitfall Trapping

Pitfall trapping within the northwest Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association recorded three Garden Sun Skinks (*Lampropholis delicata*) and one Friendly Sun Skink (*Lampropholis amicala*). No captures were made within the central west pitfall traps within the Broad-leaved Paperbark Swamp Sclerophyll Forest vegetation association.

3.3.4 Arboreal trapping

A total of three species were recorded during arboreal trapping within the study area. These were Bush Rat (*Rattus fuscipes*), Brown Antechinus and the introduced Black Rat. Bush Rat was recorded within the northwest survey block, Black Rat was recorded at both the northwest and east blocks and Brown Antechinus was recorded within all arboreal trapping blocks within the study area.

3.3.5 Spotlighting and stagwatching

Few fauna species were observed during spotlighting and stagwatching surveys within the study area. Sugar Glider (*Petaurus breviceps*) was observed feeding on sap from a Grey Ironbark on the ecotone between the Broad-leaved Paperbark Swamp Sclerophyll Forest and the Blackbutt Coastal Hills Moist Open Forest vegetation associations. Sugar Glider was also observed within the Blackbutt Coastal Hills Moist Open Forest vegetation association in the north of the central west survey block. Numerous Grey-headed Flying Fox (*Pteropus poliocephalus*) were observed flying over the study area each night shortly after dusk; however, foraging was not observed within the study area at this time. A Tawny Frogmouth (*Podargus strigoides*) was observed within the central west survey block on one occasion. The Red-backed Toadlet (*Psuedophryne coriacea*) was heard calling in the Broad-leaved Paperbark Swamp Sclerophyll Forest in the west of the study area. Only one individual Common Brushtail Possum (*Trichosurus vulpecula*) was observed exiting a hollow-bearing tree during stagwatching in the eastern survey block. No other observations were made during stagwatching surveys.

3.3.6 Call playback

The Yellow-bellied Glider (*Petaurus australis*) responded to call playback of the Powerful Owl and Masked Owl within the Blackbutt Forestry Plantation vegetation association in the southwest of the study area. Calls were heard to the north and the south of the call playback location and an individual was observed adjacent to the call playback location (Figure 3.2).

A possible Powerful Owl (*Ninox strenua*) response to call playback was heard in the northwest of the study area during call playback. High levels of background noise from the Pacific Highway reduced the listening ability of observers and a positive identification was unable to be made.

3.3.7 Ultrasonic echolocation detection

Five microchiropteran bat species were positively identified from bat call recordings within the study area, with a further three species tentatively identified. In addition, calls of the Long-eared Bat genus *Nyctophilus* were also positively identified; however, species level identification is not possible for Long-eared Bats. Of the eight microchiropteran bat species identified through call analysis, four were threatened species listed on the TSC Act. The results of ultrasonic echolocation detection in the study area and call analysis are presented in Table 3.3 below.

Table 3.3: Microchiropteran bats detected in the study area during the survey and reliability of identification.

Reliability of call identification	Scientific Name	Common Name	EPBC Act status	TSC Act status
Definite	<i>Miniopterus australis</i>	Little Bentwing Bat	–	V
Definite	<i>Mormopterus norfolkensis</i>	East Coast Freetail Bat	–	V
Definite	<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe Bat	–	–
Definite	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	–	–
Definite	<i>Vespedelus pumilis</i>	Eastern Forest Bat	–	–
Definite	<i>Nyctophilus</i> sp.	Long-eared Bat	?	?

Reliability of call identification	Scientific Name	Common Name	EPBC Act status	TSC Act status
Probable	<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	–	V
Probable	<i>Miniopterus schreibersii</i>	Large Bentwing Bat	–	V
Probable	<i>Mormopterus sp 2</i>	Freetail Bat	–	–

3.3.8 Secondary evidence

Secondary evidence included the detection of scats and forage evidence. Chewed *Allocasuarina* cones were observed at a number of locations in the eastern survey block, indicating Glossy Black Cockatoo (*Calyptorhynchus lathamii*) foraging activity (Figure 3.2). Scats were observed for the Eastern Grey Kangaroo (*Macropus giganteus*), Brush-tailed Possum and Bush Rat.

3.3.9 Threatened Fauna Species

Several threatened fauna species, listed under the TSC Act were recorded during the field investigations, including:

- Wallum Froglet
- Grey-headed Flying-fox
- Glossy Black Cockatoo
- Yellow-bellied Glider
- Little Bent-wing Bat
- Large Bent-wing Bat
- East Coast Freetail Bat
- Greater Broad-nosed Bat

The Grey-headed Flying Fox is also listed under the EPBC Act. The locations of threatened species recorded within the study area are displayed in Figure 3.2.

Sixteen threatened fauna species additional to those recorded within the study area are considered likely to occur within the study area (Appendix A), based on habitat suitability, local records and the precautionary principle (where there is some uncertainty about the suitability of habitat within the study area). Table 3.4 summarises the habitat requirements of threatened species recorded or considered likely to occur within the study area.

Table 3.4: Habitat requirements for threatened species recorded during surveys or that are considered likely to occur within study area based on Appendix A.

Species	Recorded	Large, contiguous habitats	Winter flowering trees	Tree Hollows	Specialist Habitat
Wallum Froglet (<i>Crinia tinnula</i>)	√				Wallum woodlands and sedgelands
Green-thighed Frog (<i>Litoria brevipalmata</i>)					Ephemeral creeks, soaks and swamp forest
Wallum Sedge Frog (<i>Litoria olongburensis</i>)					Wallum woodlands and sedgelands
Glossy Black-Cockatoo (<i>Calyptorhynchus lathamii</i>)	√			√	<i>Allocasuarina</i> sp.
Emu (<i>Dromaius novaehollandiae</i>)					Grasslands, woodlands, shrublands, forest
White-eared Monarch (<i>Monarcha leucotis</i>)		√			

Species	Recorded	Large, contiguous habitats	Winter flowering trees	Tree Hollows	Specialist Habitat
Square-tailed Kite (<i>Lophoictinia isura</i>)					Tropical and temperate forests and woodlands
Osprey (<i>Pandion heliaetus</i>)					Tall stags, shallow estuaries
Powerful Owl (<i>Ninox strenua</i>)				√	
Masked Owl (<i>Tyto novaehollandiae</i>)				√	
Rufous Bettong (<i>Aepyprymnus rufescens</i>)					Forests with sparse, grassy understoreys
Spotted-tailed Quoll (<i>Dasyurus maculatus</i>)		√			Large hollow logs for denning
Squirrel Glider (<i>Petaurus norfolcensis</i>)			√	√	Multiple large tree hollows (den swapping species)
Yellow-bellied Glider (<i>Petaurus australis</i>)	√		√	√	
Brush-tailed Phascogale (<i>Phascogale tapoatafa</i>)				√	
Koala (<i>Phascolarctos cinereus</i>)					Particular Eucalyptus species for foraging (refer to Table 4.1)
Common Planigale (<i>Planigale maculata</i>)					Dense, particularly mesic groundcover
Long-nosed Potoroo (<i>Potorous tridactylus</i>)					Heath and forests with dense cover and adjacent more open areas
Black Flying-Fox (<i>Pteropus alecto</i>)			√		Camps/roosts
Grey-headed Flying-Fox (<i>Pteropus poliocephalus</i>)	√		√		Camps/roosts
Hoary Wattled Bat (<i>Chalinolobus nigrogriseus</i>)				√	also rock crevices and buildings for roosts
Eastern False Pipistrelle (<i>Falsistrellus tasmaniensis</i>)				√	also buildings for roosts
Golden-tipped Bat (<i>Kerivoula papuensis</i>)					Rainforest habitat; roost within the pendulous nests of scrubwens and gerygones
Large-footed Myotis (<i>Myotis adversus</i>)					Water bodies, roost sites in culverts & under bridges
Little Bent-wing Bat (<i>Miniopterus australis</i>)	√				Roost sites in culverts & under bridges
Large Bent-wing Bat (<i>Miniopterus schreibersii</i>)	√				Roost sites in culverts & under bridges
East Coast Freetail Bat (<i>Mormopterus norfolkensis</i>)	√			√	Also buildings for roosts
Eastern Long-eared Bat (<i>Nyctophilus bifax</i>)				√	
Greater Broad-nosed Bat (<i>Scoteanax rueppellii</i>)	√			√	
Eastern Cave Bat (<i>Vespadelus troughtoni</i>)					Caves for roosts

710 Working Paper

Vegetation Survey

**VEGETATION SURVEY OF THE PREFERRED ROUTE
FOR THE UPGRADE OF THE PACIFIC HIGHWAY
BETWEEN SAPPHIRE AND
WOOLGOOLGA**

Prepared for

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1.0 INTRODUCTION

1.1 Scope

Ecos Environmental Pty Ltd has been engaged by Connell Wagner Pty Ltd to undertake a vegetation survey of the preferred route for the Sapphire to Woolgoolga upgrade of the Pacific Highway.

The specific objectives of the vegetation survey were to: -

- document the plant species identified within the study area, highlighting any species listed on the TSC Act and/or EPBC Act, and/or the ROTAP register;
- compile a list of threatened species recorded, and considered likely to occur, in the study area
- map the location and extent of distribution of threatened species and endangered ecological communities throughout the study area;
- identify and map the plant communities found along the corridor, highlighting any TSC Act and/or EPBC Act, endangered communities:
- identify constraints posed by native vegetation, particularly threatened species and endangered ecological communities; and
- recommend appropriate measures for mitigating the impacts of the proposed road on native flora, particularly Threatened species and Endangered Ecological Communities.

The remaining sub-headings of this introduction describe the location and physical environment of the study area. Section 2 explains the methodology used to survey the flora, classify and map plant communities and assess findings. Section 3 describes the results of the vegetation survey and identifies the conservation significance of recorded flora and vegetation communities with reference to State and Federal environmental legislation. Section 4 discusses the conservation significance of Threatened and significant plant species and Endangered Ecological Communities recorded during the survey and Section 5 considers options to ameliorate the potential impact of the highway corridor on these values.

1.2 Survey Area

The survey area is located in the Coffs Harbour Local Government Area on the Mid North Coast of NSW. The preferred route for the Sapphire to Woolgoolga upgrade of the Pacific Highway extends from Sapphire Beach on the northern outskirts of Coffs Harbour to Arrawarra Creek north of Woolgoolga, a distance of approximately 25 km. The area examined during the vegetation survey was confined to the projected road footprint and 20-50 metres on either side. The southern two-thirds of the proposed route closely follows the existing highway and the area surveyed consisted of the present road reserve and the edges of adjoining properties. The northern third of the proposed route veers west of Woolgoolga in an arc crossing privately owned forest and cleared land, banana plantations and sections of Wedding Bells State Forest before rejoining the present Pacific Highway at the Arrawarra turn-off.

1.3 Physical Environment

The study area encompasses the narrow coastal plain between Arrawarra and Moonee Beach and the foothills of the Coast Range, which meet the sea at Sapphire Beach.

Maximum elevation is approximately 100m west of Woolgoolga. The study area has a humid subtropical climate with a mean annual rainfall of 1600mm. Geologically, the study area forms part of the Coffs Harbour Block comprising Paleozoic metasediments (hardened sedimentary rocks) (Fisher *et al.* 1996).

1.4 Existing Vegetation Information

The following databases and studies provided existing information on the flora and plant communities of the study area:

- DECC Wildlife Atlas (records within 10km of the study area)
- EPBC Act Protected Matters Search Tool
- Australia's Virtual Herbarium
- Fischer et al. (1996) The Vegetation of the Coffs Harbour City Council LGA
- Binns, D. (1994). Flora Survey of the Dorrigo 3-Year EIS Area. State Forests of NSW.
- Moore, D. M. and Floyd, A.G. (1994). A Description of the Flora and an Assessment of Impacts of the Proposed Forestry Operations in the Grafton Management Area.
- Forest Ecosystem Classifications for Upper and Lower North East CRA Regions (NPWS 1999).

2.0 METHODOLOGY

2.1 Flora Survey

2.1.1 Survey Design

The objective of the flora survey was to search for Threatened and other rare or significant plant species, while also recording vegetation communities and variation in the overall flora. The survey was implemented by the meander traverse method (DEC 2004), which enabled searching of a wide area within the 24 km long corridor (much greater than if the survey had been quadrat-based). The vegetation survey was stratified by dividing the study area into corridor sections, each containing a predominant broad vegetation type (e.g. wet sclerophyll/rainforest, moist/dry open forest and swamp sclerophyll) and allocating one meander traverse to each section. Preliminary vegetation maps prepared by Connell Wagner were used as an initial source of information on broad vegetation type. An indicative list of Threatened and rare plant species for the Coffs Harbour-Woolgoolga area (Table 1) was derived from the DECC Wildlife Atlas database and other existing information (see above).

Vegetation data were collected from 14 traverses varying in length from 1-4 km over a total of 15 days (see Appendices 1a & 1b). Twelve days survey work was undertaken in March, June and July 2005. An additional 3 days survey work was carried out in December 2005 to examine remaining unsurveyed properties and to conduct a targeted search of potential habitat for Threatened summer flowering herbs. Survey work was spread throughout the year, thereby minimising the possibility of species being overlooked due to seasonality of growth and flowering.

On each traverse all species sighted were recorded and any unknown plants collected for later identification. Changes in vegetation communities within a traverse were recorded, including changes in the dominant overstorey and understorey species. After each traverse, species were scored for overall abundance as either: -

- 1 – rare (few individuals seen or only seen at one or a few points on the traverse);
- 2 – occasional (of patchy distribution, widespread on the traverse but not common);
- 3 - common (widespread and regularly observed along the traverse, dominant or sub-dominant within any vegetation layer – canopy, understorey or ground layer);
- 4 - very common (widespread and very abundant within any vegetation layer).

These classes indicated the overall abundance of species on a subjectively assessed, semi-quantitative scale.

The road footprint was located in the field using a colour aerial photograph of the study area overlaid with the road footprint and cadastral boundaries, and with the assistance of survey markers where installed. In addition to the meander traverses, point inspections of vegetation were made at many locations, particularly where the type and condition of vegetation indicated that Threatened species could be present, or to fill gaps in the traverse coverage. During spot inspections searches were made for Threatened flora and notes recorded on dominant species and vegetation type.

The locations of threatened and rare plant species were recorded with a eTrex GPS in GDA (MGA 1994 Zone 56) datum format and marked on a 1:25,000 topographic map. Each significant flora occurrence was given a unique identification number

between 80001 and 80100. This was written on flagging tape and attached to a closely adjoining plant, to enable surveyors to re-locate each occurrence and record its coordinates to sub-metre accuracy. Where an 'individual' plant could not be determined, the plant number referred to a clump or a cluster of plants.

Where Threatened species or Endangered Ecological Communities were encountered, more detailed sampling was carried out following the guidelines in DEC (2004). This sampling consisted of a 20m x 20m quadrat in which species composition, vegetation structure and site characteristics were recorded. Species abundance was measured as cover-abundance (the horizontal projection of foliage crown extent), estimated visually in terms of Braun Blanquet cover-abundance classes (Mueller-Dombois and Ellenberg 1974; NPWS 1995), as follows:-

- 1 sparse, <5% crown-cover
- 2 any number, <5% crown-cover
- 3 5 - 25%
- 4 25 - 50%
- 5 50 - 75%
- 6 75 - 100%

Plant taxonomy and nomenclature followed the Flora of NSW (Harden 1992, 1993, 2000, 2002). Any species that could not be identified were sent to the Royal Botanic Gardens, Sydney for identification. Dr Andrew Benwell carried out botanical fieldwork.

Table 1: Indicative list of Threatened plant species potentially present in the survey area based on records derived from the DECC Wildlife Atlas records within 10km of the survey area and other sources. TSC Act Conservation Status is shown as E – Endangered and V- Vulnerable.

Species	Cons. Status	Habitat
Possible		
<i>Amorphospermum whitei</i> Rusty Plum	V	Wet sclerophyll forest and rainforest
<i>Arthraxon hispidus</i> A Grass	V	Seepage swamps at the base of hillslopes
<i>Boronia umbellata</i> A Shrub	V	Shrubby, moist open forest on sedimentary geology
<i>Eleocharis tetraquetra</i> Square-stemmed Spike Rush	E	Coastal swamp and streamside seepage
<i>Lindsaea incisa</i> A Fern	E	Swamp sclerophyll forest/open forest ecotone
<i>Parsonsia dorrigoensis</i> A vine	V	Wet sclerophyll forest and rainforest
<i>Phaius australis</i> Swamp Orchid	E	Swamp sclerophyll forest margins with rainforest elements
<i>Quassia sp. B</i> Narrow-leaved Quassia	E	Shrubby dry sclerophyll forest usually on sedimentary geology
<i>Sarcochilus fitzgeraldii</i> Ravine Orchid	V	Rock outcrops in wet sclerophyll forest and rainforest

<i>Typhonium</i> sp. aff. <i>brownii</i> Stinky Lily	E	Rainforest and wet sclerophyll close to drainage lines
Unlikely		
<i>Allocasuarina defungens</i> Dwarf Heath Sheoak	E	Heath on sand or sedimentary geology
<i>Acronychia littoralis</i> Scented Acronychia	E	Coastal dune littoral rainforest and edges
<i>Angophora robur</i> Large-fruited Angophora	V	Dry sclerophyll forest on sandstone
<i>Thesium australe</i> Austral Toadflax	E	Grassy headlands.
<i>Zieria prostrata</i> Headland Zieria	E	Grassy headlands

2.1.2 Conservation Significance of Plant Species

The conservation significance of plant species was determined with reference to:

- Schedules and Preliminary Listings of the NSW Threatened Species Conservation Act 1995;
- Schedules of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999;
- ROTAP (Briggs and Leigh 1995) for nationally rare species;
- Sheringham and Westaway (1995) and NPWS (1998) for regionally significant plants; and

2.2 Vegetation Classification and Mapping

2.2.1 Existing Data

The scope of this study did not include the preparation of a vegetation map from raw data, as detailed vegetation mapping already existed for the study area. The approach was to use the existing vegetation data supplied by DECC (via Connell Wagner) as an initial reference for the vegetation classification and mapping, then to ground-check the mapping and classification during fieldwork and modify where any errors or inconsistencies were apparent.

The origin of the mapping was indicated on the data files as being a combination of Research Note 17 Forest Types (FCNSW 1989), CRAFTI (Comprehensive Regional Assessment Forest Type Inventory), Coffs Harbour City Council Vegetation Mapping (Fischer *et al.* 1996) and ANC. There was no field for Forest Ecosystems (NPWS 1999) in the mapping data supplied. The CRAFTI units were the types mapped by the air photo interpreters on the CRAFTI project, which was essentially an adaptation of the Forest Type system to broad-scale air photo vegetation mapping with limited ground-truthing (see Appendix 2).

2.2.2 Validating the Existing Mapping

Validation of the initial vegetation mapping, which displayed a combination of RN17 Forest Types, Coffs Harbour City Council mapping units and CRAFTI units, was carried out during flora traverses and spot inspections. This consisted of field checking the dominant species, typing of vegetation and boundaries of map polygons. Field notes were annotated on map printouts to record the main canopy species and vegetation type.

2.2.3 Classification

The basic unit of vegetation classification and mapping used for the Sapphire to Woolgoolga survey was the ‘association’, which is defined as a plant community having the same or similar vegetation structure and dominant species in the upper/canopy vegetation layer (Beadle 1981). Appendix 2 provides some background information on the systems of classification used in previous vegetation mapping of the study area (e.g. Forest Types and CRAFTI).

An examination of the initial mapping indicated that a number of Forest Type (RN17), CRAFTI and Coffs Harbour City Council vegetation mapping units were equivalent floristically and the units in these classifications were at the same level as ‘associations’. A simplified classification was therefore proposed in which floristically related units would be merged to produce a smaller number of vegetation map units, based on an assessment of floristic similarities (associations) and vegetation-terrain relationships observed during fieldwork.

As well as the problem of ‘duplicate’ vegetation types in the initial data, it was also apparent that some areas were wrongly classified in terms of vegetation type. These polygons were re-classified to the best fitting community in the merged classification, or new associations were created on the basis of the dominant species observed during fieldwork.

The final classification reduced the initial classes down to 12 associations, as listed in Table 2 and mapped in Figures 1 and 2.

(Classification of vegetation in terms of Forest Ecosystems (NPWS 1999) was considered at the start of this vegetation survey, however, the Forest Ecosystems indicated as being present in the study area in data supplied by DECC, were found to be difficult to identify in the field. Several had overlapping understorey floristic descriptions without useful indicator species (e.g. FE 153, 155, 157) and there was little information in NPWS (1999) on environmental relationships or distribution that would assist in assessing the most appropriate Forest Ecosystems for the study area.)

2.2.4 Mapping

The delineation of vegetation polygons on the initial map was retained or modified where found to be incorrect. The majority of the line work was expected to be accurate in general outline as it derived from detailed vegetation mapping by the Forestry Commission, National Parks and Wildlife Service and Coffs Harbour City Council. The final map was created by merging initial mapped vegetation units falling within each association, or altering boundaries, as indicated by fieldwork.

2.2.5 Assessment of Community Conservation Status

The conservation significance of plant communities was determined according to:

- Schedules and Preliminary Listings of the NSW Threatened Species Conservation Act 1995;
- Schedules of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999;
- Hager and Benson (1994) for plant communities.

Vegetation associations recorded in the survey corridor were compared with the descriptions of Endangered Ecological Communities (TSC Act) in the relevant Final Determinations by the Scientific Committee (DECC website) to assess whether any of the associations were equivalent to an Endangered Ecological Community. This assessment was also carried out with reference to the Commonwealth EPBC Act.

Two other references may be used in assessing the conservation status of forest plant communities in northeast NSW. The first of these is Hager and Benson (1994) which gives an inventory of the region's forest plant communities listed as associations equated with Forest Types (FCNSW 1989). Conservation status is rated as 'poorly reserved', 'inadequately reserved' and 'adequately reserved' based on the number and size of samples in conservation reserves in the lower, central and upper northeast. Rainforests in Hager and Benson (1994) are classified and assessed after Floyd (1990).

The second is the Forest Ecosystems study from the North East NSW CRA (NPWS 1999). Forest Ecosystems (NPWS 1999) are a modification of the Forest Type classification (FCNSW 1989) derived by multivariate analysis of floristic data collected across the range of Forest Types. During the NSW Comprehensive Regional Assessment, the conservation status of Forest Ecosystems was assessed on the basis of the area required to be reserved to achieve 15% of the predicted pre-European distribution. However, data on the areas of EEC's reserved and target level achieved are not given in NPWS (1999), only the estimated pre-1750 area and the extent of clearing, so it is only possible to use this reference indirectly as an indicator of plant community conservation status.

3.0 RESULTS

3.1 General Floristics and Vegetation Description

A total of 479 plant species were recorded during the survey, which included 68 naturalized or exotic species. Families exhibiting the highest diversity of species were: - Poaceae (48 species), Myrtaceae (44), Cyperaceae (31), Fabaceae (21) Asteraceae (21), Mimosaceae (15), Orchidaceae (14), Euphorbiaceae (13), Lauraceae (12), Proteaceae and Sapindaceae (9) and Rutaceae (8).

The two main broad vegetation types in the survey area were Coastal Hills Moist Open Forest (comprising five associations) and Coastal Floodplain Forest (four associations). Coastal Hills Moist Open Forest occurred throughout the corridor on hilly terrain adjoining the coastal floodplain. The five associations comprising this broad type form a complex mosaic, responding to subtle changes in topography and lithic substrate. Coastal Floodplain Forest consisting mainly of Broad-leaved Paperbark swamp forest was the predominant vegetation type in the low-lying central part of the corridor on the coastal floodplain between the Bucca Road and Double Crossing Creek south of Woolgoolga. The corridor intersects one very small area of Estuarine Complex in the central section. Small stands of Littoral Rainforest occur in a few protected gullies at Sapphire Beach and two small stands of Lowland Rainforest on Floodplain occur at Woolgoolga Creek and a stream crossed by Newmans Road.

3.2 Modifications to the Initial Vegetation Data

The following modifications were made to the initial mapping data supplied by DECC to produce the vegetation map of the survey corridor shown in Figures 1 and 2: -

- Equivalent RN17 (Forest Type), CRAFTI and Coffs Harbour City vegetation units were merged. For example Paperbark in State Forest (Forest Type 31) and Paperbark mapped by Coffs Harbour City Council were merged into a single association.
- Units with Blackbutt as an indicator species were merged into a single Blackbutt association.
- Some 'Narrow-leaved White Mahogany' polygons were changed to 'Grey Gum - Grey Ironbark' in the northern half of the survey corridor, as Grey Gum (*E. propinqua*) was judged to be a commoner canopy species than Narrow-leaved White Mahogany (*E. acmenoides*) in these areas.
- One polygon of Forest Red Gum mapped by Coffs Harbour City Council was merged into the Grey Gum-Ironbark association. (This polygon of Forest Red Gum was very localised, also contained Ironbark and Blackbutt and was not on a floodplain.)
- A Red Mahogany association was differentiated from the initial data at one location.
- A Smooth-barked Apple association was differentiated from the initial data at one location.

- Lowland Rainforest on Floodplain was differentiated from the initial data at two locations.
- Two areas of Sedgeland/Swamp mapped by Coffs Harbour City Council were found to be Paperbark (generally with a low to mid-high woodland to open woodland structure).
- Minor adjustments were made to polygon boundaries.

3.3 Description of Vegetation Associations

3.3.1 Introduction

Species abundances in the tabular descriptions below are reported qualitatively and semi-quantitatively. This was requested by fauna ecologists with Connell Wagner for modeling habitat variables and assessing impacts on fauna. Semi-quantitative abundance (numbers to the right of the qualitative abundance) is according to Braun-Blanquet scale (see Section 2.1.1).

The associations falling within listed Endangered Ecological Communities are indicated in Table 2. Equivalent Forest Types (FCNSW 1989) for the associations are also provided in the assessments below. The conservation ratings according to Hager and Benson (1994) are indicative only, as significant additions have been made to the reserve system since 1994.

There were no plant communities protected under the Federal EPBC Act in the study area

The structural terminology used below (e.g. open forest to woodland, tall to very tall etc.) follows Walker and Hopkins (1990).

Table 2: Vegetation associations of the Sapphire to Woolgoolga survey area grouped under broad ecological vegetation types and indicating equivalent Endangered Ecological Communities (TSC Act).

No.	Associations (1-12) (indicator species dominant or co-dominant)	Endangered Ecological Communities
	Rainforest	
1	Brush Box - Guioa - Native Olive	Littoral Rainforest
2	Native Olive - Strangler Fig - Brush Cherry	Lowland Rainforest on Floodplain
	Coastal Hills Moist Open Forest	
3	Blackbutt	
4	Flooded Gum	
5	Grey Gum – Ironbark	
6	Spotted Gum	
7	Narrow-leaved White Mahogany	
	Coastal Floodplain Forest	
8	Red Mahogany	Swamp Sclerophyll Forest on Floodplain
9	Smooth-barked Apple	Swamp Sclerophyll Forest on Floodplain
10	Paperbark	Swamp Sclerophyll Forest on Floodplain
11	Swamp Oak	Swamp Oak Floodplain Forest
	Estuarine Complex	
12	Swamp Oak – Saltwater Couch	Coastal Saltmarsh

3.3.2 Littoral Rainforest

Association: Brush Box (*Lophostemon confertus*) - Guioa (*Guioa semiglauca*) - Native Olive (*Olea paniculata*)

Structure: Tall to very tall (18-25m) open to closed forest.

Distribution: Restricted to a few gullies at the southern end of the corridor at Sapphire Beach within the Coffs Harbour urban area.

Habitat: Lower slopes of southeast aspect within 0.5km of the sea. Soils are red-yellow podzolics on metasediment.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Brush Box	<i>Lophostemon confertus</i>	common (3)
	Native Olive	<i>Olea paniculata</i>	common (3)
	Guioa	<i>Guioa semiglauca</i>	common (3)
	Water Vine	<i>Cissus antarctica</i>	common (3)
	Five-leaf Water Vine	<i>Cissus hypoglauca</i>	common (3)
	Scrub Bloodwood	<i>Baloghia inophylla</i>	occasional (2)
	Pepperberry Tree	<i>Cryptocarya obovata</i>	occasional (2)
	Cheese Tree	<i>Glochidion ferdinandii</i>	occasional (2)
Mid	Sandpaper Fig	<i>Ficus coronata</i>	common (3)
	Common Lilly Pilly	<i>Acmena smithii</i>	common (3)
	*Lantana	<i>Lantana camara</i>	common (3)
	Burny Vine	<i>Trophis scandens</i>	common (3)
	Veiny Wilkea	<i>Wilkea huegeliana</i>	common (3)
	Red Bean	<i>Dysoxylum muelleri</i>	common (2)
	Barb-wire Vine	<i>Smilax australis</i>	common (2)
Lower	Rasp Fern	<i>Doodia aspera</i>	common (3)
	A Grass	<i>Oplismenus imbecilis</i>	common (3)
	Rainforest Lomandra	<i>Lomandra spicata</i>	common (3)
	Morinda	<i>Morinda jasminoides</i>	common (3)
	Giant Maidenhair Fern	<i>Adiantum formosum</i>	common (2)

Condition: Small remnants close to housing or banana farms were generally in fair condition without large weed infestations although incipient populations of a wide range of environmental weeds were present.

Assessment: This rainforest community is equivalent to the Endangered Ecological Community 'Littoral Rainforest'. The stands adjacent to the existing Pacific Highway at Sapphire Beach are among the few remaining examples in the Coffs Harbour urban area.

3.3.3 Lowland Rainforest on Floodplain

Association: Strangler Fig (*Ficus watkinsiana*) - Native Olive (*Olea paniculata*)

Structure: Tall (16-25m) open to closed forest.

Distribution: Small stands occur along a stream crossed by the footprint at Newmans Road northwest of Woolgoolga township and on the floodplain of Woolgoolga Creek close to the projected road reserve.

Habitat: Floodplain alluvium derived from metasedimentary rocks.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Red Bean	<i>Dysoxylum muelleri</i>	common (3)
	Native Olive	<i>Olea paniculata</i>	common (3)
	Brush Cherry	<i>Syzygium australe</i>	common (3)
	Brush Box	<i>Lophostemon confertus</i>	common (3)
	Black Booyong	<i>Heritiera actinophylla</i>	common (3)
	Hard Quandong	<i>Elaeocarpus obovatus</i>	common (2)
	Cheese Tree	<i>Glochidion ferdinandii</i>	common (2)
	Brush Bloodwood	<i>Baloghia inophylla</i>	common (2)
	Strangler Fig	<i>Ficus watkinsiana</i>	occasional (2)
Mid	Guioa	<i>Guioa semiglauca</i>	common (3)
	Burny Vine	<i>Trophis scandens</i>	common (3)
	Water Vine	<i>Cissus antarctica</i>	common (3)
	White Bolly Gum	<i>Neolitsea dealbata</i>	common (2)
	Veiny Wilkea	<i>Wilkea huegeliana</i>	common (3)
	Cleistanthus	<i>Cleistanthus cunninghamii</i>	common (2)
	*Lantana	<i>Lantana camara</i>	common (2)
	Common Lilly Pilly	<i>Acmena smithii</i>	common (2)
	Wait-a-while	<i>Calamus muelleri</i>	common (2)
	Red Bean	<i>Dysoxylum muelleri</i>	common (2)
Lower	Rasp Fern	<i>Doodia aspera</i>	common (3)
	Brush Lomandra	<i>Lomandra spicata</i>	common (3)
	Morinda	<i>Morinda jasminoides</i>	common (3)
	Giant Maidenhair Fern	<i>Adiantum formosum</i>	common (3)

Condition: Rainforest at Newmans Road was in good to excellent condition with only minor weed invasion. The rainforest at Woolgoolga Creek Road on the edge of cleared land was also in good condition. Exotics were largely absent although Climbing Asparagus Fern was invading from the rainforest edge.

Assessment: This rainforest community is equivalent to the Endangered Ecological Community 'Lowland Rainforest on Floodplain'. Few examples of Lowland Rainforest on Floodplain' remain near the town of Woolgoolga.

3.3.4 Blackbutt Coastal Hills Moist Open Forest

Association: Coastal Blackbutt (*Eucalyptus pilularis*)

Structure: Tall to very tall (20-30m) open forest with a grass, shrub and small tree understorey. A few areas had a greater abundance of sclerophyll shrubs and sedges in the understorey.

Distribution: Common in both the northern and southern halves of the survey area.

Habitat: Undulating hills, lower to upper slopes; yellow clay soils formed on metasediment. Soils are generally of medium fertility, which imparts a 'moist' species composition to the understorey of this association.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Blackbutt	<i>Eucalyptus pilularis</i>	v. common (4-5)
	Tallowwood	<i>E. microcorys</i>	common (3)
	Grey Gum	<i>E. propinqua</i>	common (3)
	Pink Bloodwood	<i>Corymbia intermedia</i>	occasional (3)
	White Mahogany	<i>E. acmenoides</i>	occasional (2)
Mid	Blackwood Wattle	<i>Acacia melanoxylon</i>	common (3)
	Turpentine	<i>Syncarpia glomulifera</i>	common (3)
	White Bottlebrush	<i>Callistemon salignus</i>	common (3)
	*Lantana	<i>Lantana camara</i>	common (3)
	Cheese Tree	<i>Glochidion ferdandii</i>	common (2)
	Common Tea Tree	<i>Leptospermum polygalifolium</i> <i>subsp. polygalifolium</i>	common (3)
Lower	Forest Wire Grass	<i>Entolasia stricta</i>	common (3-4)
	Blady Grass	<i>Imperata cylindrica</i>	common (3)
	Bracken Fern	<i>Pteridium esculentum</i>	common (3)
	Common Mat Rush	<i>Lomandra longifolia</i>	common (3)
	Trailing Goodenia	<i>Goodenia rotundifolia</i>	common (2)
	Barb Wire Grass	<i>Cymbopogon refractus</i>	common (2)
	Kangaroo Grass	<i>Themeda australis</i>	common (2)

Condition: Generally in good condition with few environmental weeds apart from Lantana.

Assessment: Not listed as an endangered community under the TSC Act.

Generally equivalent to Forest Type 36 (Moist Blackbutt). The associations representing this forest type in the survey area were considered adequately conserved in the central zone of NE NSW by Hager and Benson (1994).

3.3.5 Flooded Gum Coastal Hills Moist Open Forest

Association: Flooded Gum (*Eucalyptus grandis*)

Structure: Tall to extremely tall (20–40m) open forest.

Distribution: Scattered, small areas in the north (e.g. Arrawarra Creek and Woolgoolga Creek) and south (e.g. Sugar Mill Creek) of the survey area.

Habitat: The floodplain of larger drainage lines, sometimes extending to adjacent lower hillslopes.

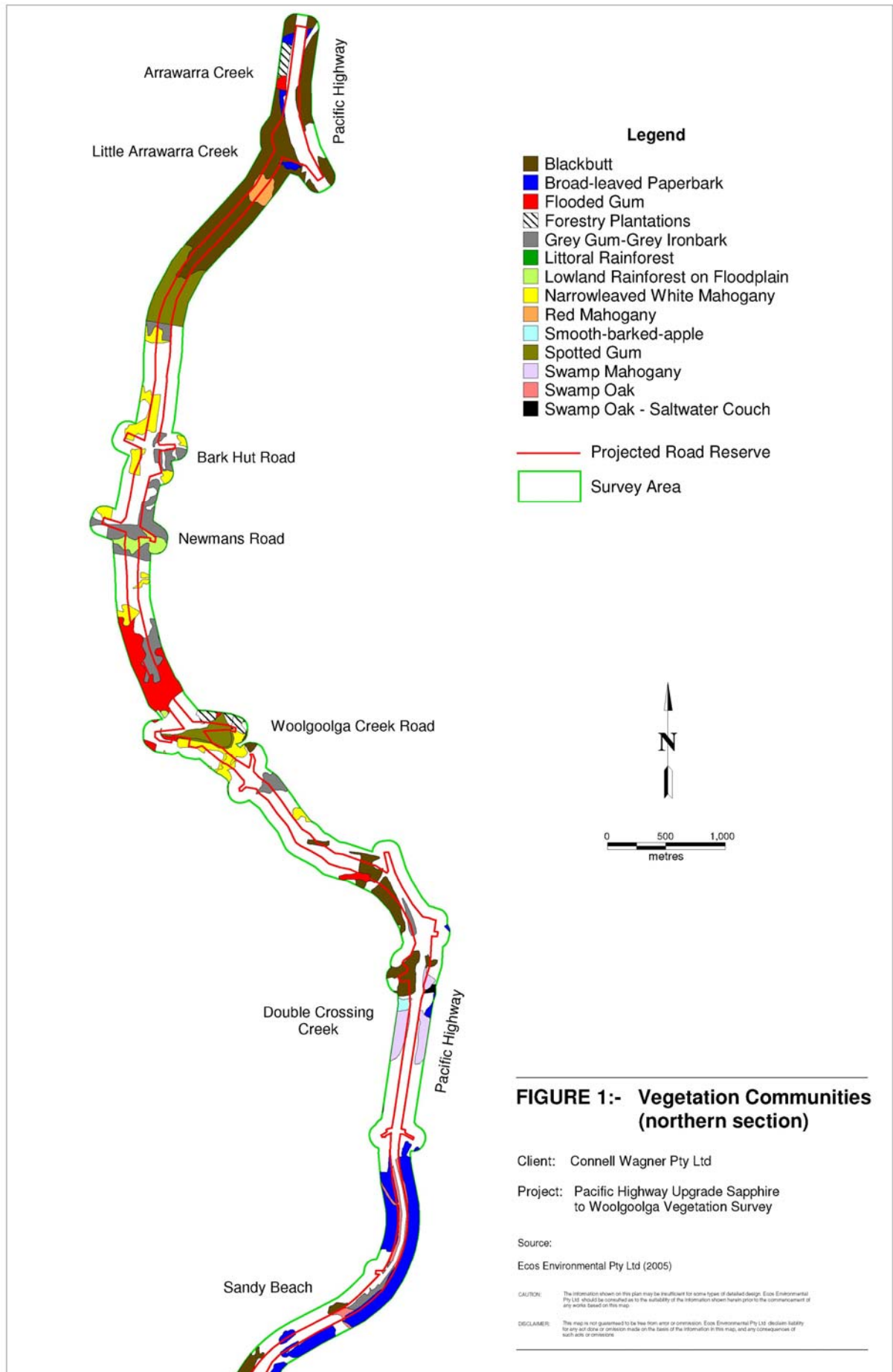
Main Species: (* introduced species)

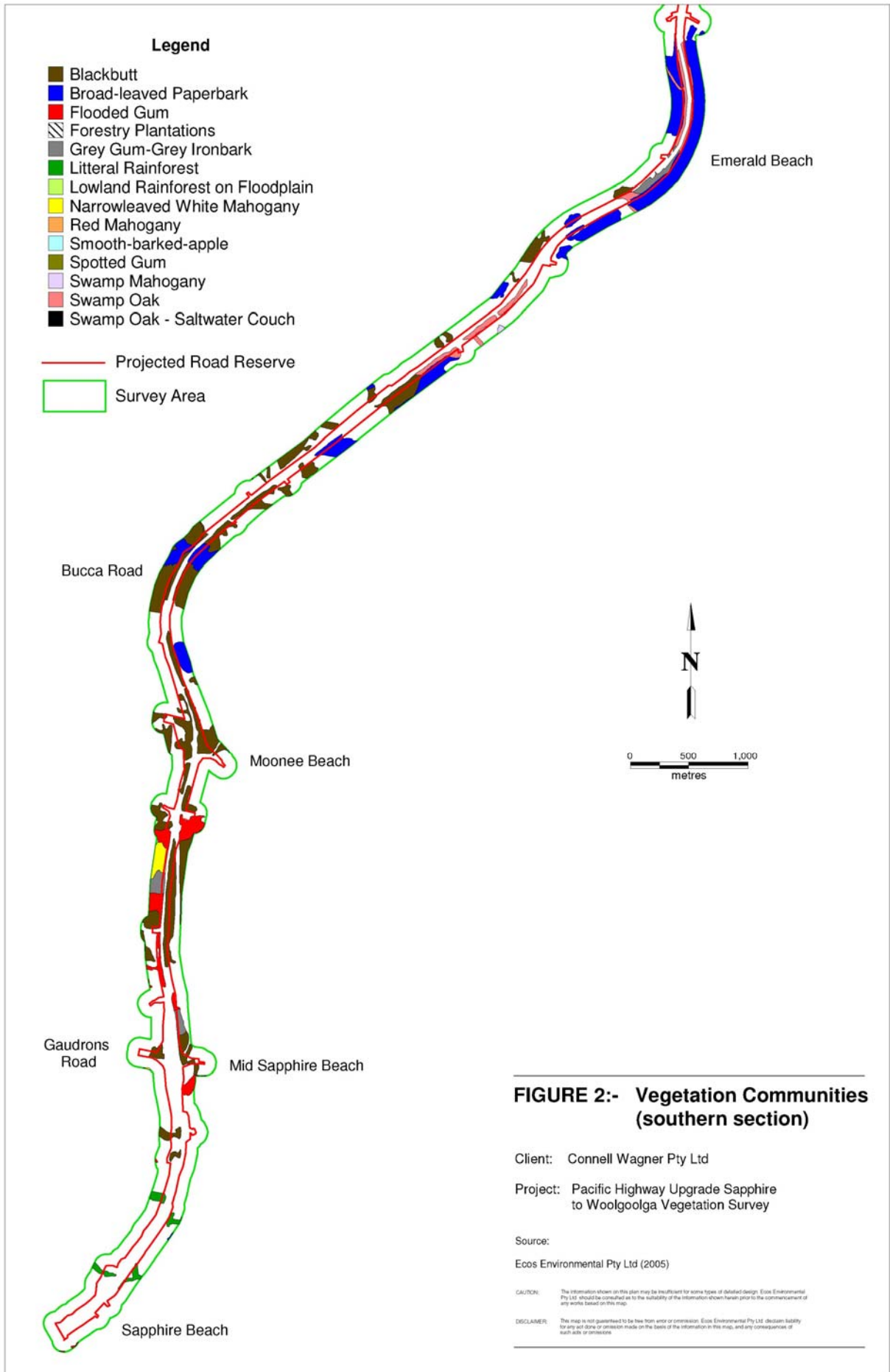
Stratum	Common Name	Botanical Name	Abundance
Upper	Flooded Gum	<i>Eucalyptus grandis</i>	common (4-5)
	Brush Box	<i>Lophostemon confertus</i>	occasional (2)
	Broad-leaved Ironbark	<i>Eucalyptus siderophloia</i>	occasional (2)
	Tallowwood	<i>Eucalyptus microcorys</i>	occasional (2)
Mid	Murrogun	<i>Cryptocarya microneura</i>	common (3)
	Morinda	<i>Morinda jasminoides</i>	common (3)
	Common Mock Olive	<i>Notelaea longifolia</i>	common (3)
	Narrow-leaf Palm Lily	<i>Cordyline stricta</i>	common (3)
	*Lantana	<i>Lantana camara</i>	common (3)
	Barb-wire Vine	<i>Smilax australis</i>	common (3)
	*Thorny Poinciana	<i>Caesalpinia decapitala</i>	common (3)
	Veiny Wilkea	<i>Wilkea huegeliana</i>	occasional (2)
	Common Lilly Pilly	<i>Acmena smithii</i>	occasional (2)
*Winter Senna	<i>Senna pendula</i>	occasional (2)	
Lower	Gristle Fern	<i>Blechnum cartilagineum</i>	common (3)
	Ottochloa Grass	<i>Ottochloa gracillima</i>	common (3)
	Rasp Fern	<i>Doodia aspera</i>	common (3)
	Settlers Flax	<i>Gymnostachys anceps</i>	occasional (2)
	Maidenhair Fern	<i>Adiantum formosus</i>	occasional (2)

Condition: Moderately high levels of environmental weeds in some areas.

Assessment: Not listed as an endangered community under the TSC Act.

Equivalent to Forest Type 48 (Flooded Gum). This community was considered inadequately conserved in the central zone of NE NSW by Hager and Benson (1994).





3.3.6 Grey Gum-Grey Ironbark-White Mahogany Coastal Hills Moist Open Forest

Association: Grey Gum (*Eucalyptus propinqua*) – Grey Ironbark (*Eucalyptus siderophloia*) – White Mahogany (*Eucalyptus acmenoides*)

Structure: Tall open forest (15-28m) with a mid-dense mid stratum of small trees and shrubs and dense grass-herb understorey.

Distribution: The northern half of the survey area, mainly north of Woolgoolga Creek.

Habitat: Generally mid to upper hill slopes; red-yellow podzolic soil formed on metasediment.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Grey Gum	<i>Eucalyptus propinqua</i>	common (3)
	Broad-leaved Ironbark	<i>Eucalyptus siderophloia</i>	common (3)
	Tallowwood	<i>Eucalyptus microcorys</i>	common (3)
	Pink Bloodwood	<i>Corymbia intermedia</i>	occasional (3)
	Spotted Gum	<i>Corymbia variegata</i>	occasional (3)
Mid	Turpentine	<i>Syncarpia glomulifera</i>	common (3)
	*Lantana	<i>Lantana camara</i>	common (3)
	Blackwood Wattle	<i>Acacia melanoxydon</i>	common (3)
	Forest Oak	<i>Allocasuarina torulosa</i>	common (3)
	Cheese Tree	<i>Glochidion ferdandii</i>	common (2)
Lower	Blady Grass	<i>Imperata cylindrica</i>	common (3)
	Bracken Fern	<i>Pteridium esculentum</i>	common (3)
	Common Mat Rush	<i>Lomandra longifolia</i>	common (3)
	Poison Pratia	<i>Pratia purpurascens</i>	common (3)
	Kangaroo Grass	<i>Themeda australis</i>	common (3)
	Rusty Desmodium	<i>Desmodium rhytidophyllum</i>	occasional (2)

Condition: Generally in good condition with few weeds, apart from Lantana.

Assessment: Not listed as an endangered community under the TSC Act.

Equivalent to Forest Type 62 (Grey Gum – Grey Ironbark-White Mahogany), which was considered adequately conserved in the central zone of NE NSW by Hager and Benson (1994).

3.3.7 Spotted Gum Coastal Hills Moist Open Forest

Association: Spotted Gum (*Corymbia variegata*)

Structure: Tall open forest (20-30m) with a grassy understorey.

Distribution: The northern half of the survey area at Woolgoolga Creek Road and Wedding Bells State Forest north of Bark Hut Road.

Habitat: Upper hill slopes; shallow, yellow podzolic soil formed on metasediment.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Spotted Gum	<i>Corymbia variegata</i>	common (3-4)
	Grey Gum	<i>Eucalyptus propinqua</i>	common (3)
	Broad-leaved Ironbark	<i>Eucalyptus siderophloia</i>	common (3)
	Pink Bloodwood	<i>Corymbia intermedia</i>	occasional (2)
Mid	*Lantana	<i>Lantana camara</i>	common (3)
	Blackwood Wattle	<i>Acacia melanoxyton</i>	common (3)
	Forest Oak	<i>Allocasuarina torulosa</i>	common (3) (3)
	Cheese Tree	<i>Glochidion ferdandii</i>	common (2)
Lower	Blady Grass	<i>Imperata cylindrica</i>	common (3-4)
	Bracken Fern	<i>Pteridium esculentum</i>	common (3)
	Common Mat Rush	<i>Lomandra longifolia</i>	common (3)
	Poison Pratia	<i>Pratia purpurascens</i>	common (3)
	Kangaroo Grass	<i>Themeda australis</i>	common (3)
	Rusty Desmodium	<i>Desmodium rhytidophyllum</i>	common (2)

Condition: Generally in good condition with few weeds.

Assessment: Not listed as an endangered community under the TSC Act.

Equivalent to Forest Type 74 (Spotted Gum – Ironbark/Grey Gum). The association representing this forest type in the survey area was considered poorly conserved in the central zone of NE NSW by Hager and Benson (1994).

3.3.8 White Mahogany Coastal Hills Moist Open Forest

Association: White Mahogany (*Eucalyptus acmenoides*)

Structure: Tall open forest (15-28m) with a grassy understorey.

Distribution: The northern half of the survey area, mainly north of Woolgoolga Creek Road.

Habitat: Mostly on mid to upper hill slopes of protected aspect; red-yellow podzolic soil formed on metasediment.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	White Mahogany	<i>Eucalyptus acmenoides</i>	common (3)
	Grey Gum	<i>Eucalyptus propinqua</i>	common (3)
	Broad-leaved Ironbark	<i>Eucalyptus siderophloia</i>	common (3)
	Tallowwood	<i>Eucalyptus microcorys</i>	common (3)
	Brush Box	<i>Lophostemon confertus</i>	occasional (3)
Mid	Forest Oak	<i>Allocasuarina torulosa</i>	common (3)
	Native Guava	<i>Eupomatia laurina</i>	common (3)
	*Lantana	<i>Lantana camara</i>	common (3)
	Morinda	<i>Morinda jasminoides</i>	common (3)
	Forest Phyllanthus	<i>Phyllanthus gastroemii</i>	occasional (2)
	Cheese Tree	<i>Glochidion ferdandii</i>	common (2)
Lower	Gristle Fern	<i>Blechnum cartilagineum</i>	common (3)
	Ottochloa Grass	<i>Ottochloa gracillima</i>	common (3)
	Rasp Fern	<i>Doodia aspera</i>	common (3)
	Common Mat Rush	<i>Lomandra longifolia</i>	common (3)
	Barbed Wire Vine	<i>Smilax australis</i>	common (3)
	Pastel Flower	<i>Pseuderanthemum variable</i>	occasional (2)

Condition: Generally in good condition with few weeds.

Assessment: Not listed as an endangered community under the TSC Act.

Equivalent to Forest Type 60 (Narrow-leaved White Mahogany-Red Mahogany-Grey Ironbark – Grey Gum). The plant communities representing this forest type in the survey area were considered inadequately conserved in northeast NSW by Hager and Benson (1994).

3.3.9 Red Mahogany Swamp Sclerophyll Forest

Association: Red Mahogany (*Eucalyptus resinifera*)

Structure: Mid-high to tall (8-15m) woodland with a dense tall shrub/small tree mid stratum and a sedge dominated ground layer.

Distribution: One small area occurs in the valley of Little Arrawarra Creek at the northern end of the survey corridor.

Habitat: Valley flat on heavy clay soil, possibly an old stream terrace.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Red Mahogany	<i>Eucalyptus resinifera</i>	common (3)
Mid	White Paperbark	<i>Melaleuca sieberi</i>	common (3)
	Prickly Paperbark	<i>Melaleuca nodosa</i>	common (3)
	Heath Banksia	<i>Banksia oblongifolia</i>	common (3)
	Black Sheoak	<i>Allocasuarina littoralis</i>	common (3)
Lower	A Sedge	<i>Ptilothrix deusta</i>	common (4)
	Wire Grass	<i>Entolasia marginata</i>	common (3)
	Kangaroo Grass	<i>Themeda australis</i>	common (3)
	Bracken Fern	<i>Pteridium esculentum</i>	common (3)
	A Hibbertia	<i>Hibbertia vestita</i>	common (3)

Condition: In good condition with no weeds.

Assessment: Equivalent to the Endangered Ecological Community ‘Swamp Sclerophyll Forest on Floodplain’. Typically the latter ecosystem is dominated by Broad-leaved Paperbark (*Melaleuca quinquenervia*) or Swamp Mahogany (*Eucalyptus robusta*), however, the Scientific Committee’s final determination for Swamp Sclerophyll Forest on Floodplain specifies that Red Mahogany (*Eucalyptus resinifera*) may be locally dominant at some sites. The associated understorey species fit well with the description of Swamp Sclerophyll Forest on Floodplain. The terrain also matches in terms of elevation and landform (point one of the final determination).

Equivalent to Forest Type 68 (Red Mahogany) which was considered poorly conserved in north east NSW by Hager and Benson (1994).

3.3.10 Smooth-barked Apple Swamp Sclerophyll Forest

Association: Smooth-barked Apple (*Angophora leiocarpa*)

Structure: Mid-high to tall (8-15m) woodland with a predominantly grassy ground layer.

Distribution: One small area occurs in the northern half of the survey area on the western side of the highway south of Double Crossing Creek.

Habitat: Valley flat on heavy clay soil derived from metasediments.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Smooth-barked Apple	<i>Angophora leiocarpa</i>	common (4)
	Swamp Mahogany	<i>Eucalyptus robusta</i>	common (3)
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>	common (3)
	Swamp Box	<i>Lophostemon suaveolens</i>	occasional (3)
Mid	White Paperbark	<i>Melaleuca sieberi</i>	common (3)
	Prickly Paperbark	<i>Melaleuca nodosa</i>	common (3)
	Heath Banksia	<i>Banksia oblongifolia</i>	occasional (3)
	Prickly Tea Tree	<i>Leptospermum juniperinum</i>	occasional (3)
Lower	A Sedge	<i>Ptilothrix deusta</i>	common (4)
	Wire Grass	<i>Entolasia marginata</i>	common (3)
	Kangaroo Grass	<i>Themeda australis</i>	common (3)
	A Hibbertia	<i>Hibbertia vestita</i>	common (3)
	A Grass	<i>Ischaemum australe</i>	common (3)

Condition: Generally in good condition with few weeds.

Assessment: In terms of terrain and associated flora this community equates with 'Swamp Sclerophyll Forest on Coastal Floodplains', an Endangered Ecological Community, however, the dominant species, *Angophora leiocarpa*, was not mentioned in the final determination. The similarity of terrain and associated flora with Swamp Sclerophyll Forest warrants a pre-cautionary approach to classification, so that for the purposes of this study, the association is considered equivalent to Swamp Sclerophyll Forest on Coastal Floodplains.

Equivalent to Forest Type 105 (Smooth-barked Apples). Considered poorly conserved in the central zone of NE NSW by Hager and Benson (1994).

3.3.11 Broad-leaved Paperbark Swamp Sclerophyll Forest

Association: Broad-leaved Paperbark (*Melaleuca quinquenervia*)

Structure: Mid-high to tall (10-15m) open forest.

Distribution: Common along the low-lying central part of the corridor between the Bucca Road and Double Crossing Creek south of Woolgoolga, but also in narrow bands along swampy drainage lines in the north and south of the survey area (some of these were too narrow to be mapped).

Habitat: Seasonally waterlogged floodplain or swampy creek lines at the edge of coastal hills and the floodplain.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Paperbark	<i>Melaleuca quinquenervia</i>	common (4-5)
	Swamp Oak	<i>Casuarina glauca</i>	occasional (2)
	Swamp Box	<i>Lophostemon suaveolens</i>	occasional (2)
	Swamp Mahogany	<i>Eucalyptus robusta</i>	occasional (2)
Mid	Broad-leaf Paperbark	<i>Melaleuca quinquenervia</i>	common (4)
	Swamp Oak	<i>Casuarina glauca</i>	occasional (2)
	Giant Silkpod Vine	<i>Parsonsia straminea</i>	occasional (2)
Lower	Swamp Ground Fern	<i>Hypolepis muelleri</i>	common (3)
	A sedge	<i>Schoenus brevifolius</i>	common (3)
	*Broad-leaf Paspalum	<i>Paspalum wettsteinii</i> *	common (3)
	Swamp Panic	<i>Entolasia marginata</i>	common (3)
	*Billygoat Weed	<i>Ageratum houstonianum</i>	common (3)
	Native Violet	<i>Viola hederacea</i>	common (2)
	A sedge	<i>Carex maculata</i>	occasional (2)

Condition: Generally in good condition with mature structure and few environmental weeds.

Assessment: Equivalent to the Endangered Ecological Community 'Swamp Sclerophyll Forest on Floodplain'.

3.3.12 Swamp Oak Swamp Sclerophyll Forest

Association: Swamp Oak (*Casuarina glauca*) grassy forest

Structure: Mid-high to tall (8-15m) woodland and open forest.

Distribution: Limited to the road reserve between the Emerald Beach turn-off to Stony Creek Road.

Habitat: Disturbed/previously cleared areas in the road reserve adjacent to Broad-leaved Paperbark forest. These sites appear to be dominated by Swamp Oak rather than Paperbark, because Swamp Oak is a better coloniser of cleared and disturbed ground.

Main Species: (* introduced species)

Stratum	Common Name	Botanical Name	Abundance
Upper	Swamp Oak	<i>Casuarina glauca</i>	common (4)
	Paperbark	<i>Melaleuca quinquenervia</i>	common (3)
Lower	*Broad-leaf Paspalum	<i>Paspalum wettsteinii</i>	common (3)
	*Billygoat Weed	<i>Ageratum houstonianum</i>	common (3)
	*Vasey Grass	<i>Paspalum urvillei</i>	common (2)
	Swamp Ground Fern	<i>Hypolepis muelleri</i>	common (3)
	*Carpet Grass	<i>Axonopus affine</i>	common (3)

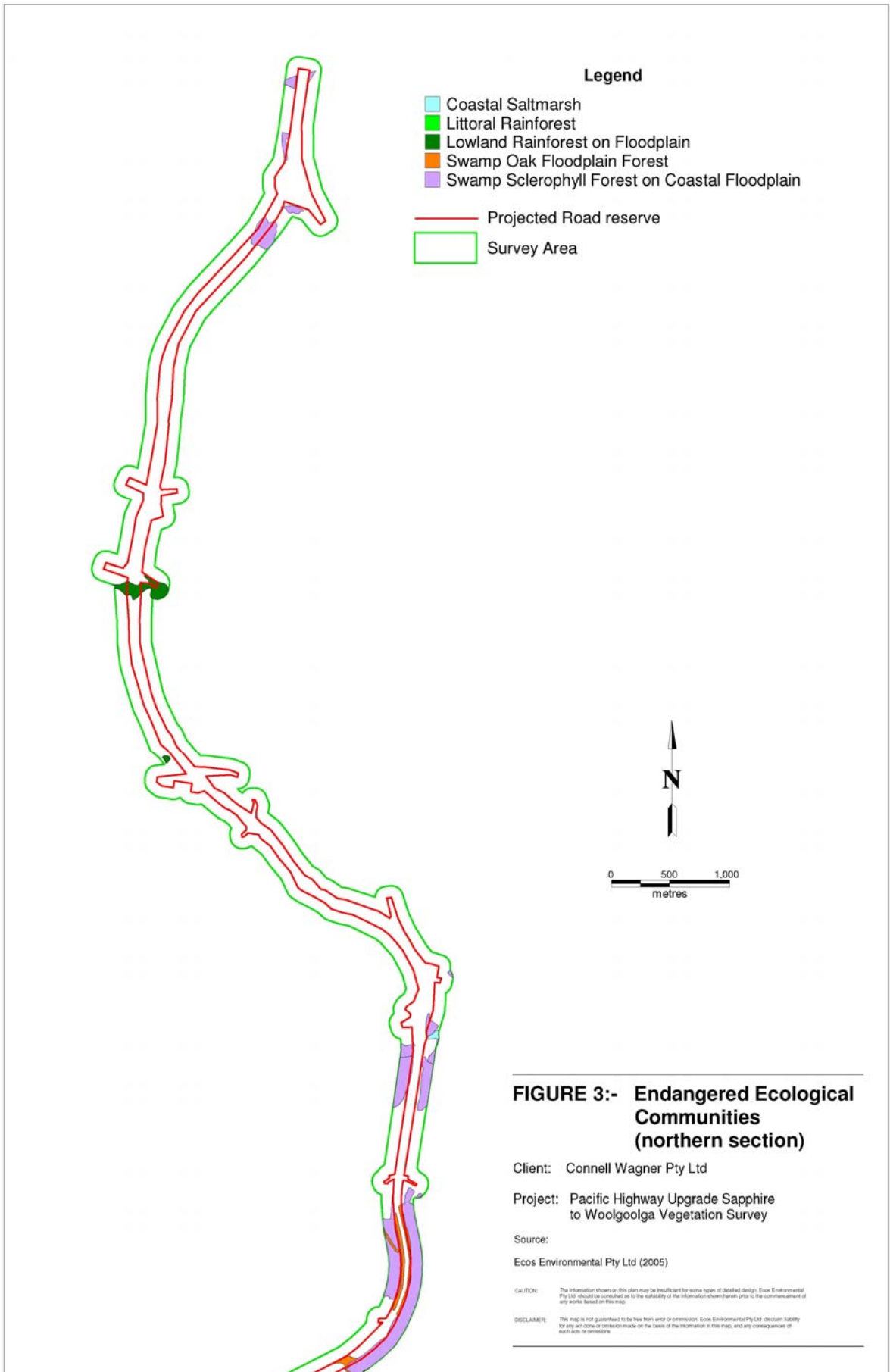
Condition: Poor condition.

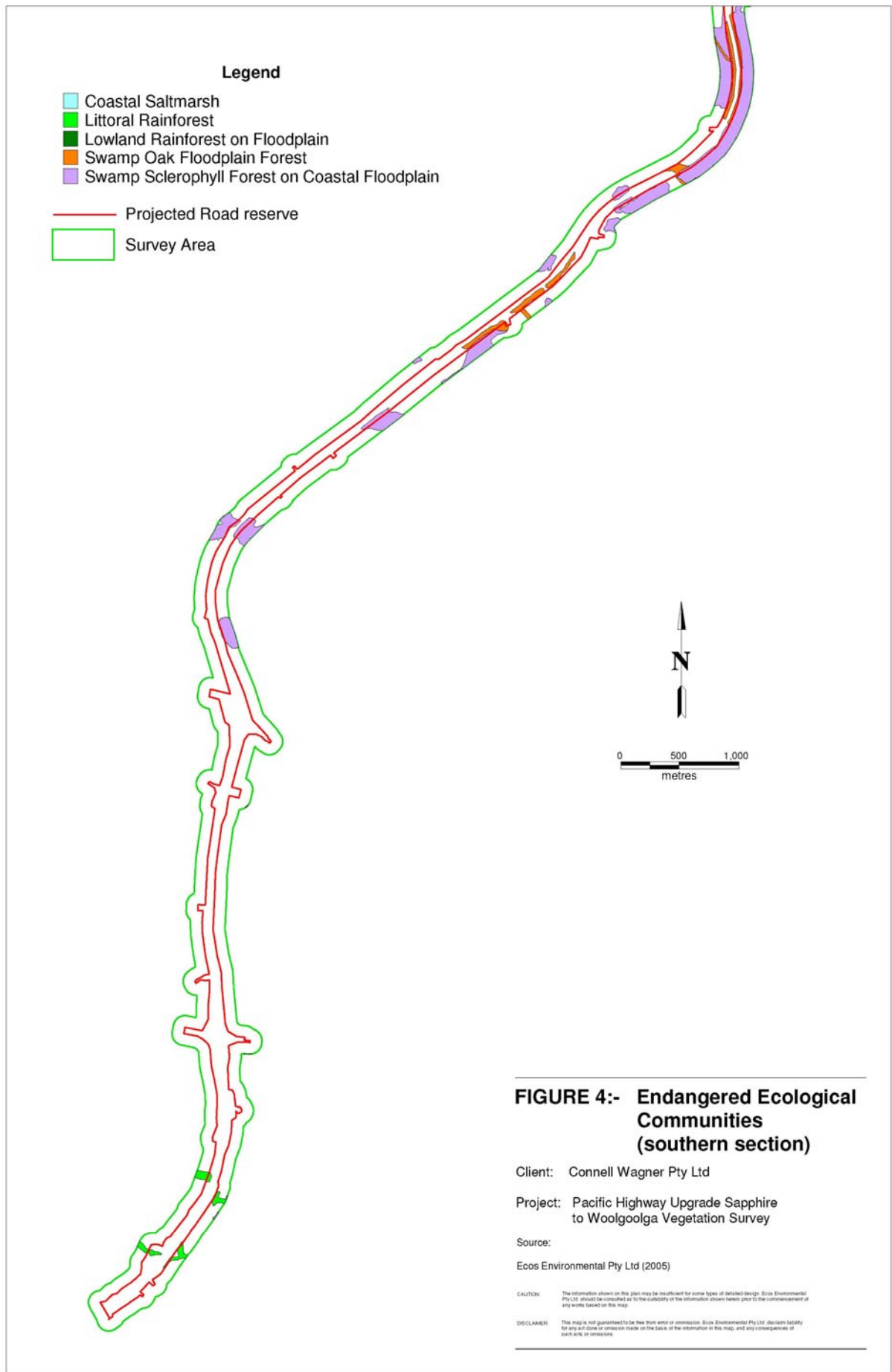
Assessment: Equivalent to the Endangered Ecological Community (TSC Act) Swamp Oak Floodplain Forest.

3.3.13 Estuarine Complex

One very small area of estuarine vegetation was intersected by the projected footprint in the tidal zone of Double Crossing Creek south of Woolgoolga. Dominant species present included Saltwater Couch (*Sporobolus virginicus*) and Swamp Oak (*Casuarina glauca*).

This vegetation type is equivalent to Coastal Saltmarsh, an Endangered Ecological Community.





3.4 Threatened Plant Species

3.4.1 Summary

Four Threatened (TSC Act) plant species were recorded within or closely adjoining the projected footprint. Three are listed as Endangered (*Marsdenia longiloba*, *Lindsaea incisa* and *Quassia sp. B*) and one as Vulnerable (*Amorphospermum whitei*). Two of these are also listed under the EPBC Act. Descriptions of recorded Threatened species, including their regional distribution, local occurrence and habitat are provided below. Threatened and rare plant species occurrences in the vicinity of the proposed route are detailed in Table 3.

3.4.2 Slender Marsdenia (*Marsdenia longiloba*)

Conservation Status: *Marsdenia longiloba* is listed as Endangered under the NSW TSC Act and as Vulnerable under the Commonwealth EPBC Act.

Description: A slender vine to 5m in height, leaves opposite, ovate to lanceolate, glabrous, pale green above, lighter on the underside, 3-10cm long and 1-5cm wide, with minute cluster glands at the base of lamina. The flowers are arranged in umbels, each flower is 7-9mm in diameter and whitish. This species is distinguished from other members of the genus by leaf colour and shape and the clear latex (rather than opaque or milky) that exudes from the leaf stalks.

Flowering has rarely been observed in this species and the fruits (follicles) have never been recorded (Harden 1992). The flowering period is reported as November to January in Quinn *et al.* (1995). The plants at Gaudrons Road were recorded with new flower buds at the end of July 2005 and one fruit (follicle) 10cm long was collected in December 2005.

Regional Distribution: This species occurs north of the Hastings River at widely scattered localities from the coast inland to the Great Escarpment ranges and extends into southeast Qld. Recorded localities include the Tweed River, Woodenbong, Byron Bay, Alstonville district, Billilimbra SF, Upper Copmanhurst, Coffs Harbour, Macleay River, Hastings River, Mt Boss (Quinn *et al.* 1995), Billinudgel and the Burringbar Range (pers.obs.).

Habitat: Moist open forest with a fern-grass understorey and occasional small rainforest trees, often on hillslopes adjacent to gully rainforest. It appears to prefer soils of medium fertility formed on substrates such as metasediment.

Local Occurrence: A small population was recorded at one location approximately 15 metres to the east of the existing highway in the road reserve just north of Gaudrons Road, Mid Sapphire Beach. The population at this site extends for a distance of approximately 50 metres parallel with the Pacific Highway and contains 20-30 plants growing amongst the ground layer vegetation or climbing 1-4 m into the understorey. Habitat consists of moist open forest dominated by Grey Gum (*E. propinqua*), Tallowwood (*E. microcorys*) and Grey Ironbark (*E. siderophloia*), which is in good condition with mature structure and few weeds present.

There are no proposed works in the immediate vicinity of the population, as the existing highway at this location would form a local access road and the closest construction activity would be at Gaudrons Road, approximately 220 metres to the south. As such, none of these individuals would be removed as a result of construction of the Proposal and there would be no long-term decrease in the size of the present population at this location.

Similar forest habitat to the Gaudrons Road site was present on several sections of the survey corridor but no other plants were recorded. This species appears to be very sparsely distributed in the greater Coffs Harbour area. Apart from the single herbarium (RBG) record for Coffs Harbour dated 1903 (Quinn *et al.* 1995), this species was also recorded 1km east of the survey corridor on Woolgoolga Creek during earlier botanical survey work (Benwell 2002) and is reported to occur on another property near Coffs Harbour (D. Binns pers.comm.).



Plate 1: Slender Marsdenia (*Marsdenia longiloba*) at Gaudrons Road, Mid Sapphire, and fruit collected in December 2005 (The Flora of NSW states that the fruit of this species has not been recorded.)

Table 3: Threatened (TSC Act) and rare plant species occurrences recorded on the preferred route of the proposed Sapphire to Woolgoolga Upgrade of the Pacific Highway.

No.	Plant name	Conservation Status (TSC Act)	No.	Growth Form	Easting GDA	Northing GDA	Location Description
80001a	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	tree (6m)	514081	6654676	property no. 176 west side of existing highway opposite Sebel Resort bottom of rock embankment
80001b	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	tree (7m)	514081	6654676	within 2m of 80001a
80001c	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	tree (5m)	514097	6654691	upslope to the north of 80001a and 8000b, closer to bananas, behind large fig
80002	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	tree (6m)	514109	6654590	east side of highway, 100m sth of Sebel Resort in rainforest patch on same creek as 80001, one tree on private property
80003	<i>Marsdenia longiloba</i>	Endangered	few plants	small vine (<2m)	514209	6656264	east side of highway in road reserve, tall open forest of Grey Gum, Ironbark and Turpentine, north of Gaudrons Rd.
80004	<i>Marsdenia longiloba</i>	Endangered	few plants	small vine (<2m)	514204	6656231	20m south of 80003 - plants scattered between these two points
80005	<i>Marsdenia longiloba</i>	Endangered	few plants	small vine (<2m)	514198	6656260	near 80004 - closer to existing road
80006	<i>Marsdenia longiloba</i>	Endangered	few plants	small vine (<2m)	514204	6656227	near 80005 - further south
80007	<i>Marsdenia longiloba</i>	Endangered	few plants	small vine (<2m)	514191	6656215	near 80006 - further south
80008	<i>Marsdenia longiloba</i>	Endangered	few plants	small vine (<2m)	514204	6656180	near 80007 - further south, 15 from existing road
80009	Red Bopple Nut <i>Hicksbeachia pinnatifolia</i>	Vulnerable	1	small tree - juvenile 0.6m high	516876	6668470	at old forestry station Woolgoolga Ck road, about 80 metres north of road across grassed area to edge of plantation, just inside the footprint
80010	Long-leaved Tuckeroo <i>Cupaniopsis newmanii</i>	ROTAP	1	small tree- 2m high	516789	6668048	opposite old forestry station Woolgoolga Ck road, on southern side of road 10 metres from edge of existing

							road, in the road reserve
80011	Rough-shelled Bush Nut <i>Macadamia tetraphylla</i>	Vulnerable	1	juvenile 0.2m high	516249	6670925	property no.241, in gully below driveway
80013	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	small tree (8m)			on property no. 364 (no-go) identified with binoculars 20m south of property no.222 at 516242 666908, on creek
80014	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	small tree (4m)	516202	6669179	on property no. 222 near creek
80020	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	2	small trees (8.5m & 4m)	516504	6668674	on property no. 131, top of northern bank of Woolgoolga Ck
80021	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	small tree (6m)	516523	6668667	on property no. 131, top of northern bank of Woolgoolga Ck 4m from 80020
80022	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	small tree (8m)	516479	6668698	on property no. 131, top of northern bank of Woolgoolga Ck
80023	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	small tree (7m)	516473	6668680	on property no. 131, top of northern bank of Woolgoolga Ck
80024	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	small tree (2m)	516504	6668674	on property no. 131, top of northern bank of Woolgoolga Ck close to 80020
80025	Rusty Plum <i>Amorphospermum whitei</i>	Vulnerable	1	small tree (4.5m)	516528	6668521	on State Forest or property no. 131? in small rainforest remnant
80026-28	Long-leaved Tuckeroo <i>Cupaniopsis newmanii</i>	ROTAP	1	small tree and two juveniles	516870	6668367	Opposite old forestry station Woolgoolga Ck road, on southern side of road 2-6 metres from edge of existing road, in the road reserve
80029	<i>Lindsaea incisa</i>	Endangered	patch	small ground fern	514029	6659846	Wedding Bells SF 20m from property no. 351 and 30m from existing highway; patch about 8m long and 2m wide
80030	Rough-shelled Bush Nut <i>Macadamia tetraphylla</i>	Vulnerable	1	small tree 6m tall	516828	6668451	Woolgoolga Creek Road, Wedding Bells State Forest, ground of old forestry station.

80031	Narrow-leaved Quassia <i>Quassia sp. B</i>	Endangered	few plants	spindly shrub 0.5-1m tall	514026	6657385	In road reserve north of Wakefield Road, northern side of drainage line.
80032	Narrow-leaved Quassia <i>Quassia sp. B</i>	Endangered	few plants	spindly shrub 0.5-1m tall	514023	6657388	Private property north of Wakefield Road, northern side of drainage line; 2m from road res.
80033	Narrow-leaved Quassia <i>Quassia sp. B</i>	Endangered	few plants	spindly shrub 0.5-1m tall	514020	6657378	Private property north of Wakefield Road, northern side of drainage line; 10m from road res.
80034	Narrow-leaved Quassia <i>Quassia sp. B</i>	Endangered	few plants	spindly shrub 0.5-1m tall	513864	6657420	Private property north of Wakefield Road, northern side of drainage line; 150m from rd. res.
80035	An Orchid <i>Cymbidium maddidum</i>	Reg. Signif.	1 clump	epiphyte, pseudobulbs	516377	6670914	Property no.241 (Bark Hut Rd west of Woolgoolga) 10m south of fence line bottom of slope
80090	Koala Bells <i>Artanema fimbriatum</i> A Daisy <i>Acmella grandiflora</i>	Rare Regionally Significant	8 plants several plants	herbs	514160	6660318	State Forest on the corner of Pacific Hwy and Bucca Road
80091	Koala Bells <i>Artanema fimbriatum</i> A Daisy <i>Acmella grandiflora</i>	Rare Regionally Significant	1 plant several plants	herbs	514213	6660307	State Forest on the corner of Pacific Hwy and Bucca Road
80092	Koala Bells <i>Artanema fimbriatum</i> A Daisy <i>Acmella grandiflora</i>	Rare Regionally Significant	1 plant several plants	herbs	514191	6660292	State Forest on the corner of Pacific Hwy and Bucca Road
80093	An Orchid <i>Cymbidium maddidum</i>	Regionally Significant	1 clump	epiphyte, pseudobulbs	516183	6669946	Property no.99 (Newmans Rd west of Woolgoolga), growing on tall stump 20m from creek
80094	An Orchid <i>Cymbidium maddidum</i>	Regionally Significant	1 clump	epiphyte, pseudobulbs	516098	6670062	Property no.99 (Newmans Rd west of Woolgoolga), growing on log across creek
80095	<i>Typhonium sp.</i> Possibly <i>Typhonium sp.</i> <i>aff brownii</i>	Endangered	several plants	rhizomatous herb	516301	6669947	Property no.99 (Newmans Rd west of Woolgoolga), growing on creek banks in strip of riparian rainforest. Plants scattered along creek for 20 metres east from the recorded location.

3.4.3 *Lindsaea incisa*

Conservation Status: *Lindsaea incisa* is listed as Endangered under the NSW TSC Act.

Description: A small ground fern with pale green, slender, erect fronds, 1-3cm wide and 10-20cm long. The paired leaves are deeply divided and form whorls of 3-4 leaflets spaced out along the stems. The fronds occur in small, often dense patches, which arise from a rhizomatous root system.

Regional Distribution: This species is distributed in central eastern Australia between Fraser Island and Coffs Harbour (Australia's Virtual Herbarium website). In NSW the species is known from scattered localities between the lower Clarence River and the Coffs Harbour district. Recorded localities include Corindi, Barcoongere State Forest, Wells Crossing, Bundjalung National Park, Waihou Flora Reserve and Copmanhurst (Sheringham and Westaway 1995; pers.obs.).

Habitat: Heathy open forest grading into swamp sclerophyll forest on seasonally waterlogged or poorly drained sites, usually along the base of hillslopes or adjacent creeks in sandstone terrain. The great majority of sites are on sedimentary geology (sandstone or siltstone) or derived alluvium (NPWS 2002; pers. obs.).

Local Occurrence: *Lindsaea incisa* was recorded at a single location in Orara East State Forest approximately 30m from the existing Pacific Highway at Yellow Water Holes. The site is at the base of hillslope on the edge of open forest and a narrow remnant of swamp sclerophyll woodland. Plants at this location occurred in a single patch about 8 m long and 2 m wide consisting of 200-300 stems. The nearest known populations to the Yellow Water Holes site are in Waihou Flora Reserve, 15 km to the northwest, and near Corindi, 15 km to the north.



Plate2: *Lindsaea incisa* in Wedding Bells SF adjacent to the existing Pacific Hwy.

In the vicinity of the population a proposed service road would be located on the western side of the existing highway. The toe of the batter slope would be located approximately 10 metres from the area of *Lindsaea incisa*. Construction of the proposed service road to the east of the patch of *Lindsaea incisa* would require measures to ensure that construction machinery and personnel are excluded from the area containing the threatened species.

3.4.4 Rusty Plum (*Amorphospermum whitei*)

Conservation Status: *Amorphospermum whitei* is listed as Vulnerable under the NSW TSC Act.

Description: Medium sized rainforest tree to 20 m in height with pale rough bark and a fluted trunk in larger trees. Leaves are alternate and prominently veined, with a smooth upper surface and rusty hairy beneath. New shoots are rusty brown (Floyd 1989).

Regional Distribution: The Macleay River to upper Tallebudgera Creek in far southern Queensland (Floyd 1989). Also reported from the Port Macquarie district (Harden 2000), the species' southern limit. Recorded localities include Nulla Nulla Creek, Warrell Creek, Oakes S.F., Bellinger River S.F., Tuckers Knob, Orara West S.F., Bruxner Park F.R., Coramba, Mt Coramba, Orara East S.F., Lower Bucca S.F., Woolgoolga Creek F.R., Waihou F.R., Sherwood N.R., Copmanhurst, Whian Whian S.F., Minyon Falls F.R., Broken Head N.R., Couchy Creek, Numinbah N.R. and Mt Cougal (Floyd 1989), Brunswick Heads N.R. (Briggs and Leigh 1996) and Mt Jerusalem (BSC 1999).

Habitat: Typical habitat consists of gully rainforest or wet sclerophyll with a well-developed rainforest understorey. Soil of medium fertility formed on metasediment or rhyolite. The altitude range of this species is from near sea level to 600 m (Floyd 1989).

Local Occurrence: Rusty Plum was recorded at several locations during the earlier route options survey (Benwell 2002). A large number of trees were seen in the upper catchment of Woolgoolga Creek adjacent to Gentle Annie Road and this population probably extends downstream to Woolgoolga Creek Nature Reserve where it is also reported (Floyd 1989), a distance of 2-3km. Other populations were recorded at Slaters Crossing Road, Bark Hut Creek, Moonee Creek and an unnamed creek on Sherwood Road near the junction with Nana Glen Road (all in Wedding Bells State Forest) and on Woolgoolga Creek between the survey area and Woolgoolga township on private property. Other occurrences are reported from Orara East SF in Sheringham and Westaway (1995). Eight out of 13 individuals in the vicinity of the Proposal would need to be removed.

Overall, flora survey work indicated that Rusty Plum is fairly widespread in rainforest and wet sclerophyll forest surrounding the study area. This species has become rare in the more cleared and developed zone surrounding coastal towns.



Plate 3: Rusty Plum (*Amorphospermum whitei*) growing on the footprint of the preferred route at Woolgoolga Creek

3.4.5 Narrow-leaved Quassia (*Quassia* sp. B)

Conservation Status: *Quassia* sp. B is listed as Endangered under both the NSW TSC Act and the EPBC Act.

Description: Shrub from 0.5 to 2 metres high, leaves narrow elliptical to oblanceolate, 4-12mm wide, glabrescent, paler underneath and with distinct secondary and intramarginal veins (Harden 2002). The population on the survey corridor had leaves matching this description, however, plants in the hinterland observed during previous fieldwork had leaves up to 20mm wide, or closer to the second *Quassia* taxon in NSW (*Quassia* sp. A).

Regional Distribution: *Quassia* sp. B is endemic to the area between Moonee Beach and Glenreagh north of Coffs Harbour and north east of Grafton. Recorded from Pine Brush State Forest, McCraes Knob (via Tucabia), Flaggy Creek (near Glenreagh), Timbertop (Kangaroo River State Forest), Wedding Bells State Forest, Conglomerate State Forest and Orara East State Forest (Quinn *et al.* 1995).

Habitat: Wet sclerophyll forest and heathy dry sclerophyll forest on sandstone and metasediment. Some records are from heathy open forest dominated by *E. planchoniana* and *E. pyrocarpa* on poor sandstone soils, while others are from wet sclerophyll forest. A. Floyd regards *Quassia* sp. 1 as a forest edge species (Quinn *et al.* 1995). The majority of locations appear to be in the ecotone between wet and dry sclerophyll forest.

Local Occurrence: A single occurrence was recorded on the southern half of the survey corridor north of Wakefield Road (Mid Sapphire). This population extended from the road reserve on the western side of the highway west (at right angles to the highway) for approximately 150 metres and contained approximately 70 plants, 4 within the present road reserve. Four of these individuals are located within the present road reserve approximately 15 metres from the construction footprint (but would not be required to be removed for construction of the Proposal), with the majority of the individuals located well outside the construction footprint. As such, none of these individuals would be removed as a result of construction of the Proposal and there would be no long-term decrease in the size of the present population at this location.

During the earlier route options vegetation survey (Benwell 2002) this species was recorded in the catchment of upper Woolgoolga Creek south of the junction of Bark Hut Road and Gentle Annie Road in Wedding Bells State Forest.

Overall, the Narrow-leaved Quassia appears to be uncommon and widely scattered in coastal foothill and range country north of Coffs Harbour. The occurrence in study area appears to be the most easterly and lowest elevation population of the species.

3.4.6 Koala Bells (*Artanema fimbriatum*)

Conservation Status: *Artanema fimbriatum* is not a legislatively protected species but was given a C2 ranking (threatened or potentially threatened) in the Upper North East Comprehensive Regional Assessment (NPWS 1998). *Artanema fimbriatum* was

included in a recent precautionary listing of potentially threatened plant species by the Royal Botanic Gardens Sydney (correspondence from B. Makinson, RBG, 23/7/04).

Description: A herb in the foxglove family growing to 50cm high with opposite, toothed leaves and 3-4cm long, blue tubular flowers (Plate 4).

Habitat: Koala Bells occurs mainly in coastal grassy floodplain forest and the edges of swamp sclerophyll forest but also in open forest on bedrock soils of medium to high fertility.

Regional Distribution: The southern limit of Koala Bells is the Macleay River valley near Kempsey (Wildlife Atlas; Australia's Virtual Herbarium). It extends northwards in small, widely scattered populations to the Qld border, in near coastal forests. The species is reported to be rare in southeast Qld (T. Bean, Qld Herb, pers.comm.).

Local Occurrence: An occurrence was recorded in swamp sclerophyll forest adjacent to the Pacific Highway and Bucca Road in Orara East State Forest. A total of ten plants were recorded at three points within a radius of approximately 30 metres. Two of the plants are located approximately 25 metres west of the Proposal footprint with the remaining eight plants located further west, approximately 75 metres from the Proposal footprint.

3.4.7 Stinky Lily (*Typhonium* sp. aff. *brownii*)

Note: a *Typhonium* species without flowers was recorded in December 2005. This could be either *Typhonium brownii*, a relatively common species, or the Endangered species *Typhonium* sp. aff. *brownii*. Until an identification can be made, the population will be treated as possibly the Endangered species.

Conservation Status: *Typhonium* sp. aff. *brownii*. is listed as Endangered under the TSC Act. This taxon has recently been recognised as a distinct species *Typhonium clemeshaii* (NPWS 2002).

Description: A rhizomatous herb to 20cm tall with glabrous, hastate to deeply two lobed leaves. The flowers consist of a floral spathe with a central stigma and are coloured green and purplish brown (NPWS 2002). The species is distinguished by the shape and length of the central flower stigma, which is intermediate between *T. brownii* and *T. eliosurum*.

Habitat: Stinky Lily occurs on fairly fertile soils, in moist eucalypt forest and its margins with subtropical rainforest (NPWS 2002).

Regional Distribution: This species is restricted to the ranges between Coffs Harbour and Woolgoolga and west to Glenreagh

Local Occurrence: The undetermined *Typhonium* species was recorded in the lowland subtropical rainforest at Newmans Road growing on the stream channel in moist alluvial soil. Several plants were scattered along a 20 metres stretch of creek bank, the closest located approximately 12 metres to the east of the proposed road footprint. Measures to protect these plants during construction would be implemented unless subsequent surveys identify them as the common *Typhonium brownii* species.

3.5 Threatened and ROTAP Species Not Native to the Study Area

In addition to the three naturally occurring Threatened species described above, two non-indigenous (not native to the study area) Threatened and one ROTAP species were recorded during the survey, as described below: -

- Rough-shelled Bush Nut (*Macadamia tetraphylla*)

Macadamia tetraphylla is listed as a Threatened species under the TSC Act and the EPBC Act (Vulnerable). This species is a small tree indigenous to the Richmond-Tweed region where it occurs in lowland rainforest on basalt, metasediment or alluvial substrates (Floyd 1989).

One planted tree was recorded in the grounds of the old forestry station on Woolgoolga Creek Road approximately 50 metres north of the road footprint. One wild growing juvenile was recorded in a wet sclerophyll gully near Bark Hut Road (Woolgoolga district), approximately 140 metres west of the proposed footprint.

- Red Bopple Nut (*Hicksbeachia pinnatifolia*)

A single Red Bopple Nut juvenile was recorded at the old forestry station on Woolgoolga Creek Rd (Plate 5) in an area of planted rainforest that included other non-indigenous natives (e.g. *Callitris macleayana*) and appeared to be 20 – 40 years old. The Red Bopple Nut was much smaller (0.6m) than other planted trees suggesting that it could have resulted from natural seed dispersal, however, there was no evidence that Red Bopple Nut occurs in the Woolgoolga district, although it does occur in the Dorrigo-Bellinger River area south of Coffs Harbour. This plant occurs approximately 50 metres north of the proposed footprint at Woolgoolga Creek Road.

- Long-leaved Tuckeroo (*Cupaniopsis newmanii*)

Cupaniopsis newmanii is a small tree with long pinnate leaves indigenous to the Richmond-Tweed region where it occurs in rainforest and adjoining wet sclerophyll forest (Floyd 1989). This species is listed in ROTAP (Briggs and Leigh 1995) as nationally rare.

Four plants were recorded 10 to 15 metres from the projected footprint in Wedding Bells State Forest near the old forestry station on Woolgoolga Creek Rd (Plate 6) and would not be required to be removed by the Proposal. The plants are 5-10 m from the existing road in moist open forest and appear to have grown from introduced (deliberately or accidentally?) seed or planted seedlings. Two individuals were producing flower buds in July during the survey. A few more mature trees were seen in State Forest adjoining Sanctuary Road in the same general locality.

3.6 Regionally Significant Species

Cymbidium maddidum

The Flora of NSW Vol.4 (Harden 1993) gives the southern limit of *Cymbidium maddidum* as the Clarence River. Occurrences were recorded in wet sclerophyll forest and rainforest near Bark Hut Road and Newmans Road west of Woolgoolga, or

approximately 100km south of the Clarence River. These represent an extension of range and the extreme southern limit of the species distribution. The occurrence at Newmans Road (two point records) is approximately 20 metres west of the proposed road footprint, while the occurrences at Bark Hut Road were approximately 20 metres west and 50 metres south of the projected footprint.

Acmella grandiflora

The Flora of NSW Vol.3 (Harden 1992) gives the southern limit of *Acmella grandiflora*, as Lismore, however, the Virtual Herbarium website shows the species occurring as far south as the Clarence River. The records from the present survey next to the existing highway in Orara East State Forest between Coffs Harbour and Woolgoolga appears to be at the extreme southern end of its geographical range. Several plants were located approximately 25 metres and 75 metres west of the Proposal footprint and would not be impacted by the Proposal.



Plate 4: *Artanema fimbriatum* (Koala Bells)

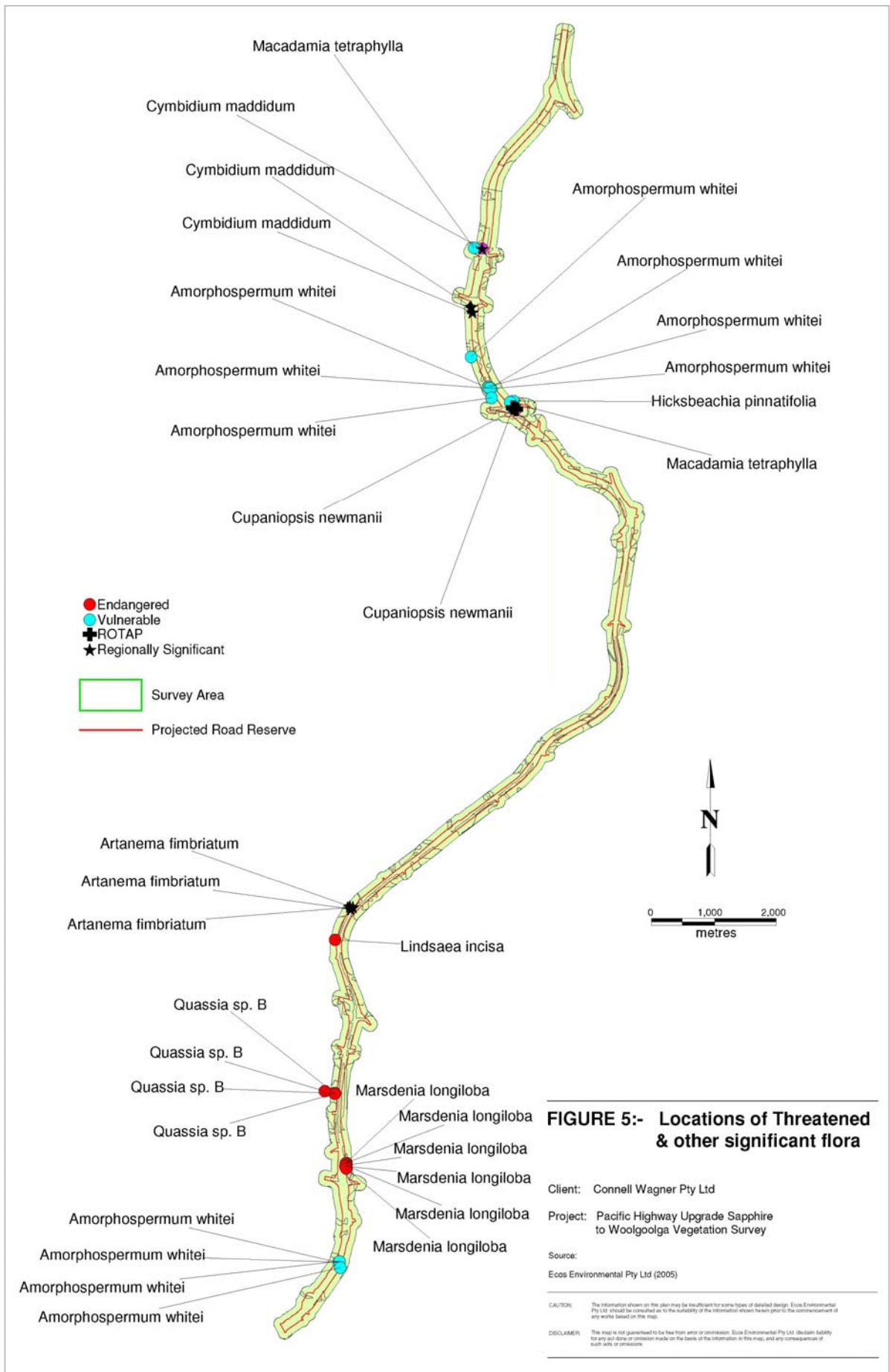




Plate 5: Red Bopple Nut (*Hickesbeachia pinnatifolia*). Juvenile plant in a planted area at the old forestry station in Wedding Bells SF, Woolgoolga Creek Road.



Plate 6: Long-leaved Tuckerroo (*Cupaniopsis newmanii*) in Wedding Bells SF near the edge of Woolgoolga Creek Road.

3.7 Endangered Ecological Communities

Five Endangered Ecological Communities (TSC Act) were recorded on or closely adjoining the proposed road footprint (Figure 3 and 4): -

- Swamp Sclerophyll Forest on Coastal Floodplains of the North Coast Bioregion
- Swamp Oak Floodplain Forest in the North Coast Bioregion
- Lowland Rainforest on Floodplain in the North Coast Bioregion
- Littoral Rainforest in the North Coast Bioregion
- Coastal Saltmarsh in the North Coast Bioregion

Swamp Sclerophyll Forest (SSF) is common in the central part of the proposed road corridor between Double Crossing Creek (near Sandy Beach) and Yellow Water Holes (near Moonee Beach). The proposed corridor through this central section is located largely within the present road reserve but also extends into the margin of adjoining properties along most of its length. Much of the Swamp Sclerophyll Forest in the road reserve is young regrowth with moderate to high levels of common exotic grasses and herbs in the understorey. Approximately 7.6 hectares of this community (excluding the Arrawarra interchange area) would be required to be removed for the Proposal.

Regrowth in the road reserve was often dominated by Swamp Oak even though adjoining swamp forest outside the road reserve was dominated by Broad-leaved Paperbark (SSF). This is apparently because Swamp Oak is a better coloniser of disturbed ground, a phenomenon commonly seen along roadsides where these two species co-occur. This change in species composition could create problems in classifying the vegetation, however, since both Swamp Sclerophyll Forest (Broad-leaved Paperbark) and Swamp Oak are EECs, it would not affect assessment of the conservation status of this general type of swamp forest vegetation. Approximately 5.3 hectares of Swamp Oak Floodplain Forest (excluding the Arrawarra interchange area) would be required to be removed for the Proposal. In effect, all swamp forest vegetation along the corridor falls within either Swamp Oak or Swamp Sclerophyll Forest, which are both EECs.

Small areas of three other EECs occur within or closely adjacent to the survey corridor. Firstly, areas of rainforest on the floodplain of Woolgoolga Creek (alongside the proposed footprint at the proposed Woolgoolga interchange) and at a small stream crossed by Newmans Road are equivalent to the EEC 'Lowland Rainforest on Floodplain in the North Coast Bioregion'. Approximately 1.0 hectare of this community (excluding the Arrawarra interchange area) would be required to be removed for the Proposal. Small areas of a second rainforest EEC, 'Littoral Rainforest' occur at Sapphire Beach adjoining the existing highway on the eastern and western side. Approximately 1.1 hectares of this community (excluding the Arrawarra interchange area) would be required to be removed for the Proposal. The other EEC is a very small area of Coastal Saltmarsh located downstream of where the projected footprint crosses Double Crossing Creek south of Woolgoolga. This community would not be impacted by the Proposal.

No examples of the EEC Lowland Rainforest, which has preliminary listing status under the TSC Act, were found in the study area. (The EEC Lowland Rainforest encompasses all areas of rainforest below 600m elevation excluding 'Lowland Rainforest on Floodplain' and 'Littoral Rainforest'.)

4.0 DISCUSSION

4.1 Threatened Plants

The Slender Marsdenia (*Marsdenia longiloba*) population located just north of Gaudrons Road at Mid Sapphire has probably the highest level of botanical constraint on the highway design. This species is listed as Endangered under the TSC Act (also as Vulnerable under the EPBC Act) and is extremely rare. Only ten records are listed in Quinn *et al.* (1995) and seven of these are from the early 1900s or late 1800s. The remaining three records are from Woodenbong, Dalmorton and Mt Boss, which are all more than 100km apart. This species also occurs in the Brunswick-Tweed district where two populations are known to the author. One of these populations was impacted by the Yelgun to Chinderah Highway Upgrade. Transplanting and cutting propagation carried out in an attempt to translocate the species during the latter project were unsuccessful (Benwell 2003).

The Endangered ground fern *Lindsaea incisa* is considered to have the next highest level of constraint on the highway design. This species is known from a total of only seven locations in NSW between the lower Clarence River and just north of Coffs Harbour. Although the plan of the highway footprint indicates it will not be directly impacted, the population is located approximately 30m from the present road and any widening in its direction would encroach into this 30m buffer zone, which is considered a minimum buffer to protect an Endangered species (Bali 2000; NPWS 1996). This species appears to have specific habitat requirements (see Section 3.4.3), which would be difficult to replicate at a site if the population was translocated.

The Endangered Narrow-leaved Quassia (*Quassia* sp. B) has a high level of constraint on the highway design but lower than the two above species. Although this species has a very restricted distribution, reasonable sized populations occur in State Forest in the hinterland ranges (e.g. Wedding Bells, Orara East and Conglomerate State Forests) where they are relatively secure. Also, the population recorded during the survey was found to extend from the road reserve west for 150 metres and contained approximately 70 mature plants, 4 of which were in the road reserve. The occurrence in the survey area is of particular interest as it represents the lowest elevation population of the species. No individuals of this species would be required to be removed for the construction of the Proposal.

The Rusty Plum (*Amorphospermum whitei*) is considered to have a lower level of botanical constraint than the other three Threatened species. Although this rainforest tree is rare close to the coast due to clearing and development, it is reasonably common in the hinterland (Section 3.4.4). Eight out of 13 individuals in the vicinity of the Proposal would need to be removed. A translocation plan should be prepared according to guidelines in ANPC (2004) to relocate impacted individuals to land with appropriate habitat and security of tenure nearby.

4.2 Threatened and ROTAP Species Not Native to the Study Area

The survey recorded three Threatened and ROTAP plant species non-indigenous to the Coffs Harbour-Woolgoolga area (see Section 3.5). These may have been accidentally or deliberately introduced. DECC advises that planted or introduced individuals of Threatened species have the same level of protection as wild growing

ones. This apparently applies to an area where the species is unlikely to have occurred historically or in recent geological time.

Potential habitat may exist for a plant species beyond its current or natural distribution due to climate change and past shrinkage in distribution caused by glacial-interglacial climatic oscillations (Myers and Giller 1988). The predicted green-house effect could also create new potential habitat and changes in species distributions.

The Red Bopple Nut occurs naturally in two metapopulations, one in the Coffs Harbour-Dorrigo district where the species is rare and the other in the Richmond-Tweed district 200km to the north where it is more common (NPWS 1998). If the lone individual is of planted origin, which seems likely, it may have been propagated from seed collected in the northern metapopulation. Some plant conservation biologists may consider it undesirable to introduce (putative) genetic variation from the north into the southern metapopulation.

A similar situation applies to the Rough-shelled Bush Nut and Long-leaved Tuckeroo except that a *species* has been introduced to a region (the Mid North Coast) where it did not occur historically, although suitable potential habitat appears to exist, as evidenced by the healthy, wild-growing individuals of Long-leaved Tuckeroo at the Woolgoolga Creek Road site. These plants may be considered to have conservation significance as populations of Threatened or nationally rare species that are extending their range in the wild as a consequence human activity and therefore should be actively protected, by either *in situ* protection or translocation.

4.3 Regionally Significant Species

Two regionally significant species were recorded in the study area, the epiphytic orchid *Cymbidium maddidum* and the perennial herb *Acmella grandiflora*. The occurrences of *Cymbidium maddidum* near Bark Hut Road and Newmans Road west of Woolgoolga and of *Acmella grandiflora* at the Bucca Road turn-off are apparently at the extreme southern limit of their distribution. Appropriate protective measures such as a marking protocol and barrier mesh fencing during highway construction are recommended to protect these species and their habitat.

4.4 Endangered Ecological Communities

Five Endangered Ecological Communities were recorded along the proposed road corridor: -

- Swamp Sclerophyll Forest on Coastal Floodplains of the North Coast Bioregion;
- Swamp Oak Floodplain Forest in the North Coast Bioregion;
- Lowland Rainforest on Floodplain in the North Coast Bioregion;
- Littoral Rainforest in the North Coast Bioregion; and
- Coastal Saltmarsh in the North Coast Bioregion

The EECs most affected by the proposed road footprint are Swamp Sclerophyll Forest on Coastal Floodplains and Swamp Oak Floodplain Forest. These two communities are fairly widespread in remnant vegetation on the coastal floodplain adjacent to the proposed corridor, although at a regional scale their extent has been greatly reduced by land clearing. Restricting the highway upgrade largely within the present road reserve in the central and southern sections of the corridor minimises the impact on these EECs. Generally, the examples of the two EECs within the proposed corridor consist of regrowth in poorer condition than the examples found on adjoining private property, Coffs Harbour Council and State Forest land.

Lowland Rainforest on Floodplain occurs in two areas within the bypass section of the Proposal. A small area on the floodplain of Woolgoolga Creek would not be impacted by the Proposal, with a larger area of the community present where the Proposal crosses Newmans Road. At this location the dual carriageways and associated batters would require the removal of approximately one hectare of this community.

Littoral Rainforest would be impacted by the Proposal (on the western side of the existing highway) at Sapphire Beach. Some areas of this community are degraded due to the adjacent cleared land and surrounding residential areas.

No examples of the EEC Lowland Rainforest (as distinct from Lowland Rainforest on Floodplain and Littoral Rainforest), which has preliminary listing status under the TSC Act, were found in the study area.

A very small area of Coastal Saltmarsh is present on the eastern side of the existing highway at Double Crossing Creek south of Woolgoolga. There would be no direct impact on this community.

5.0 RECOMMENDED AMELIORATIVE MEASURES

5.1 Threatened and Rare Plant Species

5.1.2 Slender Marsdenia (*Marsdenia longiloba*)

- The occurrence of this species is to be treated as having a very high level of significance. If there are any reasons why the population of Slender Marsdenia located to the east of the existing Pacific Highway immediately north of Gaudrons Road cannot be adequately protected during construction, then the feasibility of translocation should be investigated. Translocation would be undertaken in consultation with DECC.
- Employ protective measures such as barrier mesh fencing during vegetation clearing and highway construction.

5.1.2 *Lindsaea incisa*

- The occurrence of this species is to be treated as having a very high level of significance. The population of *Lindsaea incisa* is located in Orara East State Forest close to the boundary with the existing Pacific Highway road reserve. It is located approximately 30 metres to the west of the existing highway, however, the service road to connect Moonee Beach to Heritage Park would be located approximately 10 from the population of *Lindsaea incisa*.
- Employ protective measures such as barrier mesh fencing during vegetation clearing and highway construction.

5.1.3 Rusty Plum (*Amorphospermum whitei*)

- Eight out of 13 individuals in the vicinity of the Proposal would be impacted. Flora survey work has indicated that Rusty Plum is fairly widespread in rainforest and wet sclerophyll forest in the study area, with the species seen in the upper catchment of Woolgoolga Creek where it is thought to extend downstream to Woolgoolga Creek Nature Reserve where it is also recorded.
- Investigate the feasibility of translocation of impacted individuals. Translocation would be undertaken in consultation with DECC.

5.1.4 Narrow-leaved Quassia (*Quassia* sp. B)

- No individuals of this species would be required to be removed for the construction of the Proposal, however protective measures such as barrier mesh fencing would be employed during vegetation clearing and highway construction.

5.1.5 Koala Bells (*Artanema fimbriatum*)

- Koala Bells were located in one location on the western side of the existing highway south of the Bucca Road turn off, outside of the area to be impacted by the highway and proposed service road. Employ protective measures such as barrier fencing during vegetation clearing and highway construction.

5.1.6 Stinky Lily (*Typhonium sp. aff. brownii*) To be confirmed.

- The (potential) occurrence of this species is to be treated as having a very high level of significance. Despite surveys during the appropriate season, no plants were flowering, therefore it could not be determined whether they were the relatively common species or the endangered species. Surveys should be conducted during summer of 2006-07 to check for flowering so that this species can be accurately determined.
- If the species is determined to be the endangered species, then investigate the feasibility of translocation. Translocation would be undertaken in consultation with DECC.
- Employ protective measures such as barrier fencing during vegetation clearing and highway construction.

5.1.7 Other Significant Flora

- Employ protective measures such as barrier fencing during vegetation clearing and highway construction.
- Where a species will be directly impacted, investigate the feasibility of translocation. Translocation would be undertaken in consultation with DECC.

5.2 Translocation

Where it is not possible to modify the highway design to avoid directly impacting species of conservation significance, because of engineering, economic or social factors, a translocation strategy should be developed for the subject plants, in accordance with ANPC (2004), "Guidelines for the Translocation of Threatened Plants in Australia". The translocation strategy would be developed in consultation with DECC. Translocation, which is defined as the "deliberate transfer of plants or regenerative plant material from one place to another, including existing or new sites or those where the taxon is now extinct" (ANPC 2004), may entail a range of measures including transplanting, seed/cutting propagation and reintroduction, and habitat rehabilitation.

The aim of translocation is not simply to undertake the salvage and removal of individuals to a new location, but to promote the establishment of reproductive and sustainable stands of the subject species, to compensate for losses to population numbers and habitat incurred during development of the highway upgrade. This requires consideration of genetic, demographic and ecological issues, as well as a follow-up maintenance commitment to ensure the population is given a reasonable chance of becoming established, reproductive and self-sustaining.

5.3 Endangered Ecological Communities

Clearing of Endangered Ecological Communities should be minimised wherever possible and the spread of weed species to these ecosystems as a consequence of road

construction should be addressed in the Environmental Management Plan for the highway upgrade.

5.4 Weed Control and Topsoil Re-use

Earthworks during road construction have the potential to spread seed of noxious and environmental weeds already present in soil along the highway corridor and into adjoining plant communities. A weed management strategy that addresses vegetation clearing and topsoil stockpiling and re-use should be formulated to mitigate these potential effects. This strategy should be integrated with revegetation and landscape planning for the project.

Vegetation cleared from sections of the highway corridor with high levels of noxious or invasive environmental weeds (Plate 7) should be mulched and disposed of under the edges of fill batters or sites appropriate from a road engineering perspective. Where topsoil stripping is required in any cut section with high levels of exotic or pest plants, the topsoil from these sections should also be disposed of by burial.

Generally the strategy would aim to prevent the spread of pest plants by salvaging topsoil from sections of the corridor with low levels of exotic plants, for storage and re-spreading on the highway batters after construction. Previous experience with topsoil salvage and re-use by the RTA should be carefully considered in developing improved strategies of topsoil re-use in highway revegetation.

The native soil seedbank present in largely weed-free topsoil should be utilised for revegetation, although problems with timing and method of soil storage are still being resolved (J. O'Donnell, RTA, pers.com.).

5.5 Seed Collection and Revegetation

Seed collection to be undertaken prior to and during vegetation clearing from a range of hardy native species suitable for tubestock propagation or hydro-seeding of the highway verges. For revegetation, primary reliance to be on re-use of the topsoil seedbank, which would be salvaged from parts of the corridor with low levels of weeds and directed to appropriate habitat. Tubestock propagation or hydro-seeding from locally collected seed would be used to augment revegetation results achieved by topsoil re-use, for example, by the addition of non-soil seedbank species (e.g. *Eucalyptus*, *Melaleuca*, *Casuarina*) where required.



Plate 7: Impenetrable thicket of exotic Prickly Poinciana (*Caealpinea decapitala*) and Coral Tree (*Erythrina crista-galli*) (red flowers) along Woolgoolga Creek next to Wedding Bells SF. During clearing of heavily weed-infested vegetation, cleared material should be mulched and buried together with the topsoil to prevent spread to new areas during highway construction.

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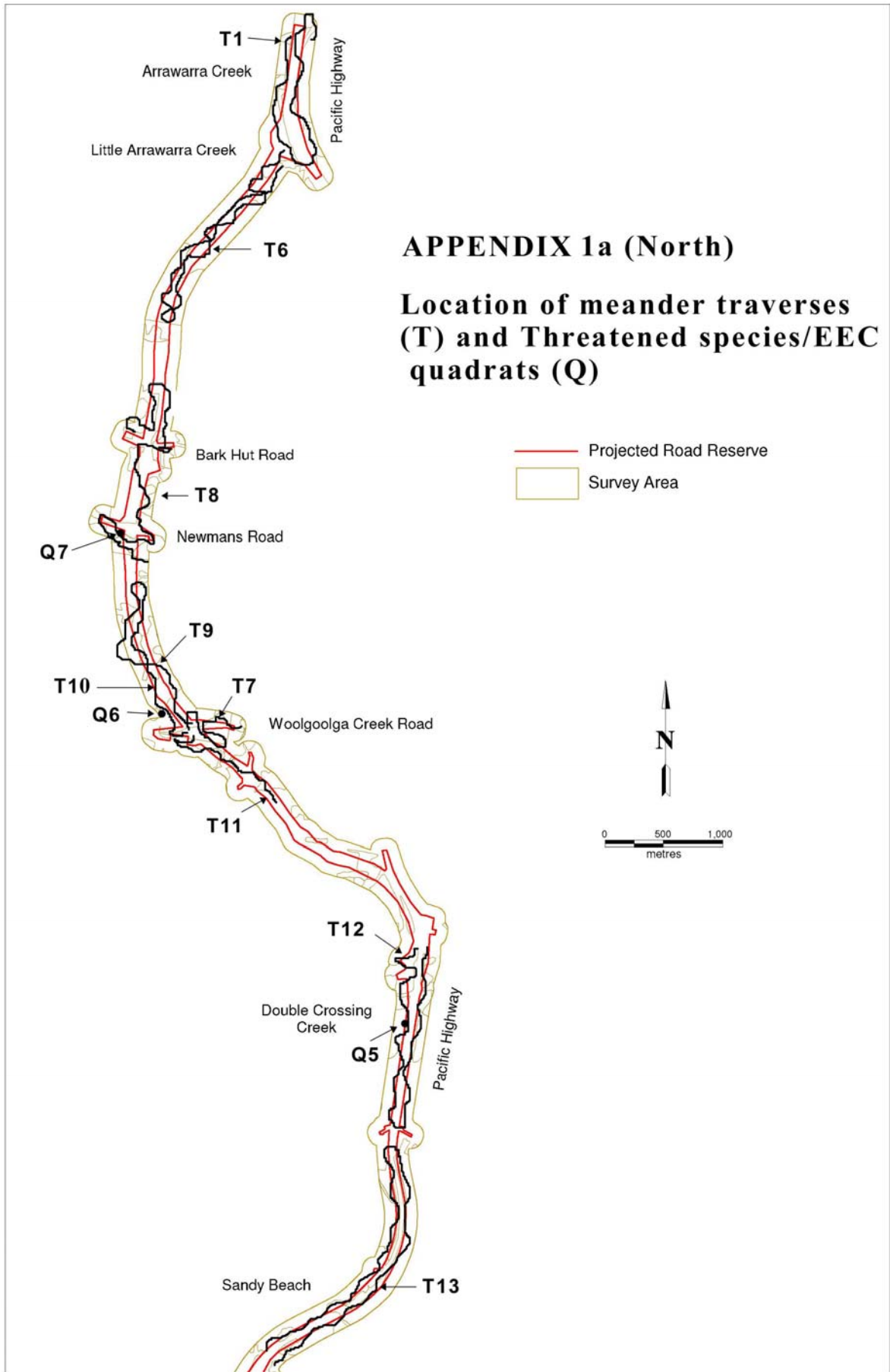
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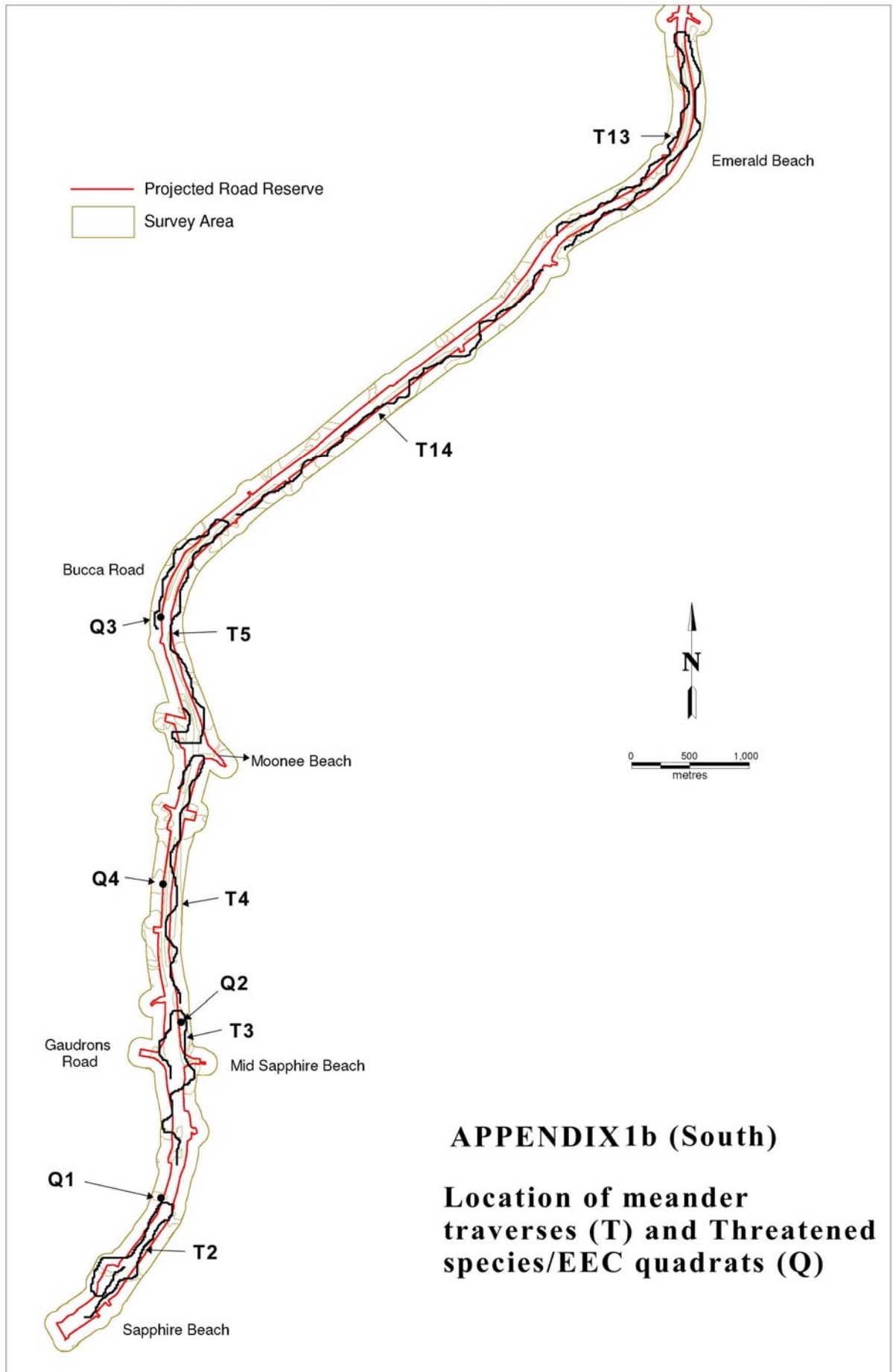
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APPENDIX 2:

Background on Vegetation Classification Schemes used in North East NSW

There are many different schemes for classifying vegetation communities. Existing vegetation maps of the study area use four different plant community schemes - Forest Types (FCNSW 1989), 'vegetation communities' (Fischer *et al.* 1996), Forest Ecosystems (NPWS 1999) and CRAFTI (NPWS 1999). Forest Types, vegetation communities and CRAFTI identify closely corresponding or similar vegetation entities and these three classification frameworks are derived by same traditional methods of classification based on the 'association' concept and mapping based on aerial photograph interpretation and ground-truthing. Forest Ecosystems differ from Forest Types/vegetation communities/associations in being derived from quadrat data by a complex process of multivariate statistical analysis (see below).

The use of different systems of classification to describe and map plant communities is confusing for specialists and non-specialist alike. Since vegetation classification frameworks form the basis of assessments of plant community conservation status, further information is provided below on systems of classification (ie. associations, Forest Types, vegetation communities, Forest Ecosystems).

Associations

The association has traditionally been the basic unit of vegetation classification and mapping in Australia. An association is defined as a unit of vegetation having the same overall structure and dominant species in the overstorey (Beadle and Costin 1952; Beadle 1981), and the same dominant species in the understorey (Neldner 1993). 'Structure' refers to the life form, height and crown cover of the upper vegetation stratum (Specht 1970). Associations as the primary vegetation unit can be grouped together into broader units (e.g. forest types, broad ecological vegetation types), which may be more appropriate for coarse scale vegetation mapping, for example, at a regional or State level.

Forest Types

The Forest Type system of vegetation classification and mapping was developed by G.N. Bauer and other plant ecologists with the Forestry Commission of NSW (now State Forests of NSW) over several decades. A Forest Type is defined as any group of tree-dominated stands that possess general similarity in composition and character (FCNSW 1989). The similarity of Forest Types with associations is evident. Some Forest Types are equivalent to associations while others are broader or include several floristically related associations.

Forest Types is a prescribed system of classification comprising over 200 types, which vegetation is mapped or fitted to, although the system also make provision for recognition of new Forest Types. A total of 87 Forest Types (excluding rainforest, non-forest and cleared/artificial types) are recognised in upper north eastern NSW (NPWS 1996). These are described in Research Note No.17 (FCNSW 1989). The system was developed primarily for mapping forest vegetation but includes classes for general types of non-forest land cover.

The Forest Type classification is designed for mapping forest vegetation at a scale of 1:25,000, a relatively high resolution which may delineate forest stands as small as 2 hectares in area or 50 metres in width. Some forest types are floristically and ecologically relatively uniform, while others are more heterogeneous (NPWS 1996). The classification is based primarily on overstorey floristics although some forest types have the same overstorey indicators but differ in understorey floristics (e.g. moist and dry Blackbutt - Forests Types 36 and 37).

CRAFTI

CRAFTI was the CRA Aerial Photograph Interpretation Project (NPWS 1999), an acronym for Comprehensive Regional Assessment Forest Type Inventory. The CRAFTI project was primarily focused on mapping vegetation on non-Crown Lands. The vegetation classification adopted for the CRAFTI project was based on existing Forest Type and association classification frameworks, adapted to broad-scale vegetation mapping by aerial photograph interpretation.

Coffs Harbour City Council LGA Mapping

Fisher *et al.* (1996) described the vegetation of the Coffs Harbour Local Government Area in terms of 'vegetation communities'. These units were described as being of similar floristic and ecological resolution to 'forest types', 'associations' and 'floristic groups'.

Associations were originally defined as plant species assemblages having similar canopy species composition and structure (Beadle 1981). Fisher *et al.* (1996) used the term association in a broader, api-based sense. "Communities of similar structure but varying floristic composition are difficult to map from aerial photography and may be grouped as an association." (p. 13).

'Floristic groups' are numerically derived vegetation units produced by cluster analysis of floristic data collected from vegetation survey plots. Fisher *et al.* (1996) aimed to make the classification of vegetation in the Coffs Harbour area consistent with floristic groups derived by the numerical method in the regional NRAC study (NPWS 1995).

Forest Ecosystems

The Forest Ecosystem classification is a derivation of the Forest Type classification, which represents an attempt to arrive at a floristically and ecologically more comprehensive and balanced classification of forest vegetation in northeast NSW than the Forest Type system. NPWS (1999) developed a classification of 157 Forest Ecosystems for northeast NSW (16 non-eucalypt types). Of these, 43 represented unmodified Forest Types and 98 were derived by splitting and amalgamating Forest Types using multivariate data analysis tools.

According to NPWS (1999), Forest Ecosystems were mapped predictively over crown lands with existing fine scale vegetation mapping (e.g. Forest Type mapping in State Forest) but were not extrapolated to private lands, apparently because of the potential for mis-classification of vegetation and inaccurate spatial boundaries. For non-crown lands, modeling was used to predict the *proportions* of Forest Ecosystems in areas of

natural vegetation (NPWS 1999) but modeling of their actual distribution was not carried out, or reported. Instead, indicative maps were produced of probable Forest Ecosystem distribution, which displayed vegetation as a random mosaic of square grid units where more than one Forest Ecosystem was predicted to occur in an area of vegetation (the number of grid units of each FE proportional to its probability). This form of vegetation map has limited application in environmental planning at the scale of LGA's where the boundaries of actual vegetation communities are required.

APPENDIX 3: Threatened Species and Endangered Ecological Community Quadrats

Quadrat 1 *Amorphospermum whitei* (Rusty Plum) – TSC Act Vulnerable

Location: Western side of Pacific Highway opposite Sebels Resort, bottom of steep rock fill embankment, in gully (GDA 0514081 6654676).

Vegetation Type: Lowland subtropical rainforest, tall closed forest.

Substrate: red-yellow podzol on metasediment

Slope Aspect: southwest

Slope Angle: 10-25°

Disturbance history: no evidence of recent fire

Quadrat Size: 20m x 20m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	12-18	70	<i>Olea paniculata</i>	<i>Ficus watkinsiana</i>	<i>Lophostemon confertus</i>
Mid	1-6	80	<i>Ficus coronata</i>	<i>Lantana camara</i>	<i>Dysoxylum muelleri</i>
Lower	0-1	40	<i>Oplismenus imbecilis</i>	<i>Ageratum adenophorum</i>	<i>Doodia aspera</i>

Species (* exotic species)	Habit	Cover-abundance Class
<i>Acmena smithii</i>	T	1
<i>Alphitonia excelsa</i>	T	2
<i>Alpinea caerulea</i>	H	2
<i>Amorphospermum whitei</i>	T	1
<i>Aphanopetalum resinosum</i>	V	1
<i>Archontophoenix cunninghamiana</i>	P	2
<i>Arytera divaricata</i>	T	2
<i>Baloghia inophylla</i>	T	2
<i>Beilschmedia elliptica</i>	T	1
<i>Calamus muelleri</i>	V	3
<i>Cissus antarctica</i>	V	3
<i>Cissus hypoglauca</i>	V	3
<i>Cleistanthus cunninghamii</i>	S	2
<i>Cordyline stricta</i>	S	2
<i>Cyathea leichhardtiana</i>	S	1
<i>Diospyros pentamera</i>	T	2
<i>Doodia aspera</i>	F	3
<i>Drypetes australasica</i>	T	1
<i>Dysoxylum muelleri</i>	T	2
<i>Ficus coronata</i>	T	2
<i>Ficus fraseri</i>	T	2
<i>Ficus watkinsiana</i>	T	3
<i>Flagellaria indica</i>	V	2

<i>Guoia semiglauca</i>	<i>T</i>	2
<i>Legnephora moorei</i>	<i>V</i>	2
<i>Lomandra spicata</i>	<i>H</i>	2
<i>Lophostemon confertus</i>	<i>T</i>	3
<i>Maclura cochinchinensis</i>	<i>V</i>	2
<i>Melodinus australis</i>	<i>V</i>	2
<i>Olea paniculata</i>	<i>T</i>	3
<i>Oplismenus imbecillus</i>	<i>G</i>	3
<i>Ripogonum album</i>	<i>V</i>	2
<i>Ripogonum ellseyanum</i>	<i>V</i>	2
<i>Smilax australis</i>	<i>V</i>	2
<i>Syzygium oleosum</i>	<i>T</i>	1
<i>Wilkea hugeliana</i>	<i>S</i>	2
* <i>Ageratum adenophorum</i>	<i>H</i>	2
* <i>Anredera cordifolia</i>	<i>V</i>	1
* <i>Araujia hortorum</i>	<i>V</i>	1
* <i>Ochna serrulata</i>	<i>S</i>	1
* <i>Schefflera actinophylla</i>	<i>T</i>	2
* <i>Senna pendula</i>	<i>S</i>	2

Quadrat 2 *Marsdenia longiloba* (Slender Marsdenia) – TSC Act Endangered

Location: Eastern side of the Pacific Highway in road reserve 100-200 metres north of Gaudrons Road. (GDA 0514221 6656202).

Vegetation Type: Grey Gum – Tallowood – Ironbark, tall to very tall open forest.

Substrate: red podzol on metasediment

Slope Aspect: flat

Slope Angle: 2°

Disturbance history: No evidence of recent fire, probably unburnt for 20 years or more. No recent logging or other disturbance.

Quadrat Size: 20m x 20m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	20-28	70	<i>Eucalyptus propinqua</i>	<i>Eucalyptus microcorys</i>	<i>Eucalyptus siderophloia</i>
Mid	3-6	60	<i>Syncarpia glomulifera</i>	<i>Elaeocarpus obovatus</i>	<i>Lophostemon confertus</i>
Lower	0-1	80	<i>Ottochloa gracillima</i>	<i>Blechnum cartilagineum</i>	<i>Imperata cylindrica</i>

Species (* exotic species)	Habit	Cover-abundance Class
<i>Blechnum cartilagineum</i>	F	3
<i>Cissus antarctica</i>	V	1
<i>Cordyline stricta</i>	S	2
<i>Cryptocarya triplinervis</i>	T	1
<i>Cupaniopsis anacardioides</i>	T	2
<i>Cyclophyllum coprosmoides</i>	T	1
<i>Desmodium gunnii</i>	H	2
<i>Desmodium rhytidophyllum</i>	H	2
<i>Dianella caerulea</i>	G	2
<i>Digitaria parviflora</i>	G	1
<i>Dioscorea transversa</i>	V	2
<i>Elaeocarpus obovatus</i>	T	3
<i>Entolasia stricta</i>	G	2
<i>Eucalyptus microcorys</i>	T	4
<i>Eucalyptus pilularis</i>	T	2
<i>Eucalyptus propinqua</i>	T	3
<i>Eucalyptus siderophloia</i>	T	2
<i>Ficus platypoda</i>	T	1
<i>Geitonoplesium cymosum</i>	V	2
<i>Glycine clandestina</i>	H	2
<i>Imperata cylindrica</i>	G	4
<i>Jagera pseudorhus</i>	T	1
* <i>Lantana camara</i>	S	2
<i>Lomandra laxa</i>	G	2
<i>Lomandra longifolia</i>	G	1

<i>Lophostemon confertus</i>	<i>T</i>	2
<i>Maclura cochinchinensis</i>	<i>V</i>	2
<i>Marsdenia longiloba</i>	<i>V</i>	2
<i>Maytenus bilocularis</i>	<i>S</i>	1
<i>Maytenus silvestris</i>	<i>S</i>	2
<i>Notelaea longifolia</i>	<i>T</i>	2
<i>Ottchloa gracillima</i>	<i>G</i>	4
<i>Pittosporum undulatum</i>	<i>T</i>	2
<i>Pseuderanthemum variable</i>	<i>H</i>	2
<i>Pteridium esculentum</i>	<i>F</i>	1
<i>Rapanea varibilis</i>	<i>T</i>	2
<i>Rhodamnia rubescens</i>	<i>T</i>	1
* <i>Senna pendula</i>	<i>S</i>	2
<i>Smilax australis</i>	<i>V</i>	2
<i>Syncarpia glomulifera</i>	<i>T</i>	3
<i>Wikstroemia indica</i>	<i>S</i>	1

Quadrat 3 *Lindsaea incisa* (A Fern) – TSC Act Endangered

Location: Western side of the Pacific Highway, 30 metres from road edge near boundary of Orara East State Forest and clear private property (GDA 0514029 6659846).

Vegetation Type: Heathy dry sclerophyll/swamp sclerophyll ecotone.

Substrate: heavy grey clay

Slope Aspect: flat

Slope Angle: 2°

Disturbance history: No evidence of recent fire, probably unburnt for 10 years or more. No recent logging or other disturbance.

Quadrat Size: 20m x 20m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	15-22	60	<i>Eucalyptus resinifera</i>	<i>Eucalyptus planchoniana</i>	<i>Angophora leiocarpa</i>
Mid	2-6	40	<i>Leptospermum polygalifolium</i>	<i>Leucopogon pimelioides</i>	<i>Syncarpia glomulifera</i>
Lower	0-1	100	<i>Ptilothrix deusta</i>	<i>Dampiera stricta</i>	<i>Banksia spinulosa subsp. collina</i>

Species	Habit	Cover-abundance Class
<i>Acacia myrtifolia</i>	S	1
<i>Allocasuarina littoralis</i>	T	1
<i>Angophora costata</i>	T	3
<i>Banksia spinulosa subsp. collina</i>	S	3
<i>Billardiera scandens</i>	V	1
<i>Comesperma ericinum</i>	S	1
<i>Dampiera stricta</i>	H	3
<i>Dianella caerulea</i>	G	1
<i>Entolasia marginata</i>	G	3
<i>Entolasia stricta</i>	G	2
<i>Entolasia stricta</i>	G	2
<i>Eucalyptus planchoniana</i>	T	3
<i>Eucalyptus resinifera</i>	T	3
<i>Eucalyptus tindaliae</i>	T	1
<i>Goodenia heterophylla</i>	H	1
<i>Hibbertia aspera</i>	S	2
<i>Hibbertia vestita</i>	S	3
<i>Leptospermum juniperinum</i>	S	2
<i>Leptospermum polygalifolium</i>	S	3
<i>Leucopogon pimelioides</i>	S	2
<i>Lindsaea incisa</i>	F	2
<i>Lindsaea linearis</i>	F	1
<i>Melaleuca sieberi</i>	T	2
<i>Notelaea ovata</i>	S	1

<i>Patersonia glabrata</i>	<i>H</i>	2
<i>Persoonia stradbokensis</i>	<i>T</i>	1
<i>Ptilothrix deusta</i>	<i>H</i>	4
<i>Pultenaea retusa</i>	<i>S</i>	2
<i>Smilax glycyphylla</i>	<i>V</i>	1
<i>Syncarpia glomulifera</i>	<i>T</i>	3
<i>Themeda australis</i>	<i>G</i>	2
<i>Xanthorrhoea fulva</i>	<i>S</i>	2

Quadrat 4 *Quassia* sp. B (Narrow-leaved Quassia) – TSC Act Endangered

Location: North of Wakefield Road western side of highway, northern side of drainage line. (GDA 514026 6657385).

Vegetation Type: Grey Gum – Grey Ironbark grading into Flooded Gum along a drainage line.

Substrate: yellow podzol on metasediment

Slope Aspect: south-east

Slope Angle: 10°

Disturbance history: Burnt 5-10 years ago. Habitat logged in the past.

Quadrat Size: 20m x 20m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	20-28	70	<i>Eucalyptus propinqua</i>	<i>Eucalyptus siderophloia</i>	<i>Eucalyptus pilularis</i>
Mid	4-12	60	<i>Syncarpia glomulifera</i>	<i>Notelaea longifolia</i>	<i>Cryptocarya microneura</i>
Lower	0-1	60			

Species (* exotic species)	Habit	Cover-abundance Class
* <i>Lantana camara</i>	<i>S</i>	1
* <i>Passiflora edulis</i>	<i>V</i>	1
* <i>Senna pendula</i>	<i>S</i>	1
<i>Acmena smithii</i>	<i>T</i>	2
<i>Acronychia oblongifolia</i>	<i>T</i>	2
<i>Adiantum formosum</i>	<i>F</i>	1
<i>Angophora leiocarpa</i>	<i>T</i>	1
<i>Blechnum cartilagineum</i>	<i>F</i>	3
<i>Breynia oblongifolia</i>	<i>S</i>	2
<i>Calochlaena dubia</i>	<i>F</i>	1
<i>Clematis glycinoides</i>	<i>V</i>	1
<i>Cordyline stricta</i>	<i>S</i>	2
<i>Corymbia intermedia</i>	<i>T</i>	2
<i>Croton verreauxii</i>	<i>S</i>	2
<i>Cryptocarya microneura</i>	<i>T</i>	3
<i>Dioscorea transversa</i>	<i>V</i>	2
<i>Elaeocarpus obovatus</i>	<i>T</i>	1

<i>Endiandra discolor</i>	T	1
<i>Eucalyptus grandis</i>	T	2
<i>Eucalyptus pilularis</i>	T	3
<i>Eucalyptus propinqua</i>	T	4
<i>Eucalyptus siderophloia</i>	T	3
<i>Eucalyptus umbra</i>	T	2
<i>Eustrephus latifolius</i>	V	1
<i>Guioa semiglauca</i>	T	1
<i>Gymnostachys anceps</i>	H	2
<i>Lomandra longifolia</i>	G	1
<i>Lophostemon confertus</i>	T	2
<i>Maytenus silvestris</i>	S	1
<i>Morinda jasminoides</i>	V	2
<i>Notelaea longifolia</i>	T	3
<i>Ottochloa gracillima</i>	G	3
<i>Parsonsia straminea</i>	V	2
<i>Pseuderanthemum variable</i>	H	2
<i>Rapanea variabilis</i>	T	1
<i>Rhodamnia rubescens</i>	T	2
<i>Scolopia braunii</i>	S	2
<i>Smilax australis</i>	V	2
<i>Smilax glycyphylla</i>	V	1
<i>Stephania japonica</i>	V	1
<i>Syncarpia glomulifera</i>	T	3
<i>Tripladenia cunninghamii</i>	H	2
<i>Zieria smithii</i>	S	1

Quadrat 5 Endangered Ecological Community (TSC Act) – Swamp Sclerophyll Forest on Coastal Floodplains

Location: Western side of the Pacific Highway, 200m south of Double Crossing Creek, in road reserve (GDA 0518559 6665428).

Vegetation Type: Swamp sclerophyll forest regrowth

Substrate: Heavy grey clay, flooded.

Slope Aspect: nil

Slope Angle: nil

Disturbance history: cleared in the past

Quadrat Size: 20m x 20m.

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	6-10	70	<i>Melaleuca quinquenervia</i>	<i>Casuarina glauca</i>	
Mid	1-5	50	<i>Melaleuca sieberi</i>	<i>Melaleuca quinquenervia</i>	
Lower	0-1	90	<i>Baumea teretifolia</i>	<i>Baumea sp.</i>	<i>Schoenus brevifolius</i>

Species	Habit	Cover-abundance Class
<i>Melaleuca quinquenervia</i>	<i>T</i>	5
<i>Baumea teretifolia</i>	<i>H</i>	4
<i>Lophostemon suaveolens</i>	<i>T</i>	3
<i>Melaleuca sieberi</i>	<i>T</i>	3
<i>Schoenus brevifolius</i>	<i>H</i>	3
<i>Baumea sp.</i>	<i>H</i>	2
<i>Callistemon pachyphyllus</i>	<i>S</i>	2
<i>Casuarina glauca</i>	<i>T</i>	2
<i>Gonocarpus tetragynus</i>	<i>H</i>	2
<i>Ischaemum australe</i>	<i>G</i>	2
<i>Leptospermum juniperinum</i>	<i>S</i>	2
<i>Viola betonicifolia</i>	<i>H</i>	2
<i>Eucalyptus robusta</i>	<i>T</i>	1
<i>Fimbriostylis nutans</i>	<i>H</i>	1
<i>Melaleuca thymifolia</i>	<i>S</i>	1
<i>Philydrum lanuginosum</i>	<i>H</i>	1
<i>Pultenaea retusa</i>	<i>S</i>	1
<i>Themeda australis</i>	<i>G</i>	1

Quadrat 6 Endangered Ecological Community (TSC Act) – Lowland Rainforest on Floodplain

Location: Northwest corner of the old forestry station block of Wedding Bells State Forest on Woolgoolga Creek Rd (GDA 0516528 6668521).

Vegetation Type: Lowland subtropical rainforest on the floodplain of Woolgoolga Creek, tall closed forest.

Substrate: alluvium.

Slope Aspect: flat

Slope Angle: level

Disturbance history: been logged and grazed in the past.

Quadrat Size: 20m x 20m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	12-18	70	<i>Olea paniculata</i>	<i>Alphitonia excelsa</i>	<i>Ficus watkinsiana</i>
Mid	1-6	80	<i>Guioa semiglauca</i>	<i>Trophis scandens</i>	<i>Neolitsea dealbata</i>
Lower	0-1	40	<i>Morinda jasminoides</i>	<i>Doodia aspera</i>	<i>Adiantum formosum</i>

Species (* exotic species)	Growth Habit	Cover-abundance Class
<i>Acmena smithii</i>	T	2
<i>Acronychia oblongifolia</i>	T	1
<i>Adiantum formosum</i>	F	2
<i>Alectryon subcinereus</i>	T	2
<i>Alphitonia excelsa</i>	T	3
<i>Alpinea caerulea</i>	H	1
<i>Amorphospermum whitei</i>	T	2
<i>Aphananthe philipensis</i>	T	2
<i>Archontophoenix cunninghamiana</i>	P	1
<i>Blechnum cartilagineum</i>	F	2
<i>Brachychiton acerifolius</i>	T	1
<i>Cordyline stricta</i>	S	1
<i>Croton verrauxii</i>	S	2
<i>Cryptocarya obovata</i>	T	2
<i>Decaspermum humile</i>	T	2
<i>Diospyros australis</i>	S	1
<i>Diospyros pentamera</i>	T	1
<i>Diploglottis australis</i>	T	1
<i>Doodia aspera</i>	F	3
<i>Dysoxylum muelleri</i>	T	2
<i>Elaeocarpus obovatus</i>	T	1
<i>Euodia micrococca</i>	T	1
<i>Ficus coronata</i>	T	1
<i>Ficus watkinsiana</i>	T	3
<i>Glochidion ferdinandii</i>	T	2

<i>Guilfoylia monostylis</i>	T	1
<i>Guoia semiglauca</i>	T	2
<i>Hippocratea barbata</i>	V	2
<i>Litsea reticulata</i>	T	1
<i>Lomandra spicata</i>	H	2
<i>Morinda jasminoides</i>	V	3
<i>Neolitsea dealbata</i>	T	2
<i>Notelaea longifolia</i>	T	3
<i>Olea paniculata</i>	T	4
<i>Rhodamnania rubescens</i>	T	2
<i>Rhodomyrtus psidioides</i>	T	1
<i>Rubus moorei</i>	V	2
<i>Synoum glandulosum</i>	T	1
<i>Syzygium australe</i>	T	2
<i>Trophis scandens</i>	V	3
<i>Wilkea huegeliana</i>	S	1
* <i>Ochna serrulata</i>	S	2
* <i>Protoasparagus plumosus</i>	V	2

Quadrat 7 Endangered Ecological Community (TSC Act) – Lowland Rainforest on Floodplain

Location: Newmans Rd northwest of Woolgoolga township, small stream western side of road. (GDA 516188 6669966).

Vegetation Type: Lowland subtropical rainforest on narrow floodplain with recently deposited flood debris showing extent of inundation.

Substrate: alluvium.

Slope Aspect: flat

Slope Angle: level

Disturbance history: been logged and grazed in the past.

Quadrat Size: 20m x 20m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	18-30	70	<i>Heritiera actinophylla</i>	<i>Lophostemon confertus</i>	<i>Dysoxylum muelleri</i>
Mid 1	8-18	70	<i>Hodgkinsonia ovatifolia</i>	<i>Cissus antarctica</i>	<i>Baloghia inophylla</i>
Mid 2	1-8	50	<i>Calamus muelleri</i>	<i>Cleistanthus cunninghamii</i>	<i>Neolitsea dealbata</i>
Lower	0-1	60	<i>Arachnoides aristata</i>	<i>Doodia aspera</i>	<i>Lomandra spicata</i>

Species (* exotic species)	Growth Habit	Cover-abundance Class
<i>Actephila lindleyi</i>	S	2
<i>Adiantum formosum</i>	F	2
<i>Alangium villosum</i>	T	1

<i>Alchornea ilicifolia</i>	S	2
<i>Alphitonia excelsa</i>	T	2
<i>Arachnoides aristata</i>	F	3
<i>Archontophoenix cunninghamiana</i>	P	2
<i>Backhousia myrtifolia</i>	T	2
<i>Backhousia sciadophora</i>	T	2
<i>Baloghia inophylla</i>	T	2
<i>Calamus muelleri</i>	V	3
<i>Cissus antarctica</i>	V	3
<i>Claoxylon australe</i>	T	1
<i>Cleistanthus cunninghamii</i>	S	3
<i>Clerodendron tomentosum</i>	S	1
<i>Cordyline petiolaris</i>	S	2
<i>Cymbidium maddidum</i>	E	1
<i>Daphnandra</i> sp. A	S	1
<i>Derris involuta</i>	V	2
<i>Diospyros australis</i>	S	1
<i>Diospyros pentamera</i>	T	2
<i>Doodia aspera</i>	F	4
<i>Dysoxylum muelleri</i>	T	3
<i>Endiandra muelleri</i> subsp. <i>muelleri</i>	T	2
<i>Ficus coronata</i>	T	2
<i>Ficus watkinsiana</i>	T	3
<i>Gymnostachys anceps</i>	H	2
<i>Heritiera actinophylla</i>	T	3
<i>Hodgkinsonia ovatifolia</i>	T	3
<i>Ixora beckleri</i>	S	2
<i>Lastreopsis decomposita</i>	F	2
<i>Legnephora moorei</i>	V	2
<i>Lomandra spicata</i>	H	2
<i>Lophostemon confertus</i>	T	3
<i>Mallotus philippensis</i>	T	2
<i>Melia azedarach</i>	T	1
<i>Neolitsea dealbata</i>	T	2
<i>Olea paniculata</i>	T	3
* <i>Passiflora suberosa</i>	V	2
<i>Pellaea paradoxa</i>	F	1
<i>Pouteria australis</i>	T	1
<i>Psychotria loniceroides</i>	S	1
<i>Rauwenhoffia leichhardtiana</i>	V	3
<i>Sarcomelicope simplicifolia</i>	T	2
<i>Smilax australis</i>	V	2
<i>Syzygium francisii</i>	T	2
<i>Tabernaemontana pandaqui</i>	S	1
<i>Tetrastigma nitens</i>	V	2
<i>Trophis scandens</i>	V	2
<i>Wilkea huegeliana</i>	S	2

APPENDIX 4: Species lists from 14 flora traverses recorded during the vegetation survey of the Sapphire Beach to Woolgoolga Highway Corridor. Species abundances are given as r – rare; o – occasional; c – common and vc – very common. ‘O’ opportunistic

Botanical Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	O
Acacia aulacocarpa	A wattle															x
*Acacia baileyana	Cootamundra wattle												r			
Acacia binervata	Two-veined wattle								o		o					
Acacia concurrens	Curracabah	o														
Acacia falcata		r	r												o	
Acacia fimbriata	Qld golden wattle	o	r				o									
Acacia floribunda			r			o										
Acacia irrorata	Black wattle					r			o	o						
Acacia longifolia		r														
Acacia longissima	Narrow-leaved wattle				r	r										
Acacia melanoxylon	Sally wattle	o		c	c	o		o	o		o	o				
Acacia myrtifolia		r	r			o							r		r	
Acacia o'shanesii		o					o									
Acacia sophorae	Coast wattle												r	r		
Acalypha nemorum			r													
Acmella grandiflora						r										
Acmena hemilampra	Lilly pilly		r													
Acmena smithii	Common lilly pilly	r			r		o				o					
Acronychia imperforata	Beach acronychia			r												
Acronychia oblongifolia	Common actronychia			r	o			r			o	o				
Actephila lindleyi	Actephila								r							
Adiantum aethiopicum	Maidenhair fern	r					o		o			r				
Adiantum formosum	Black-stem maidenhair fern			r						o	o	r				
Adiantum hispidulum			r				r				o					
*Ageratina adenophorum	Crofton weed		r		r										o	
*Ageratum houstonianum	Blue goat weed	o				o							c			

Agrostis avenacea						r											
Alangium villosum	Alangium								r								
Alchornea ilicifolia	Native holly								o								
Alectryon subcinereus										o	r						
Alocasia brisbanensis	Cunjevoi lily										r						
Allocasuarina littoralis	Black sheoak						o							o	o		
Allocasuarina torulosa	Black sheoak	o	r		o	o		o	o	o							
Alphitonia excelsa	Red ash	r	r		o			r	o		r	r					
Alpinia caerulea	Native ginger							r	o	o	o	r					
Amorphospermum whitei	Rusty plum		r								r						
Amyema cambagei	Casuarina mistletoe																x
Amyema pendula		r															
*Andropogon virginicus	Whiskey grass					r								r			
Aneilema acuminatum								r				r					
Angophora leiocarpa	Smooth-barked apple				r	o								o			
*Anredera cordifolia	Anredera		r														
Aphananthe philipensis												r					
Aphanopetalum resinosum		r										o					
Arachnoides aristata										o							
*Araujia hortorum	Moth vine		r														
Archidendron grandiflorum									r		o	o					
Archirhodomyrtus beckleri								r			o						
Archontophoenix cunninghamii	Bangalow palm				r			r	r	r	r	r					
Aristida benthamii	A grass																x
Aristida ramosa subsp. speciosa						r											
Aristida vagans	A grass	o				o	o									o	
Arytera divaricata	Coogera								r								
Asterotricha latifolia																	r
Austrostephania aculeata		r							r		r		r				
Ambrosia artemisiifolia	Annual ragweed	o			o												
Araucaria cunninghamii	Hoop pine		o														

Artanema fimbriatum	Koala bells					r											
Arthrochilus prolixus	Hammer orchid																x
Arytera divaricata			r					r									
Asclepias curassavica*	A herb	o															
*Aster subulatus																	r
Austrodanthonia tenuior	A wallaby grass																r
Austrosteenisia blacki	Bloodvine		r														
Astrotricha latifolia			r														
*Axonopus compressus	Carpet grass	r															
Babingtonia angusta					o												
*Baccharis halimifolia	Groundsel bush		r	r	r						r		r	o			
Backhousia myrtifolia	Grey myrtle	o					o	o	o	r							
Backhousia sciadophora	Shatterwood								r								
Bacopa monnieri													r				
Baloghia inophylla	Brush bloodwood		r						o								
Banksia integrifolia	Coast banksia		c														r
Banksia oblongifolia	Heath banksia	r					r							o			
Banksia spinulosa var. collina	Hairpin banksia				r	r	r							r			
Baumea articulata																	r
Baumea juncea		r				o								c			
Baumea rubiginosa	A sedge					r											o
Baumea teretifolia														vc			
Beilschmedia elliptica										r							
*Bidens pilosa	Farmers friends												o				
Billardiera scandens		o		o			o										r
Blandfordia grandiflora	Christmas bells					r											
Blechnum cartilagineum	Gristle fern		o	o			o	c	r	o	c						
Blechnum indicum	Bungwal fern												c				
Boronia parviflora	Small boronia																o
Bothriochloa macra	Red-leg grass		r	r													
Botrychium australe	Parsley fern					r											r

Brachychiton acerifolium												r				
Breynia oblongifolia	Coffee bush	o	o		o	r	o	o	o		o	o			o	
Brunoniella australis	A herb												r			
*Caesalpinia decapitala	Thorny poinciana							r			o					
Caldcluvia paniculosa	Caldcluvia										r	r				
Callistemon pachyphyllus	Wallum bottlebrush												o			
Callistemon salignus	Willow bottlebrush	o			c	o	o								o	
Callitris macleyanus (p)	Brush cypress pine							r								
Calamus muelleri	Southern lawyer vine		r						o	o						
Calochlaena dubia	Soft ground fern	r							o	o	o			r	o	
Calystegia marginata	A herb	o			r		o								c	
Capillipedium spicegerum	Scented-top grass	o	o	o		r				r			o	o		
Carex appressa					r											
Carex breviculmis									o							
Carex maculata	A sedge				r		o							o		
Cassine australe			r								r					
Casuarina glauca	Swamp oak												c	c		
Cayratia clematidea	A vine							r								
Centaurium spicatum						r										
Centella asiatica	Arthritis plant	c												o		
*Chamaecrista mimosoides	Sensitive plant	r														
Chamaecysce drummondii	Caustic weed				o											
Cheilanthes sieberi	A fern													r		
Chiloglottis sp.	An orchid											r				
*Chloris gayana		o	c	o	c										o	
Choricarpia leptopetala	Brown myrtle						r	r		o	r					
Chorizandra cymbaria														o		
Chorizema parviflora	A pea															x
Christella dentata			r							o						
*Chrysanthemoides monilifera		r					r					r	c	c		
Chrysocephalum apiculatum	Yellow buttons															x

*Cinnamomum camphora	Camphor laurel	r	o	o				r	r					r	r	
Cissus antarctica	Water vine		o	r				o	o	c	c	o			r	
Cissus hypoglauca	Five-leaf water vine		o					r	o			o				
Cissus sterculifolia				r					r							
Citriobatus pauciflorus										r						
*Citrus limonia	Lemon tree							r				r				
Claoxylon australe									r							
Cleistanthus cunninghamii	Cleistanthus		r						o							
Clematis glycinoides	Clematis								r	o						
Clerodendron floribundum	Smooth clerodendron								r							
Clerodendron tomentosum	Hairy clerodendron							r	r	r						
*Commelina benghalensis	A herb			o				r								
Comesperma defoliatum						r										
Comesperma ericinum	Matchheads					r										
*Conyza bonnariensis	Fleabane					r										
Cordyline petiolaris	Long-leaf palm lily		r						o		o					
Cordyline stricta	Narrow-leaved palm lily	r	r	o	r		o	o	o	o	o	o				
Corymbia gummifera	Red bloodwood						o									
Corymbia intermedia	Pink bloodwood	o	r	o	o		o		c			o		o	o	
Corymbia variegata	Spotted gum						o		c		c	o				
*Corymbia torrelliana	Cadaghi														r	
*Cotoneaster lactea			r													
*Crassocephalum crepidoides	Thickheads			o												
*Crotalaria lanceolata	A pea	r	o	c		o										
Crotalaria montana	A pea	r				r										
Croton verreauxii					r		r	o		c	o	o				
Cryptocarya microneura	Murrogun			o			o	o	o	r	o	o				
Cryptocarya obovata	Pigeonberry tree								r		o	r				
Cryptocarya rigida	Forest maple		r	o			r	o		o		o				
Cryptocarya triplinervis	Three-veined laurel		o	r										r		
Cryptostylis sp.	An orchid				r		r									

Cupaniopsis anacardioides	Tuckeroo			o	o	r			r	r							
Cupaniopsis newmanii	Long-leaf tuckeroo								r				r				
Cyclophyllum coprosmoides	Coast canthium			r					o				o			r	
Cymbidium maddidum										r							
Cymbopogon refractus	Barb wire grass	r		r	r	o	o		o	r				o	o		
Cyathea australis	Rough treefern								r					r			
Cyathea cooperi	Straw treefern		r	r													
Cyathea leichhardtiana	Prickly treefern		r														
Cynodon dactylon	Couch grass																x
Cyperus difformis	A sedge																x
Cyperus enervis										r							
Cyperus eragrostis				r													
Cyperus haspan subsp.juncoides	A sedge																x
Cyperus pilosus	A sedge			r		r											
Dampiera stricta	A dampiera	r			r	o	o							o			
Daphnandra sp. A										r			r				
Davidsonia puriens (p)										r							
Davesia ulicifolia	A pea	r							o								
Davesia umbellata															r		
Decaspermum humile	Silky myrtle												r				
Denhamia celastroides				r					r		r						
Derris involuta	Derris vine									o							
Desmodium rhytidophyllum	Rusty desmodium	c	r	o		o	o	r	o	o	o						
*Desmodium uncinatum	Silver-leaf desmodium		o														
Desmodium gunnii				r	r		o		o		o						
Dianella caerulea	Blue flax lily	o		o					o		o	o	o				
Dianella revoluta		o															
Dichantheum sericeum	Queensland bluegrass		r	r													
Dichelachne rara	Narrow plume grass															r	
Dichondra repens	Kidney leaf				r		r		o								
Digitaria parviflora										r							

<i>Digitaria ramularis</i>	A grass	r		o				o							r		
<i>Digitaria scrobiculatum</i>		o															
<i>Dioscorea transversa</i>				o				o			o	o					
<i>Diospyros australis</i>									r		r	r					
<i>Diospyros pentamera</i>	Grey ebony		r					r	r		r						
<i>Diploglottis australis</i>								r			r						
<i>Dodonaea triquetra</i>	A hop bush	r		r	r	o	c			r	o						
<i>Doodia aspera</i>	Rasp fern		r	o			o	c	c	o	o	o					
<i>Drypetes australascica</i>	Yellow tulip		r														
<i>Duboisia myoporoides</i>	Soft corkwood				r										r		
<i>Dysoxylum muelleri</i>	Red bean		o							o	o	o					
* <i>Echinochloa crus-galli</i>	Barnyard grass			r													
<i>Echinopogon caespitosus</i>		o		o													o
<i>Eclipta prostrata</i>	White eclipta																
<i>Elaeocarpus obovatus</i>	Hard quandong			r				r			o	r					
<i>Elaeocarpus reticulatus</i>	Blue berry ash				r	r						o					o
<i>Eleocharis acuta</i>	A sedge					r											
<i>Embelia australiana</i>	Embelia									o	o	o	r				
<i>Endiandra discolor</i>	Domatia tree			r				r			r						
<i>Endiandra muelleri</i> ssp <i>muelleri</i>	Domatia tree									o		o					
<i>Endiandra sieberi</i>	Hard corkwood																
<i>Entolasia marginata</i>	A grass	c															c
<i>Entolasia stricta</i>	A grass	o		r	c	c	vc	o			o	c	c	o			
<i>Epacris pulchella</i>		r				r											
<i>Eragrostis benthamii</i>		r															
<i>Eragrostis brownii</i>	A grass	o				o											c
<i>Eragrostis sororia</i>	A grass	o															o
* <i>Eriobotrya japonica</i>	Loquat									r							
* <i>Erythrina crista-galli</i>	Coral tree									r		o					
<i>Eucalyptus acmenoides</i>										c	c			o			
<i>Eucalyptus carnea</i>								o									r

<i>Eucalyptus eugenoides</i>	White stringybark					r												
<i>Eucalyptus grandis</i>	Flooded gum	r		o				o			c	c						
<i>Eucalyptus microcorys</i>	Tallowwood	r		o	o		o	c	o	c	o	o						
<i>Eucalyptus pilularis</i>	Coastal blackbutt	c	o	c	c	vc	vc					r	o			c		
<i>Eucalyptus planchoniana</i>	Needlebark stringybark					r												
<i>Eucalyptus propinqua</i>	Grey gum			o			o	c	c	c	c	c						
<i>Eucalyptus resinifera</i>	Red mahogany	o					o										r	
<i>Eucalyptus robusta</i>	Swamp mahogany												o				o	
<i>Eucalyptus siderophloia</i>	Broad-leaved ironbark	r	r	o		o	o	r	o	o	o			r		o		
<i>Eucalyptus tereticornis</i>	Forest red gum	o	r	o											o			
<i>Euphomatia bennettiana</i>												r						
<i>Euphomatia laurina</i>		r		r			o		o	c	o	o						
<i>Euroschinus falcata</i>										r							r	
<i>Eustrephus latifolius</i>	A vine		r				o	o										
<i>Exocarpus cupressiformis</i>	Cherry ballart	r																
<i>Ficus coronata</i>	Sandpaper fig	r			r		o	o	o	o	c	o						
<i>Ficus fraseri</i>	Sandpaper fig		r															
<i>Ficus platypoda</i>	Rusty fig/rock fig			r														
<i>Ficus watkinsiana</i>	Strangler fig		r						r		r							
<i>Fimbristylis nutans</i>	A sedge												o					
<i>Flagellaria indica</i>	Whip vine		r															
<i>Flindersia schottiana</i>	Cudgerie tree		r		r							r						
<i>Gahnia aspera</i>		r					r	r			o	o		o				
<i>Gahnia clarkei</i>					o	r	r											
<i>Gahnia sieberana</i>	Red-fruit saw sedge				r		o						r					
<i>Geitonoplesium cymosum</i>	A vine	o		o	o			o	o	o							o	
<i>Gleichenia dicarpa</i>	Coral fern																	o
<i>Glochidion ferdinandi</i>	Cheese tree	o		c	o	o	c	o			o	o	r				r	
<i>Glycine clandestina</i>	A pea	o	o			o				c								
<i>Gompholobium pinnatum</i>	A pea					r												
<i>Gomphocarpus fruticosus</i>	Cotton bush			o														

Gonocarpus humilis		o															
Gonocarpus tetragynus							o					c					
Goodenia paniculata	A goodenia	r				r	r										
Goodenia rotundifolia	A goodenia	c				c	c					o	o				
Grevillea robusta (p)	Silky oak															r	
Guilfoylia monostylis									r		r						
Guioa semiglauca		r	o	o	o		r	c	r	o	c	o				o	
Gymnostachys anceps	Settlers flax			r				r	o		o	o					
Haemodorum planifolium	Bloodroot lily																x
Hakea florulenta	A hakea	o					r						r				
Hardenbergia violacea		r		r								r					
Harpullia pendula (p)	Tulipwood							r									
Heritiera actinophylla	Black booyong								o								
Hibbertia aspera		c	r	o	o	c	c		r		o		c				
Hibbertia dentata				r							r						
Hibbertia scandens	Trailing guinea flower	r				r					r			r			
Hibbertia vestita	An hibbertia	c				c	c						c	o	o		
Hibiscus diversifolius														r			
Hibiscus heterophyllus		r					r				r						
Hickesbeachia pinnatifolia	Red bopple nut							r									
Hippocratea barbata											r						
Hodgkinsoniae ovatifolia			r						o								
Hovea acutifolia			r		r	r											
Hybanthus enneaspermus	A herb	o															
Hydrocotyle peduncularis		r											o				
Hymenosporum flavum	Native frangipanni									r							
*Hypoestes sanguinolenta	Polka dot plant							r									
Hypolepis muelleri	Harsh ground fern												c		r		
Hypoxis hygrometrica		o													r		
Imperata cylindrica	Blady grass	vc	c	c	c	c	c		c		c			o	c		
*Ipomoea cairica	Five-leaf morning glory			r	o												

*Ipomoea purpurea	Common morning glory	r				r											
Isachne globosa	Swamp millet					o											o
Ischaemum austale	A grass	r											c				
Ixora beckleri	Ixora								o								
*Jacaranda mimosifolia	Jacaranda								r								
Jacksonia scoparia	Native broom	r	o	o		o	r						r	r			
Jagera pseudorhus	Foambark tree		r	r				r	r		o	r					
Juncus prismatocarpus	A rush																o
*Lantana camara	Lantana	o			c	o	c	c	c	c	c	c		o	c		
Lastreopsis decomposita	Trim shield fern								o		o						
Legnephora moorei	Round-leave vine			r					r								
Lepidosperma laterale	Common sword sedge					r	c			r				o			
Lepidosperma quadrangulata	Rectangular sedge													r			
Leptospermum juniperinum	Prickly teatree																x
Leptospermum polygalifolium subsp. polygalifolium	Common teatree	o				r	c										
Leucopogon juniperinus							r							c			
Leucopogon lanceolatus							o										
Leucopogon pimelioides		r			r	o							r	r			
*Lilium formosanum		r	r		o								r		r		
Lindsaea linearis	A fern						o						r				
Linospadix monostachys	Walking stick palm								r								
Litsea australis	Brown bolly gum			r													
Litsea reticulata	Bolly gum									r							
Livistonia australis							r										
Lobelia alata		r												r			
Lobelia armstrongii	A herb					r										o	
Lobelia dentata						r											
Lobelia trigonocaulis																	x
Lomandra laxa											o						
Lomandra longifolia	Long-leaf lomandra	c		o	o	o	c	c	c	c	o	c	c	c	c		

Lomandra multiflora	A lomandra																
Lomandra spicata		r					o		o		o						
Lomatia silaifolia	Crinklebush												r				
Lonicera japonica	Japanese honeysuckle				r												
Lophostemon confertus	Brush box		r	o	o		o	o	o	r	o						
Lophostemon suaveolens	Swamp box	c				c	o						c	c			
Macadamia integrifolia (p)	Smooth-shelled bush nut												r				
Macadamia tetraphylla (p)	Rough-shelled bush nut							r	r								
Macadamia tetraphylla (s)	Rough-shelled bush nut								r								
Macaranga tanarius	Macaranga												r				
Maclura cochinchinensis	Cockspur		r	r				o			o	o					
*Macroptilium atropurpureum	Siratro	o	o		c												
Mallotus discolor										r	r						
Mallotus philipinensis	Red kamala							r	o		o						
Marsdenia flavescens											o						
Marsdenia longiloba				r													
Marsdenia rostrata	Common milk vine		o	r	o			o			o	o		r			
Maytenus bilocularis				r													
Maytenus silvestris				r			o		r		r						
Melaleuca nodosa		r															
Melaleuca quinquenervia	Broad-leaved paperbark	o			r	o	o						vc	vc			
Melaleuca sieberi	A paperbark	o				r	o						c				
Melaleuca stypheloides																r	
Melaleuca thymifolia													r			r	
Melia azedarach	White cedar							r	r								
Melicope elleryana	Pink euodia														r		
Melicope micrococca											r						
*Melinus minutiflora	Molassus grass		o	o													
*Melinus repens			r														
Melodinus australis			o									r					
Microlaena stipoides	A grass	r				r								r			

* <i>Modiola caroliniana</i>	Red-flowered mallow		r		o												
<i>Morinda jasminoides</i>		r	r	c	o		c	c	o	c	c	c					o
<i>Murdania gramineum</i>	A herb	r															r
<i>Neolitsea dealbata</i>	White bolly gum		r					r	o	o	o						
<i>Nephrolepis cordifolia</i>	Fishbone fern				o												
* <i>Nerium oleander</i>						r											
<i>Notelaea longifolia</i>	Mock olive	o	r	o	o		o	c	o	o	c	o		r			
<i>Notelaea ovata</i>	Mock olive						o	r						o			
* <i>Nymphaea capensis</i>	Introduced waterlily						r										r
* <i>Ochna serrulata</i>	Ochna		r		r			r					r				
<i>Olea paniculata</i>	Native olive		o	o				o	o		c	r					
<i>Oplismenus aemulus</i>	A grass	o		c													o
<i>Oplismenus imbecilis</i>									o								
<i>Ottochloa gracillima</i>	A grass	c		o	o		o	o	c			c		c			
<i>Oxalis chnoodes</i>	A herb																
<i>Ozothamnus diosmifolium</i>							o	r				o					
<i>Pandorea pandorana</i>							r		r	r			r				
<i>Panicum simile</i>	A grass			r			o										
<i>Parsonsia straminea</i>	Giant silkpod vine	o		o				o	r	o	o	o					
<i>Paspalidium distans</i>	A grass				r												
<i>Paspalum scrobiculatum</i>	A grass					r			r								
* <i>Paspalum urvillei</i>	Vasy grass	o			o												
* <i>Paspalum wettsteinii</i>					c	o		o	o	c	c	c	vc				c
* <i>Passiflora edulis</i>				r				r									
* <i>Passiflora suberosa</i>	Corky passionfruit							r	o			o					
* <i>Passiflora subpeltata</i>	White passionfruit			o				r	o			r					
<i>Patersonia glabrata</i>	A native iris	r					o										
<i>Patersonia sericea</i>	A native iris												o				r
<i>Pellaea paradoxa</i>	Sickle fern								r								
<i>Persicaria dichotoma</i>	A herb												r				
<i>Persicaria strigosa</i>	A herb			r													

<i>Pteridium esculentum</i>	Bracken fern	c	o	c	c	c	vc	o			o					
<i>Pterostylis nutans</i>													r			
<i>Ptilothrix deusta</i>	A sedge	r					c					c		r		
<i>Pultenaea petiolaris</i>	A bushpea															
<i>Pultenaea retusa</i>	A bushpea	o	r	o		r	r		r			c	o			
<i>Pultenaea villosa</i>	A bushpea				r		r					o				
<i>Pyrrosia rupestris</i>				r												
<i>Rapanea howittiana</i>	Brush muttonwood	r					r				r		r			
<i>Rapanea variabilis</i>	Muttonwood	r	r		r			r	r	r						
<i>Rauwenhoffia leichhardtiana</i>			o						o							
<i>Rhodamnia rubescens</i>				r				o		o	o					
<i>Rhodomyrtus psidioides</i>	Native guava	r									r	r		r	r	
* <i>Richardia brasiliensis</i>						r										
<i>Ripogonum album</i>	White supplejack		r													
<i>Ripogonum ellseyanum</i>										r						
<i>Rostellularia adscendens</i>	A herb										o					
* <i>Rubus fruticosus</i>	Blackberry					r										
<i>Rubus hillii</i>	A bramble				r							r				
<i>Rubus moorei</i>										r	o					
<i>Rubus parviflorus</i>	Small-leaf bramble		o												r	
<i>Rubus rosifolius</i>							r									
<i>Sacciolepis indica</i>	Indian cup grass			r												
* <i>Sansevieria trifasciata</i>	Mother-in-law's tongue			r												
<i>Sarcomelicope simplicifolia</i>	Bauerella								r							
<i>Sarcopetalum harveyanum</i>								r			r					
* <i>Schefflera actinophylla</i>	Umbrella tree		o	o				r	o			r				
* <i>Schinus terebinthifolia</i>			o													
<i>Schizomeria ovata</i>										o	r					
<i>Scolopia braunii</i>	Flintwood		r							r			r			
<i>Schoenus apogon</i>	A sedge														o	
<i>Schoenus brevifolius</i>	A sedge											c				

*Senna X floribunda	A cassia	r					r										
*Senna pendula	Winter senna		o	o	o			o	r					o	o		
*Setaria palmifolia															r		
*Setaria sphacelata	Pigeon grass	r		r													
*Sida rhombifolia	Paddy's lucerne		o	o	o		r										
Sloanea woollsii										r	r						
Smilax australis	Barb-wire vine	o	o	o	o		o	c	c	o				r	o		
Smilax glycyphylla				r	o			r	r			o	r				
Solanum densivestitum				r	r												
*Solanum mauritianum	Tobacco weed					r											
Sorghum leiocladum	Native sorghum		r														
*Sporobolus indicus	Parramatta grass	r	o	o					c				o		o		
Sporobolus virginicus	Saltwater couch												r				
Stackhousia viminea						r											
Stephania japonica	Snake vine			o	o	r		o	o	o				o			
Sticherus lobatus	Fan fern		r														
*Strelitzia reginae	Bird of paradise flower																r
*Syagrus romanzoffiana	Queen palm								r								
Syncarpia glomulifera	Turpentine	o		o	c	c	vc		o	c	o	o				r	
Synoum glandulosum				o	r			c	o	c	o	o				r	
Syzygium australe	Brush cherry						o					o					
Syzygium francisii	Giant water gum								r								
Syzygium oleosum	Blue lily pilly		r										r				
Tabernaemontana pandacaqui	Banana bush			r			r	r	o	o	o	o					
*Tagetes minuta															o		
Tetrastigma nitens				r						o							
Themeda australis	Kangaroo grass	vc	o		o	c	c		c	o	o		c	c			
Tragia novae-hollandiae										o							
Trema aspera	Poison peach				r												
*Tephrosia grandiflora																	x
Tricoryne elatior	A herb					r											

Triglochin procerum s. lat.	Waterribbons						r								r	
Tripladenia cunninghamii				o					c							
Tristaniopsis laurina							r								r	
Trochocarpa laurina				r			o	o	o	c		o				
Trophis scandens	Burny vine							r				o				
Toona ciliata												r				
Tylophora paniculata									o			o				
Typha orientalis	Bullrush					r								r		
Typhonium sp.	Stinky lily								r							
Velleia paradoxa	A herb	r												o		
Vernonia cinerea	A herb	o						o								
Villarsia exaltata						r										
Viola betonicifolia		r					r							o		
Viola hederacea	Native violet	o												o		
Wikstroemia indica	A shrub			r												
Wilkea huegliana	Veiny wilkea		o	o					c	o	o	c	o			r
Xanthorrhoea latifolia							o									
Xanthorrhoea macronema	Bottlebrush grass tree				o		r									r
Zieria smithii	Sandfly bush				o		r			o		o	r			
*Zingiber officinale	Ginger							r								

7od Working Paper

Targeted Frog Survey

PROPOSED PACIFIC HIGHWAY UPGRADE BETWEEN SAPPHIRE AND ARRAWARRA: TARGETED FROG SURVEY

PREPARED BY:

LEWIS ECOLOGICAL SURVEYS

FOR:

CONNELL WAGNER



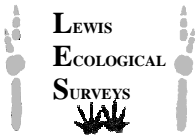
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This ecological report has been prepared for *Connell Wagner Pty Ltd (CW)*: Principal Representative (Lachlan Sweeney). This report relies upon data, surveys, measurements and results based on a short-term objective study in response to a brief provided by the client (CW). Although conclusions have been based on the available data at the time, some professional judgement has been applied in reaching the conclusions. Every attempt has been made to ensure the accuracy and objectivity of the reports findings, conclusions and recommendations. *Lewis Ecological Surveys* does not accept responsibility for its use by other parties.



.....
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Top – Lake Russell (Site 12) adjacent to the existing alignment provides potential habitat for the Green and Golden Bell Frog (*Litoria aurea*)

Bottom – Little Arrawarra Gully (Site 26) in Wedding Bells State Forest provide suitable habitat for Green-thighed Frog (*Litoria brevipalmata*)

Inset – Green-thighed Frog recorded at Skinners Creek (site 11) 1 km west of the proposed alignment.

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EXECUTIVE SUMMARY

The NSW *Roads and Traffic Authority* (RTA) have identified a preferred upgrade route of the Pacific Highway between Sapphire and Arrawarra in northeastern New South Wales. In order to adequately assess the ecological impacts of the proposal a specialist frog survey was conducted between the 7th and 28th January 2006 which followed several pronounced rainfall events (>50 mm in 24 hrs) triggering an optimal survey period for target species including the Green-thighed Frog (*Litoria brevipalmata*), Giant Barred Frog (*Mixophyes iteratus*), Wallum Froglet (*Crinia tinnula*) and Green and Golden Bell Frog (*Litoria aurea*). Field surveys used a multidisciplinary approach of active search and call imitation/broadcast for set time periods of four main aquatic habitats: streams, dams/lagoons, wetlands and ephemeral habitats.

Twenty species of frog were recorded during the survey and comprise nine Myobatrachid (ground dwelling) and 11 Hylid (Tree Frogs) species. Two of these species are considered ‘conservation significant’ with the Green-thighed Frog (*Litoria brevipalmata*) currently listed as ‘vulnerable’ under the New South Wales *Threatened Species Conservation Act* 1995 and the undescribed Whirring Tree Frog (*Litoria revelata* sp) awaiting formal identification. The Green-thighed Frog was recorded at Skinners Creek located ~ 1km west of the proposed footprint (~chainage 14100¹) in Orara East State Forest and represents the first record of this species in the study area. The undescribed Whirring Tree Frog was recorded in the southern study area 500m east of the proposed alignment (~ chainage 10900) and has been previously recorded from paperbark wetlands further to the south east.

Although no conservation significant frog fauna were recorded in close proximity to the proposed footprint several locations provide suitable habitat. They include:

- Green-thighed Frog habitat on the eastern side of the proposed footprint at ~chainage 10900 (south of Moonee township), Yellow Waterholes (~chainage 14000) and in Wedding Bells State Forest between ~chainages 30000-32000;
- Giant Barred Frog habitat at ~chainages 25350 (Woolgoolga Creek), 26800 (Poundyard Creek), 30350 (Arrawarra Gully) and 31050 (Arrawarra Creek);
- Green and Golden Bell Frog at ~chainage 16600 (Lake Russell);
- Wallum Froglet east of the proposed alignment at ~chainage 19000 (Emerald Beach Heathland) and on the western side of the alignment at ~chainage 32000.

Among the recommendations outlined in this report are the need to install frog friendly mitigation devices (culverts and bridges) where the footprint crosses prominent drainage lines (i.e. Woolgoolga Creek) and a need to maintain existing hydrological regimes in order to avoid altering local frog diversity and abundance, particularly in areas which provide potential Green-thighed Frog and Wallum Froglet habitat because of their specialised habitat/breeding requirements. Other recommendations include the exclusion of site office complexes, staging areas and batching plants from areas identified as providing known or potential habitat for conservation significant frog fauna.

¹ Chainage values supplied 7.8.2007. Footnote previously read “Due to difficulties in obtaining mapping files the chainage markers are derived approximates”.

1.0 INTRODUCTION

1.1 OVERVIEW AND BACKGROUND

The NSW *Roads and Traffic Authority* (RTA) has identified a preferred upgrade route of the Pacific Highway between Sapphire and Arrawarra in northeastern New South Wales (Figure 1). The route follows the existing carriageway from Sapphire northward to the southern outskirts of Woolgoolga (Double Crossing Creek) before deviating west through a mosaic of forested, agricultural and rural residential land and rejoining the existing alignment at Arrawarra Creek. In order to adequately assess the ecological impacts of the proposal *Connell Wagner* (principal contractor) have commissioned *Lewis Ecological Surveys* to conduct a specialist frog survey. The primary objectives of the frog survey were to:

- Identify potential target species of conservation significance within the study area;
- Implement a series of standardised surveys to identify and quantify the status of these target species; and
- Provide recommendations to mitigate against impacts arising from the proposal.

2.0 STUDY AREA

2.1 STUDY AREA AND EXISTING LANDSCAPE

The study area incorporates all lands within 1 km of the proposed alignment (Figure 1). The topography is generally flat coastal lands (<10m asl) rising to undulating and steep hills (<150m asl). Major drainage lines include Sugar Mill, Cunninghams, Skinners, Moonee, Double Crossing, Woolgoolga and Arrawarra Creeks with several large artificial (i.e. Lake Russell) and natural (Hearn's Lake) lake/wetland systems. Cunninghams and Double Crossing Creeks are both intertidal in the immediate vicinity of the proposed footprint and do not provide suitable frog habitat whilst Moonee Creek is in a highly degraded state in the vicinity of the proposed alignment and does not represent suitable habitat for target species.

Substantial tracts of vegetation have been modified in pursuit of pastoral (cattle) and horticultural (banana) development, and more recently a mosaic of rural and residential development providing satellite townships north of Coffs Harbour (i.e. Moonee, Safety Beach). Despite this, the study area comprises several large tracts of vegetation including Orara East and Wedding Bells State Forests, Moonee Beach and Arrawarra Nature Reserves and Coffs Coast Regional Parks. Collectively they support a diverse range of vegetation types from estuarine habitats (i.e. saltmarsh and mangroves), freshwater lakes, coastal heathlands, paperbark wetlands, swamp sclerophyll, dry sclerophyll, wet sclerophyll and sub tropical forests.

3.0 METHODS

Field surveys were conducted between the 7th and 28th January 2006 which followed several pronounced rainfall events (>50 mm in 24 hrs) resulting in excess of 200 mm falling in the study area over a few days (BOM 2006). This triggered an optimal survey period for target species including the Green-thighed Frog (*Litoria brevipalmata*), Giant Barred Frog (*Mixophyes iteratus*), undescribed Whirring Tree Frog (*Litoria revelata sp.*), Wallum Froglet (*Crinia tinnula*), Wallum Sedge Frog (*Litoria olongburensis*) and Green and Golden Bell Frog (*Litoria aurea*). Although species such as the Marsupial Frog (*Assa darlingtoni*), Mountain Frog (*Philoria sphagnicollis*) Southern Barred Frog (*Mixophyes balbus*) and New England Tree Frog (*Litoria subglandulosa*) occur in the Coffs Harbour region they were not considered in this current assessment as they are upland species generally associated with the Dorrigo Plateau in the Coffs Harbour region (Lemckert and Morse 1999; Lemckert 1999; DEC 2006; pers. obs).

3.1 SITE SELECTION

Sites were initially selected remotely from 1:25000 topographic maps with the primary objective being to select a broad range of sites covering the four main aquatic habitats: streams, dams/lagoons, wetlands and ephemeral depressions and watercourses that were likely to provide habitat for the target species. Field recognisance was then used at the commencement of the field survey to refine the site selection process. Subsequently, some sites were omitted due to poor habitat condition (transformed into residential estate or cleared land) and/or logistic constraints (i.e. access denied) in preference to neighbouring sites with improved habitat quality and access.

3.2 FIELD METHODS

3.2.1 Habitat Assessment

Habitat attributes thought to influence frog distribution and a broad habitat description were recorded at each site. They included an assessment on aquatic attributes, vegetation, disturbance and substrate type. General information was also collected and included location (AMG's), land tenure and site topography (upper slope, stream, wetland).

i. Aquatic Attributes

Information collected for aquatic attributes included the type of water body present, its dimensions, substrate and whether the water was flowing or still, and a measure of its visibility/turbidity. At stream sites the stream flow type was recorded as pools, pool/riffles or riffles along with the average stream width.

ii. Vegetation

Information collected on vegetation attributes included a broad description of the surrounding and adjacent (100m) vegetation type. The dominant species in each stratum present (i.e. overstorey, midstorey, understorey, shrub layer, ground cover) was also recorded. At stream sites the width of the perceived riparian zone was also recorded as an average of both sides.



Figure 1. Location of survey sites and broad aquatic habitat type.



Figure 2. Significant frog locations and areas of potential habitat.

iii. Disturbance

Information was collected on the level of disturbance at each site. A subjective scaling system was used to assign each site a relative rating from nil for no obvious signs of anthropogenic events (i.e. under scrubbing, clearing, logging, grazing, refuse, roads, weed infestation, fragmentation, erosion) to severe where multiple (>3) types of disturbance were evident. A site assigned a low rating generally had evidence of at least one anthropogenic practise whilst a moderate rating was assigned to a site if there was evidence of at least two anthropogenic practices.

3.2.2 Surveying Stream Habitats

The primary target species likely to be found at stream sites was the Giant Barred Frog (*Mixophyes iteratus*). A total of 12 streams were surveyed using a 500m transect or 60 min search time (Table 1). During the survey period active search techniques were employed by two people using 50 watt hand held spotlight, call imitation at regular intervals and illumination of the water column to identify and capture tadpoles. The objective of this approach was to obtain a higher degree of accuracy arising from a single visit although transects of reduced length and time have been effective in the detection of this species elsewhere in north eastern NSW (see Lewis and Rohweder 2005). In this study 87% of their frog records were obtained during the first survey.

3.2.3 Surveying Dam and Lagoon Habitats

The primary target species likely to be found in dams and lagoons was the Green and Golden Bell Frog (*Litoria aurea*) and an undescribed species of Whirring Tree Frog (*Litoria revelata sp.*). Six dams and lagoons were surveyed for 30 min at night by two observers using 50 watt spotlights (Table 1). During this time active search techniques were employed along with call imitation. In addition, a 20 min survey was undertaken during the day to survey for basking individuals and to identify tadpoles, an approach which has proved an effective technique in the past (Goldingay and Lewis 1999; Lewis and Goldingay 1997).

3.2.4 Surveying Wetland Habitats

The principal target species likely to be found in wetland habitats included the Wallum Froglet (*Crinia tinnula*), Green and Golden Bell Frog, undescribed species of Whirring Tree Frog and to a lesser extent Wallum Sedge Frog (*Litoria olongburensis*). Four wetlands were surveyed by two observers for 30 min at night using a 50 watt spotlight (Table 1). During this time active search techniques were employed along with call imitation for the Green and Golden Bell Frog and call broadcast using a 12 watt megaphone for Wallum Froglet and Wallum Sedge Frog in wallum type habitats (sites 2, 13-15, 17, 31).

3.2.5 Surveying Ephemeral Habitats

The primary target species likely to be found in ephemeral habitats was the Green-thighed Frog (*Litoria brevipalmata*), undescribed Whirring Tree Frog and to a lesser extent Wallum Froglet in Swamp Sclerophyll and Wallum related habitats. A total of 19 ephemeral sites were surveyed by two observers using a 20 min active search technique (Table 1).

Table 1. Number of sites surveyed in each habitat type, survey effort and target species. Numbers in parentheses represent person survey effort (i.e. survey between 2100-2130 by 2 people is 30 (60). Und. = Undescribed.

Aquatic Habitat	No. Sites Surveyed	Active Search Time	Total Effort	Target Species
Stream	12	60	720 (1440)	Giant Barred Frog
Dam/Lagoon	6	30	180 (360)	Green and Golden Bell Frog, Und. Whirring Tree Frog
Wetland	4	20	80 (160)	Wallum Froglet, Wallum Sedge Frog, Green & Golden Bell Frog, Und. Whirring Tree Frog
Ephemeral	19	20	380 (760)	Green-thighed Frog, Und. Whirring Tree Frog, Wallum Froglet

4.0 RESULTS AND DISCUSSION

Twenty species of frog were recorded during the survey (Table 2). They comprise nine species from the Myobatrachid family (ground dwelling frogs) and 11 from the Hylid family (tree frogs). Two species of conservation significance were recorded: Green-thighed Frog (*Litoria brevipalmata*) and an undescribed species of Whirring Tree Frog (*Litoria revelata sp.*).

4.1 GREEN-THIGHED FROG (*LITORIA BREVIPALMATA*)

Green-thighed Frog was recorded at Skinners Creek located ~ 1km west of the proposed footprint (~chainage 14100) in Orara East State Forest (Figure 2; Appendix 1). Three males were heard calling from a flooded oxbow lagoon section of Skinners Creek in wet sclerophyll forest (Flooded Gum, Grey Gum overstorey with Lilly Pilly understorey). This observation followed localised flooding of the Coffs Harbour region which received in excess of 200 mm leading up to the survey (Appendix 2). This represents the first record of this species in the study area with the nearest historic records occurring to the north west at Ramornie (50 km west of Grafton) and south west in the Thora area near Bellingen (DEC 2006). This is consistent with its patchy distribution northward of Ourimbah where it is known from relatively few records (Lewis 2000).

Despite being recorded at only one location potential habitat for this cryptic species exists in several areas including:

- Areas to the east of ~chainage 10900 (South Moonee Township)
- Yellow Water Holes on the western side of existing highway at Central Bucca intersection (~chainage 14000); and

- Drainage lines and depressions in Wedding Bells State Forest between chainages 30000-32000 (Figure 2).

4.2 UNDESCRIBED WHIRRING TREE FROG (*LITORIA*

REVELATA SP.)

The undescribed Whirring Tree Frog was recorded in the southern study area south of Moonee township (Figure 2). Five males were heard calling from a flooded depression in Swamp Sclerophyll Forest 500m east of the proposed alignment (~10900). It is at present difficult to determine its relative status in the Coffs Harbour region given it may often be confused with either the Jervis Bay Tree Frog (*Litoria jervisensis*) or the Whirring Tree Frog (*Litoria revelata*), however it is known to occupy a broad range of habitats from coastal paperbark wetlands near sea level to montane (i.e. mountainous, upland) wet eucalypt and temperate rainforests at almost 1000m above sea level (unpublished data). Within the study area the Whirring Tree Frog has been previously recorded in an adjacent paperbark wetland 700 m to the southeast (pers. obs; Figure 2).

The following is a general account of species recorded during the survey according to broad habitat type.

4.3 STREAM SITES

Twelve species of frog were recorded at stream sites (Table 2). Species often recorded in this habitat included the Tusked Frog (*Adelotus brevis*), Great Barred Frog (*Mixophyes fasciolatus*), Eastern Dwarf Frog (*Litoria fallax*) and Red-backed Toadlet (*Pseudophyrne coriacea*). The latter two species were recorded at more intermittent stream sites.

Table 2. Frog species and the habitat type they were recorded in. Numbers represent the number of sites in each habitat type. Numbers in parentheses represent percentage of total number of sites for each habitat type. C = Common, V = Vulnerable, U = Unknown.

Common Name/Group	Scientific Name	Status	Habitat				No. Sites
			Stream	Dam/Lagoon	Wetland	Ephemeral	
MYOBATRACHIDAE							
Tusked Frog	<i>Adelotus brevis</i>	C	8 (67)	1 (17)	1 (25)	1 (5)	11 (27)
Eastern Sign-bearing Froglet	<i>Crinia parinsignifera</i>	C	-	-	2 (50)	7 (37)	9 (22)
Common Eastern Froglet	<i>Crinia signifera</i>	C	3 (25)	1 (17)	2 (50)	12 (63)	18 (44)
Striped Marsh Frog	<i>Limnodynastes peroni</i>	C	3 (25)	-	4 (100)	13 (68)	20 (45)
Spotted Grass Frog	<i>Limnodynastes tasmaniensis</i>	C	-	-	-	1 (5)	1 (2)
Pobblebonk	<i>Limnodynastes sp.</i>	C	-	1 (17)	-	-	1 (2)
Great Barred Frog	<i>Mixophyes fasciolatus</i>	C	7 (58)	-	1 (25)	3 (16)	11 (27)
Red-backed Toadlet	<i>Pseudophyrne coriacea</i>	C	10 (83)	1 (17)	1 (25)	10 (53)	22 (54)
Smooth Toadlet	<i>Uperoleia laevigata</i>	C	1 (8)	-	3 (75)	7 (37)	11 (27)
HYLIDAE							
Green-thighed Frog	<i>Litoria brevipalmata</i>	V	1* (8)	-	-	-	1 (2)
Common Green Tree Frog	<i>Litoria caerulea</i>	C	-	1 (17)	-	3 (16)	4 (10)
Bleating Tree Frog	<i>Litoria dentata</i>	C	-	2 (33)	-	5 (26)	7 (17)
Eastern Dwarf Frog	<i>Litoria fallax</i>	C	4 (33)	4 (67)	3 (75)	13 (68)	24 (59)
Graceful Tree Frog	<i>Litoria gracilentia</i>	C	2 (17)	1 (17)	1 (25)	6 (32)	10 (24)
Broad-palmed Frog	<i>Litoria latopalmata</i>	C	-	1 (17)	-	-	1 (2)
Stony Creek Frog	<i>Litoria lesueurii</i>	C	1 (8)	1 (17)	-	-	2 (5)
Rocket Frog	<i>Litoria nasuta</i>	C	-	4 (67)	-	2 (11)	6 (15)
Peron's Tree Frog	<i>Litoria peronii</i>	C	1 (8)	2 (33)	-	-	3 (7)
Undescribed Whirring Tree Frog	<i>Litoria revelata sp.</i>	U	-	-	-	1 (5)	1 (2)
Tyler's Tree Frog	<i>Litoria tyleri</i>	C	1 (8)	3 (50)	3 (75)	9 (47)	16 (39)

4.3.1 Conservation Significant Species

The record of the Green-thighed Frog has been assigned to this category given it was observed in an oxbow lagoon system of Skinners Creek. Potential habitat was also identified at this site for the endangered Giant Barred Frog. Other potential locations for the Giant Barred Frog include the southern tributary of Poundyard Creek (~Chainage 26800), Woolgoolga and Arrawarra Creeks which provide suitable habitat in the form of adequate riparian vegetation, steep sided stream banks and pool-riffles. These characteristics were identified as principal habitat components during a detailed study of this species in northeastern NSW (Lewis and Rohweder 2005). The fragmented nature of the Poundyard Creek site may indicate less optimal habitat for Giant Barred Frog given it normally requires large tracts of unfragmented riparian forest. Historic records of the Giant Barred Frog exist several kilometres further to the west of the proposed alignment in Sherwood Nature Reserve, Central Bucca and west of Emerald Beach (DEC 2006). This includes the headwaters and upper reaches of several creeks surveyed during the current survey (i.e. Woolgoolga Creek), however, much of the footprint occurs in or near the intertidal zone and therefore considered sub optimal habitat.

4.4 DAM/LAGOON SITES

Thirteen species of frog were recorded at dam and lagoon sites with most of these species (77%) being members of the hylid family (Table 2). Species regularly encountered in this habitat included the Bleating Tree Frog (*Litoria dentata*), Eastern Dwarf Frog, Rocket Frog (*Litoria nasuta*), Peron's Tree Frog (*Litoria peronii*) and Tyler's Tree Frog (*Litoria tyleri*).

4.4.1 Conservation Significant Species

No conservation significant species were recorded in this habitat type. Although potential habitat does exist for the Green and Golden Bell Frog (*Litoria aurea*) at Lake Russell there are no historic records to substantiate its existence in the study area. This is despite several detailed studies of this species across its range (White and Pyke 1996) and more locally (Lewis and Goldingay 1999). The nearest records for this species occur ~12km to the north at Blue Lake (Yuraygir National Park) or over 60 km further south in Hat Head National Park (DEC 2006; pers. obs).

4.5 WETLAND SITES

Ten species of frog were recorded at wetland sites with most of the species (70%) representing the Myobatrachid family (Table 2). Species commonly encountered in this habitat include the Eastern Sign-bearing Froglet (*Crinia parinsignifera*), Common Eastern Froglet (*Crinia signifera*), Striped Marsh Frog (*Limnodynastes peroni*), Red-backed Toadlet, Smooth Toadlet (*Uperoleia laevigata*), Eastern Dwarf Frog and Tyler's Tree Frog.

4.5.1 Conservation Significant Species

Although no conservation significant species were recorded in this habitat the undescribed Whirring Tree Frog has been previously recorded at wetlands south of Moonee (pers. obs., Figure 2). This site was resurveyed as part of the current assessment (site 2) although no individuals were recorded. Potential habitat was identified for the Wallum Froglet at two locations: heathland north of Emerald Beach (~chainage 19000) and west of Arrawarra on the western verge of the Pacific Highway (~chainage 32000). A single historic record occurs in the Hearn's Lake area ~1.5 km east of the proposed footprint (DEC 2006; Figure 2).

4.6 EPHEMERAL SITES

Fifteen species of frog were recorded from ephemeral habitats (Table 2). Species regularly encountered in this habitat included the Common Eastern Froglet, Striped Marsh Frog, Red-backed Toadlet, Eastern Dwarf Frog, and Tyler's Tree Frog.

4.6.1 Conservation Significant Species

The undescribed Whirring Tree Frog was recorded at one location south of Moonee and ~ 500m east of the proposed alignment (~chainage 10900). Potential habitat for the Green-thighed Frog exists at several sites including Yellow Waterholes (~chainage 14000) and throughout the ephemeral gully and depressions within Wedding Bells State Forest.

5.0 CONSERVATION VALUE

The study area is considered to provide moderate conservation value to frog fauna for three reasons. Firstly, it provides known habitat for conservation significant frogs, and secondly it provides potential habitat for Wallum Froglet and Giant Barred Frog at several discreet locations. The third reason is the high diversity which suggests frogs perform an important ecological function in the local area. In order to maintain these ecological values the recommendations outlined in section six should be adopted.

6.0 RECOMMENDATIONS

Although no rare frog fauna were recorded on or in close proximity to the proposed footprint a series of recommendations have been outlined below to reduce impacts on frog sensitive habitats. They are designed to confirm with best management practices (BMP's) and include:

- Minimal habitat removal;
- Timing of habitat removal and construction activities;
- Installation of frog friendly underpasses;
- Maintenance of existing hydrological values; and
- Pre-clearing surveys for target species at select sites.

6.1 MINIMISE HABITAT REMOVAL

The proposal will remove substantial areas of vegetated lands particularly in the northern part of the study area. Where possible the development footprint should be reduced to a minimum but still within safe working guidelines for the construction and eventual operational phase of the project. Construction site offices, equipment and material staging areas and batching plants should not be constructed on or in close proximity to the areas identified in figure two because they contain known or potential habitat for conservation significant frog fauna.

6.2 TIMING OF CONSTRUCTION ACTIVITIES

Where feasible the removal of habitat along drainage lines should avoid periods of wet weather. Its objective is to minimise direct impacts to frogs which may have selected areas within the development footprint as aestivation (i.e. hibernation) or breeding sites, and will also reduce the risk of potential secondary impacts such as sedimentation in adjoining habitats.

6.3 FROG UNDERPASSES AND CULVERTS

Frog friendly underpasses and culverts are recommended at six strategic points along the proposed footprint. They include:

- Bridge or culvert structure at Sugar Mill Creek;
- Culvert linking Lake Russell to lands further to the east including Moonee Nature Reserve;
- Bridge across Woolgoolga Creek;
- Bridge or an adequate culvert across the main tributary of Poundyard Creek (on Newman's Road);
- Bridge or an adequate culvert across Little Arrawarra Gully; and
- Bridge across Arrawarra Creek.

The bridge design should incorporate sufficient terrestrial habitats on either side of the creek and seek to maximise the opportunity for vegetation (sedges and rushes such as *Lomandra* and *Gahnia*) to grow either side and possibly under the bridge by maximising light levels. Attempts should be made to install culverts in a similar manner.

Whilst it could be argued that there is little justification for the installation of these structures one must consider that potential habitat was identified at both Woolgoolga, Poundyard and Arrawarra Creeks for the Giant Barred Frog and these structures will also facilitate east west movements for other vertebrate fauna.

6.4 MAINTENCE OF EXISTING HYDROLOGICAL REGIMES

Where the footprint traverses across or near lands identified as having suitable habitat for rare frog fauna the existing hydrological regime should be maintained. This will ensure the proposal reduces the likelihood of altering local species diversity and abundance. For example, the hydrological features at Yellow Waterholes (~chainage 14000) and Little Arrawarra Gully (~chainage 30350) should be maintained in an ephemeral state for Green-thighed Frog. In order to maintain the hydrological features of wallum habitats (low p H waters) north of Emerald Beach (~chainage 19000) and near Arrawarra (~chainage 31500) sedimentation ponds should be installed and the water should not be treated with neutralising agents such as lime.

6.5 PRE-CLEARING SURVEYS

Pre-clearing surveys should be conducted prior to the removal of habitat at several key sites. They include a survey of Woolgoolga, Poundyard and Arrawarra Creeks and Little Arrawarra Gully for the Giant Barred Frog. Should individuals be detected within the development footprint permission from relevant agencies should be sought for translocation into immediate habitat. Targeted surveys should also be undertaken for Wallum Froglet in the paperbark wetland (~chainage 32000) in a similar manner. The timing of these surveys should occur as close as possible to the clearing event taking into account the target species ecology.

7.0 CONCLUSIONS

The current study found high frog diversity occurs in the Sapphire to Arrawarra study area with 20 species recorded including two species of conservation significance. Both the Green-thighed Frog and undescribed Whirring Tree Frog were recorded a considerable distance (>500m) from the proposed development footprint and as such the impacts associated with the proposal in these two cases should be considered insignificant. A further two species, the Giant Barred Frog and Wallum Froglet may also occur at several discreet locations in close proximity to the proposed alignment. Provided the recommendations outlined in section six are adopted in conjunction with best management practices it is likely that impacts on these and other species would be negligible.

8.0 REFERENCES

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APPENDIX ONE - SITE DESCRIPTIONS



Site No: 1 (Western side Pacific Highway – 200m north of Headlands Road)

Picture Orientation: 245°

E: 514221 **N:** 6655641

Land Tenure: Private

Waterbody Type: Dam

Dimensions: 0.04ha

Hydrological Features: Permanent artificial dam

Water Visibility: 0.3m

Substrate: Soil

Fringing Vegetation: Sedges (Typha), Grass (Molasses, Bladey, Tall Paspalum), Ferns (Blechnum)

Riparian Zone Width: n/a

Aquatic Vegetation Cover: 75% (Typha and Lilies)

Site Disturbance: Severe (Plantation, Clearing, Roads, Pollution)

Surrounding Vegetation Type: Banana Plantation

Dominant Species

- Overstorey: Camphor Laurel, Radiata Pine
- Midstorey: Absent
- Understorey: Absent
- Shrublayer: Senna, Lantana
- Ground Cover: Molasses Grass, Bladey Grass, Tall Paspalum, Typha, Blechnum

Adjacent Vegetation Type: Dry Sclerophyll Forest, Agriculture

Survey Results

Survey Results

- Tusked Frog (*Adelotus brevis*) – 6 (w)
- Eastern Dwarf Frog (*Litoria fallax*) – 13 (ob, w)
- Rocket Frog (*Litoria nasuta*) – 7 (w)
- Peron's Tree Frog (*Litoria peronii*) – 1 (w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): low
- Green-thighed Frog (*Litoria brevipalmata*): nil
- Wallum Froglet (*Crinia tinnula*): nil
- Whirring Tree Frog (*Litoria revelata sp*): low
- Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Site has limited value for pond dwelling frog fauna.



Site No: 2 (Moonee South – 750m east of Highway)

Picture Orientation: 180°

E: 514728 **N:** 6656729

Land Tenure: Private

Waterbody Type: Paperbark Wetland

Dimensions: 6 ha

Hydrological Features: Natural semi permanent wetland

Water Visibility: 0.3m

Substrate: Soil

Fringing Vegetation: Sedges (Gahnia), Ferns (Blechnum), Vines (Monkey Rope)

Riparian Zone Width: n/a

Aquatic Vegetation Cover: 75%

Site Disturbance: Low (Drainage, grazing)

Surrounding Vegetation Type: Swamp Sclerophyll Forest

Dominant Species

- Overstorey: Broad-leaved Paperbark, Swamp Mahogany
- Midstorey: Broad-leaved Paperbark, Swamp Mahogany
- Understorey: Broad-leaved Paperbark, Swamp Mahogany
- Shrublayer: Walking Stick Palm, Senna
- Ground Cover: Gahnia, Blechnum, Monkey Rope

Adjacent Vegetation Type: Dry Sclerophyll Forest, Agriculture

Survey Results

- Striped Marsh Frog (*Limnodynastes peroni*) - >100 (ob, w)
- Smooth Toadlet (*Uperoleia laevis*) – 1 (w)
- Great Barred Frog (*Mixophyes fasciolatus*) – 3 (w)
- Tusked Frog (*Adelotus brevis*) – 3 (w)
- Eastern Dwarf Frog (*Litoria fallax*) – 20 (ob, w)
- Tyler's Tree Frog (*Litoria tyleri*) – 50 (ob, w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): low
- Green-thighed Frog (*Litoria brevipalmata*): low
- Wallum Froglet (*Crinia tinnula*): low
- Whirring Tree Frog (*Litoria revelata sp*): known
- Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Potential habitat value for most of target species.



Site No: 3 (Moonee South – 550m east of Highway)

Picture Orientation: 070°

E: 514691 **N:** 6657315

Land Tenure: Private

Waterbody Type: Ephemeral Depression

Dimensions: 1.3 ha

Hydrological Features: Natural ephemeral depression

Water Visibility: 0.5m

Substrate: Soil

Fringing Vegetation: Rushes (*Lomandra*), Ferns (*Blechnum*), Tussocks (*Carax* sp), Grass (*Basket*), Herbs (*Hydrocotyle*), Vines (*Smilax*)

Riparian Zone Width: n/a

Aquatic Vegetation Cover: n/a

Site Disturbance: Low (Vehicle Trails, Rubbish)

Surrounding Vegetation Type: Swamp Sclerophyll Forest

Dominant Species

Overstorey: Swamp Mahogany, Swamp Oak, Coastal Blackbutt, Broad-leaved paperbark

Midstorey: Weeping Bottlebrush, Broad-leaved Paperbark, Swamp Oak

Understorey: Cheese Tree, Weeping Bottlebrush

Shrublayer: Senna, Walking Stick Palm

Ground Cover: *Lomandra*, *Blechnum*, *Carax* sp, *Basket* Grass, *Smilax*, *Hydrocotyle*

Adjacent Vegetation Type: Dry Sclerophyll Forest

Survey Results

Great Barred Frog (*Mixophyes fasciolatus*) – 15 (ob, w)

Tyler's Tree Frog (*Litoria tyleri*) – >100 (ob, w)

Undescribed Whirring Tree Frog (*Litoria revelata* sp) – 5 (ob, w)

Smooth Toadlet (*Uperoleia laevis*) - >100 (ob, w)

Common Eastern Froglet (*Crinia signifera*) – 20 (w)

Striped Marsh Frog (*Limnodynastes peroni*) – 10 (ob, w)

Eastern Dwarf Frog (*Litoria fallax*) – 4 (ob, w)

Bleating Tree Frog (*Litoria dentata*) – 4 (ob, w)

Suitability For Target Species

Green and Golden Bell Frog (*Litoria aurea*): nil

Green-thighed Frog (*Litoria brevipalmata*): moderate

Wallum Froglet (*Crinia tinnula*): nil

Whirring Tree Frog (*Litoria revelata* sp): known

Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Suitable site for ephemeral frog species.



Site No: 4 (Moonee South – 350m east of Highway)

Picture Orientation: 200°

E: 514457 **N:** 6657325

Land Tenure: Private

Waterbody Type: Permanent Creek

Dimensions: Pools (10-30m in length and 3-6m wide)

Hydrological Features: Natural permanent creek

Water Visibility: 0.4m

Substrate: Gravel, Soil

Fringing Vegetation: Rushes (*Lomandra*), Ferns (*Blechnum*), Tussocks (*Carax* sp)

Riparian Zone Width: 5m

Aquatic Vegetation Cover: 0%

Site Disturbance: Severe (Roads, Clearing, Grazing, Rubbish, Fragmentation, Pollution, Erosion)

Surrounding Vegetation Type: Wet Sclerophyll Forest

Dominant Species

Overstorey: Flooded Gum

Midstorey: Weeping Bottlebrush, Cheese Tree

Understorey: Senna, Lantana

Shrublayer: Lantana, Senna

Ground Cover: *Lomandra*, *Blechnum*, *Carax* sp

Adjacent Vegetation Type: Dry Sclerophyll Forest, Agriculture

Survey Results:

Eastern Dwarf Frog (*Litoria fallax*) – 14 (ob, w)

Red Backed Toadlet (*Pseudophyrne coriacea*) – 3 (ob, w)

Smooth Toadlet (*Uperoleia laevis*) - 7 (w)

Suitability For Target Species

Green and Golden Bell Frog (*Litoria aurea*): nil

Green-thighed Frog (*Litoria brevipalmata*): low

Wallum Froglet (*Crinia tinnula*): nil

Whirring Tree Frog (*Litoria revelata* sp): moderate

Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Limited habitat value to target species.



Site No: 5 (Fairview Drive – 300m west of Highway)
Picture Orientation: 080°
E: 513792 **N:** 6657400
Land Tenure: Private
Waterbody Type: Ephemeral Watercourse intermittent pools
Dimensions: Pools (1-5m in length and 0.5-2m wide)
Hydrological Features: Natural Ephemeral Watercourse
Water Visibility: 0.2m
Substrate: Soil
Fringing Vegetation: Sedges (Gahnia), Grass (Broad-leaved Paspalum), Tussocks (Carax sp), Vines (Monkey Rope)
Riparian Zone Width: 20m
Aquatic Vegetation Cover: n/a
Site Disturbance: Moderate (Fragmentation, roads, pollution, underscrubbing)
Surrounding Vegetation Type: Wet Sclerophyll Forest
Dominant Species
 Overstorey: Flooded Gum
 Midstorey: Flooded Gum, Grey Gum, Swamp Mahogany, Weeping Bottlebrush
 Understorey: Weeping Bottlebrush, Cheese Tree
 Shrublayer: Coffee Bush, Lantana, Walking Stick Palm
 Ground Cover: Gahnia, Broad-leaved Paspalum, Carax sp, Monkey Rope
Adjacent Vegetation Type: Plantation, Dry Sclerophyll Forest
Survey Results:
 Eastern Dwarf Frog (*Litoria fallax*) – 17 (ob, w)
 Great Barred Frog (*Mixophyes fasciolatus*) – 1 (w)
 Tusked Frog (*Adelotus brevis*) – 2 (w)
 Tyler’s Tree Frog (*Litoria tyleri*) – 14 (ob, w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): nil
General Comments: Site has limited value for Green-thighed Frog



Site No: 6 (Moonee South – Eastern Side of Highway)
Picture Orientation: 200°
E: 514146 **N:** 6657625
Land Tenure: RTA Road Reserve
Waterbody Type: Ephemeral depression
Dimensions: numerous 0.002 ha
Hydrological Features: Artificial ephemeral depression
Water Visibility: 0.2m
Substrate: Soil
Fringing Vegetation: Sedges (Gahnia, Lomandra), Grass (Basket Grass, Whiskey Grass), Vines (Glocyene), Tussocks (Carax sp)
Riparian Zone Width: n/a
Aquatic Vegetation Cover: 0%
Site Disturbance: Severe (Roads, Rubbish Dumping, Fragmentation, Pollution)
Surrounding Vegetation Type: Dry Sclerophyll Forest
Dominant Species
 Overstorey: Coastal Blackbutt, Flooded Gum, Pink Bloodwood
 Midstorey: Coastal Blackbutt, Red Mahogany, Pink Bloodwood
 Understorey: Weeping Bottlebrush, Cheese Tree, Black She-oak
 Shrublayer: Lantana, Doodenea, Weeping Bottlebrush
 Ground Cover: Gahnia, Lomandra, Basket Grass, Whiskey Grass
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Eastern Dwarf Frog (*Litoria fallax*) – 7 (ob, w)
 Striped Marsh Frog (*Limnodynastes peroni*) – 4 (ob, w)
 Great Barred Frog (*Mixophyes fasciolatus*) – 1 (w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 1 (w)
 Graceful Tree Frog (*Litoria gracilentia*) – 1 (w)
 Tyler’s Tree Frog (*Litoria tyleri*) – 2 (ob, w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): nil
General Comments: Generally unsuitable for target species.



Site No: 7 (Moonee Beach South – eastern side of highway)
Picture Orientation: 100°
E: 514352 **N:** 6657692
Land Tenure: Private
Waterbody Type: Ephemeral depression
Dimensions: 0.002ha
Hydrological Features: Natural ephemeral watercourse
Water Visibility: 0.2m
Substrate: Soil
Fringing Vegetation: Sedges (Gahnia), Grass (Basket Grass, Bladey, Broad-leaved Paspalum), Herbs (Hydrocotyle), Ferns (Bracken)
Riparian Zone Width: n/a
Aquatic Vegetation Cover: n/a
Site Disturbance: Moderate (Logging, Vehicle Trails, Rubbish dumping)
Surrounding Vegetation Type: Dry Sclerophyll Forest
Dominant Species
 Overstorey: Red Mahogany, Coastal Blackbutt, Tallowwood
 Midstorey: Turpentine
 Understorey: Turpentine, Geebung, Cheese Tree, Weeping Bottlebrush
 Shrublayer: Walking Stick Palm, Weeping Bottlebrush, Cheese Tree
 Ground Cover: Gahnia, Basket Grass, Bladey Grass, Broad-leaved Paspalum, Hydrocotyle, Bracken
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Striped Marsh Frog (*Limnodynastes peroni*) – 3 (ob)
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 25 (w)
 Common Eastern Froglet (*Crinia signifera*) – 5 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): nil
General Comments: Marginal habitat for Green-thighed Frog.



Site No: 8 (Moonee South - Western Side of Highway)
Picture Orientation: 280°
E: 514095 **N:** 6657910
Land Tenure: RTA Road Reserve & Private
Waterbody Type: Semi Permanent Creek
Dimensions: Pools (10-30m in length and 1.5-2m wide)
Hydrological Features: Natural semi permanent creek
Water Visibility: 0.3m
Substrate: Gravel, Soil
Fringing Vegetation: Sedges (Lomandra), Grass (Basket Grass, Broad-leaved Paspalum), Ferns (Maiden Hair, Blechnum, Tree Fern), Vines (Monkey Rope, Native Grape), Tussocks (Carax sp)
Riparian Zone Width: 20m
Aquatic Vegetation Cover: n/a
Site Disturbance: Moderate (Roads, Utility Easements, Fragmentation, Plantation)
Surrounding Vegetation Type: Wet Sclerophyll Forest
Dominant Species
 Overstorey: Flooded Gum
 Midstorey: Flooded Gum, Brush Box
 Understorey: Brush Box, Bangalow Palm, *Acacia melonoxlyn*, Sandpaper Fig
 Shrublayer: Lantana, Senna, Rainforest sp
 Ground Cover: Lomandra, Basket Grass, Broad-leaved Paspalum, Maiden Hair Fern, Blechnum, Tree Fern, Monkey Rope, Native Grape, Carax sp
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 7 (w)
 Peron's Tree Frog (*Litoria peronii*) – 1 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): low
General Comments: Generally unsuitable for target species



Site No: 9 (Southern side of Lower Bucca Road- western side of highway)
Picture Orientation: 180°
E: 514212 N: 6660349
Land Tenure: Crown
Waterbody Type: Ephemeral depression
Dimensions: numerous 0.0001 ha areas
Hydrological Features: Natural ephemeral depression
Water Visibility: 0.1m
Substrate: Soil
Fringing Vegetation: Sedges (Gahnia), Grass (Basket Grass, Bladey Grass, Eragrostis)
Riparian Zone Width: n/a
Aquatic Vegetation Cover: 0%
Site Disturbance: Low (Roads, Rubbish Dumping)
Surrounding Vegetation Type: Swamp Sclerophyll Forest
Dominant Species
 Overstorey: Forest Red Gum
 Midstorey: Swamp Box, Broad-leaved Paperbark, Swamp Mahogany
 Understorey: Weeping Bottlebrush, Cheese Tree, Broad-leaved Paperbark, Swamp Box
 Shrublayer: *Pultenea villosa*, *Melaleuca styphelioides*, Groundsel, Swamp Box
 Ground Cover: Gahnia, Basket Grass, Paspalum
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Tyler's Tree Frog (*Litoria tyleri*) – 2 (w)
 Striped Marsh Frog (*Limnodynastes peroni*) – 4 (w)
 Eastern Dwarf Frog (*Litoria fallax*) – 15 (ob, w)
 Bleating Tree Frog (*Litoria dentata*) – 7 (ob, w)
 Spotted Marsh Frog (*Limnodynastes tasmaniensis*) – 3 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): moderate
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): low
 Giant Barred Frog (*Mixophyes iteratus*): nil
General Comments: Suitable habitat for Green-thighed Frog.



Site No: 10 (Lower Skinners Creek – western side of highway adjacent powerline easement)
Picture Orientation: 240°
E: 514312 N: 6660453
Land Tenure: Private
Waterbody Type: Permanent Creek
Dimensions: Pools (2-15m in length and 1-2m wide)
Hydrological Features: Natural permanent creek
Water Visibility: 0.2m
Substrate: Soil
Fringing Vegetation: Sedges (Gahnia, Lomandra), Grass (Basket Grass), Ferns (False Bracken), Vines (Monkey Rope)
Riparian Zone Width: 5m
Aquatic Vegetation Cover: 0%
Site Disturbance: Moderate (Logging, Vehicle Trails, Powerline easement)
Surrounding Vegetation Type: Swamp Sclerophyll Forest
Dominant Species
 Overstorey: Red Mahogany, Coastal Blackbutt, Tallowwood
 Midstorey: Red Mahogany, Turpentine, Swamp Box, Weeping Bottlebrush
 Understorey: Turpentine, Weeping Bottlebrush
 Shrublayer: Walking Stick Palm, Lilly Pilly, Weeping Bottlebrush
 Ground Cover: Gahnia, Lomandra, Basket Grass, False Bracken, Monkey Rope
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Common Eastern Froglet (*Crinia signifera*) – 15 (w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) – >100 (w)
 Striped Marsh Frog (*Limnodynastes peroni*) – 1 (w)
 Eastern Dwarf Frog (*Litoria fallax*) – 1 (obs)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): moderate
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): moderate
 Giant Barred Frog (*Mixophyes iteratus*): low
General Comments: Suitable habitat for Green-thighed Frog.



Site No: 11 (Upper Skinners Creek – western side of highway on Eastern Boundary Road)
Picture Orientation: 025°
E: 513525 **N:** 6661051
Land Tenure: State Forest
Waterbody Type: Oxbow Lagoon adjacent Skinners Creek
Dimensions: 0.01ha
Hydrological Features: Natural ephemeral oxbow
Water Visibility: 0.2m
Substrate: Soil
Fringing Vegetation: Tussocks (*Carax* sp), Sedges (*Gahnia*), Ferns (Maiden Hair, *Blechnum*)
Riparian Zone Width: 25m
Aquatic Vegetation Cover: 0%
Site Disturbance: Low (Logging, Vehicle Trails)
Surrounding Vegetation Type: Wet Sclerophyll Forest
Dominant Species
 Overstorey: Flooded Gum, Grey Gum
 Midstorey: Flooded Gum, Grey Gum, *Waterhousia floribunda*
 Understorey: Lilly Pilly, Rainforest sp
 Shrublayer: Sandpaper Fig, Rainforest sp.
 Ground Cover: *Carax*, *Gahnia*, *Blechnum*, Maiden Hair Fern
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results
 Green-thighed Frog (*Litoria brevipalmata*) – 3 (ob, w)
 Great Barred Frog (*Mixophyes fasciolatus*) – 6 (ob, w)
 Striped Marsh Frog (*Limnodynastes peroni*) – 5 (w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 60 (w)
 Tusked Frog (*Adelotus brevis*) – 3 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): known
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): moderate
 Giant Barred Frog (*Mixophyes iteratus*): moderate
General Comments: Green-thighed Frog recorded and site has potential for both the Whirring Tree Frog and Giant Barred Frog.



Site No: 12 (Lake Russel – western side of highway)
Picture Orientation: 000°
E: 516150 **N:** 6661940
Land Tenure: Private
Waterbody Type: Lagoon/Lake
Dimensions: 7.5ha
Hydrological Features: Artificial permanent lake
Water Visibility: 1.2m
Substrate: Soil
Fringing Vegetation: Grass (*Paspalum*, *Bladey*), Herbs (*Hydrocotyle*), Ferns (*Bracken*), Vines (*Monkey Rope*)
Riparian Zone Width: n/a
Aquatic Vegetation Cover: 35% (Common Spike Rush, Lillies)
Site Disturbance: Severe (Artificial construction, fragmentation, roads, grazing, clearing)
Surrounding Vegetation Type: Mixed (Agricultural, Plantation, Paperbark Wetland)
Dominant Species
 Overstorey: Broad-leaved Paperbark, Swamp Oak, Coastal Blackbutt
 Midstorey: Broad-leaved Paperbark, Swamp Oak
 Understorey: Absent
 Shrublayer: Senna, Cheese Tree, Lantana, Coastal Wattle
 Ground Cover: *Paspalum*, *Bladey* Grass, *Hydrocotyle*, *Bracken*
Adjacent Vegetation Type: Mixed (Swamp Sclerophyll Forest, Agriculture, Dry Sclerophyll)
Survey Results
 Tyler’s Tree Frog (*Litoria tylei*) – 2 (w)
 Eastern Dwarf Frog (*Litoria fallax*) – >200 (ob, w)
 Common Eastern Froglet (*Crinia signifera*) – 1 (w)
 Rocket Frog (*Litoria nasuta*) – 7 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): moderate
 Green-thighed Frog (*Litoria brevipalmata*): nil
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): nil
General Comments: Suitable site for bell frogs.



Site No: 13 (500m North Emerald Beach)
Picture Orientation: 040°
E: 518188 **N:** 6662999
Land Tenure: Crown-Coffs Harbour Council
Waterbody Type: Ephemeral wetland
Dimensions: numerous small depression 0.001ha
Hydrological Features: Natural ephemeral wetland
Water Visibility: 0.1m
Substrate: Sand
Fringing Vegetation: Various sedges and grass trees
Riparian Zone Width: n/a
Aquatic Vegetation Cover: n/a
Site Disturbance: Low (Vehicle trails)
Surrounding Vegetation Type: Coastal Heathland

Dominant Species

- Overstorey: Coastal Wattle
- Midstorey: absent
- Understorey: absent
- Shrublayer: *Banksia oblongifolia*
- Ground Cover: sedges and wallum epacrids

Adjacent Vegetation Type: Swamp Sclerophyll Forest

Survey Results

- Striped Marsh Frog (*Limnodynastes peroni*) – 2 (w)
- Common Eastern Froglet (*Crinia signifera*) – 2 (w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): nil
- Green-thighed Frog (*Litoria brevipalmata*): nil
- Wallum Sedge Frog (*Litoria olongburensis*): low
- Wallum Froglet (*Crinia tinnula*): moderate
- Whirring Tree Frog (*Litoria revelata sp*): nil
- Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Suitable site for Wallum Froglet.



Site No: 14 (500m north of Emerald Beach – eastern side of highway)
Picture Orientation: 040°
E: 518111 **N:** 6663105
Land Tenure: Crown – Coffs Harbour Council
Waterbody Type: Paperbark Wetland
Dimensions: 0.75ha
Hydrological Features: Natural permanent wetland
Water Visibility: 0.4m
Substrate: Soil
Fringing Vegetation: Various sedges (Baumea), Ferns (False Bracken), Grass (Whiskey Grass)
Riparian Zone Width: n/a
Aquatic Vegetation Cover: 80%
Site Disturbance: Low (Vehicle Trails, Altered Drainage, Fragmentation)
Surrounding Vegetation Type: Paperbark Wetland

Dominant Species

- Overstorey: Broad-leaved Paperbark, Swamp Oak
- Midstorey: Broad-leaved Paperbark, Swamp Oak
- Understorey: Broad-leaved Paperbark
- Shrublayer: Broad-leaved Paperbark, Groundsel
- Ground Cover: *Baumea sp.*

Adjacent Vegetation Type: Heathland

Survey Results:

- Striped Marsh Frog (*Limnodynastes peroni*) – >100 (ob, w)
- Common Eastern Froglet (*Crinia signifera*) – 6 (w)
- Smooth Toadlet (*Uperoleia laevis*) – 1 (w)
- Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 10 (w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): low
- Green-thighed Frog (*Litoria brevipalmata*): nil
- Wallum Froglet (*Crinia tinnula*): low
- Whirring Tree Frog (*Litoria revelata sp*): low
- Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Generally has low potential for most target species.



Site No: 15 (Moonee Nature Reserve opposite Graham Drive – eastern side of highway)

Picture Orientation: 100°

E: N:

Land Tenure: Nature Reserve

Waterbody Type: Paperbark Wetland

Dimensions: ~9ha

Hydrological Features: Natural permanent wetland

Water Visibility: 0.9m

Substrate: Soil

Fringing Vegetation: Various sedges, Ferns (Blechnum), Grass (Bladey, Carpet Grass)

Riparian Zone Width: n/a

Aquatic Vegetation Cover: 40%

Site Disturbance: None

Surrounding Vegetation Type: Paperbark Wetland

Dominant Species

Overstorey: Broad-leaved Paperbark

Midstorey: Broad-leaved Paperbark

Understorey: Broad-leaved Paperbark

Shrublayer: absent

Ground Cover: Bladey Grass, Blechnum, Sedges

Adjacent Vegetation Type: Swamp Sclerophyll Forest

Survey Results:

Tyler's Tree Frog (*Litoria tyleri*) – 50 (ob, w)

Eastern Dwarf Frog (*Litoria fallax*) – 30 (ob, w)

Striped Marsh Frog (*Limnodynastes peroni*) – >100 (ob, w)

Common Eastern Froglet (*Crinia signifera*) – 8 (w)

Suitability For Target Species

Green and Golden Bell Frog (*Litoria aurea*): low

Green-thighed Frog (*Litoria brevipalmata*): low

Wallum Froglet (*Crinia tinnula*): low

Whirring Tree Frog (*Litoria revelata sp*): low

Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Generally has low potential for most target species.



Site No: 16 (0.4 km north of Graham Drive Pacific Highway Intersection – western side of highway)

Picture Orientation: 320°

E: 518511 **N:** 6664395

Land Tenure: Private

Waterbody Type: Ephemeral Depression

Dimensions: 0.09ha

Hydrological Features: Natural with ephemeral depressions

Water Visibility: 0.1m

Substrate: Soil

Fringing Vegetation: Various sedges, Ferns (Blechnum), Vines (Monkey Rope), Grass (Bladey Grass)

Riparian Zone Width: n/a

Aquatic Vegetation Cover: n/a

Site Disturbance: Low (roads, fragmentation)

Surrounding Vegetation Type: Swamp Sclerophyll Forest

Dominant Species

Overstorey: Broad-leaved Paperbark, Swamp Oak

Midstorey: Broad-leaved Paperbark, Swamp Oak

Understorey: Broad-leaved Paperbark, Swamp Oak, Swamp Box, Senna

Shrublayer: Senna, Groundsel

Ground Cover: Bladey Grass, Blechnum, Sedges

Adjacent Vegetation Type: Agriculture and Rural Residential

Survey Results

Tyler's Tree Frog (*Litoria tyleri*) – 4 (w)

Smooth Toadlet (*Uperoleia laevigata*) – 30 (w)

Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 3 (w)

Striped Marsh Frog (*Limnodynastes peroni*) – 28 (w)

Eastern Dwarf Frog (*Litoria fallax*) – 13 (ob, w)

Suitability For Target Species

Green and Golden Bell Frog (*Litoria aurea*): nil

Green-thighed Frog (*Litoria brevipalmata*): low

Wallum Froglet (*Crinia tinnula*): low

Whirring Tree Frog (*Litoria revelata sp*): nil

Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Generally unlikely to have target species.



Site No: 17 (0.5 km south of Double Crossing Creek western side of Pacific Highway)

Picture Orientation: 200°

E: 518541 **N:** 6665471

Land Tenure: RTA Road Reserve and Private

Waterbody Type: Ephemeral Depression

Dimensions: 2.5 ha

Hydrological Features: Natural with ephemeral

Water Visibility: 0.2m

Substrate: Soil

Fringing Vegetation: Various sedges, paspalum, bladey grass, Rhodes grass

Riparian Zone Width: n/a

Aquatic Vegetation Cover: 85%

Site Disturbance: Severe (roads, pollution, clearing, fragmentation)

Surrounding Vegetation Type: Swamp Sclerophyll Forest

Dominant Species

- Overstorey: Broad-leaved Paperbark, Swamp Oak
- Midstorey: Broad-leaved Paperbark, Swamp Oak, Swamp Box
- Understorey: Broad-leaved Paperbark, Swamp Oak, *Leptospermum sp.*
- Shrublayer: Callistemon sp, Groundsel, Swamp Oak
- Ground Cover: Bladey Grass, Paspalum, Rhodes Grass, *Schoenus sp.*

Adjacent Vegetation Type: Agricultural

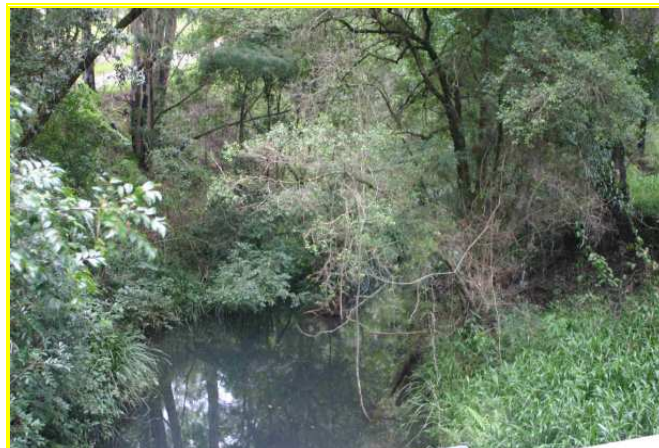
Survey Results:

- Tyler's Tree Frog (*Litoria tyleri*) – 5 (w)
- Eastern Dwarf Frog (*Litoria fallax*) – 20 (ob, w)
- Bleating Tree Frog (*Litoria dentata*) – 15 (ob, w)
- Smooth Toadlet (*Uperoleia laevisgata*) – 50 (w)
- Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – >100 (w)
- Common Eastern Froglet (*Crinia signifera*) – 10 (w)
- Common Green Tree Frog (*Litoria caerulea*) – 3 (w)
- Rocket Frog (*Litoria nasuta*) - >100 (ob, w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): nil
- Green-thighed Frog (*Litoria brevipalmata*): low
- Wallum Froglet (*Crinia tinnula*): low
- Whirring Tree Frog (*Litoria revelata sp*): nil
- Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Generally unlikely to have target species.



Site No: 18 (Upper Woolgoolga Creek)

Picture Orientation: 250°

E: 515912 **N:** 6668265

Land Tenure: Crown – RTA Road Reserve

Waterbody Type: Permanent Creek

Dimensions: Pools (20-80m in length and 3-4m wide)

Hydrological Features: Natural with permanent pools

Water Visibility: 1.2m

Substrate: Gravel, Rock

Fringing Vegetation: Rushes (Lomandra), Ferns (Maiden Hair Fern, Whirled Fern), Vines (Native Grape), Grasses (Basket Grass, Broad-leaved Paspalum)

Riparian Zone Width: 10m

Aquatic Vegetation Cover: n/a

Site Disturbance: Moderate (grazing, roads, fragmentation)

Surrounding Vegetation Type: Wet Sclerophyll Forest

Dominant Species

- Overstorey: Grey Gum, Tallowwood
- Midstorey: Brush Box, White Mahogany, Forest Oak, *Waterhousia floribunda*
- Understorey: Lilly Pilly, *Waterhousia floribunda*
- Shrublayer: Rainforest sp, Lantana
- Ground Cover: Lomandra, Basket Grass, Maiden Hair Fern, Whirled Fern, Native Grape, Lantana

Adjacent Vegetation Type: Agriculture

Survey Results:

- Great Barred Frog (*Mixophyes fasciolatus*) – 2 (w)
- Stony Creek Frog (*Litoria lesueurii*) – 1 (ob)
- Red-backed Toadlet (*Pseudophyrne coriacea*) – 2 (w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): nil
- Green-thighed Frog (*Litoria brevipalmata*): nil
- Wallum Froglet (*Crinia tinnula*): nil
- Whirring Tree Frog (*Litoria revelata sp*): nil
- Giant Barred Frog (*Mixophyes iteratus*): moderate

General Comments: Suitable habitat for creek dwelling species such as Giant Barred Frog.



Site No: 19 (Upper Woolgoolga Creek Road)
Picture Orientation: 90°
E: 515544 **N:** 6668283
Land Tenure: Private
Waterbody Type: Ephemeral Depression
Dimensions: 0.06 ha
Hydrological Features: Natural with ephemeral depression
Water Visibility: 0.1m
Substrate: Soil
Fringing Vegetation: Grass (Broad-leaved Paspalum), Sedges (Juncus), Ferns (False Bracken), Vines (Native Grape)
Aquatic Vegetation Cover: 0%
Site Disturbance: Severe (fragmentation, agriculture, grazing, clearing)
Surrounding Vegetation Type: Fragmented Wet Sclerophyll Forest
Dominant Species
 Overstorey: Flooded Gum
 Midstorey: Lilly Pilly, Sandpaper Fig, Red Ash, Red Cedar
 Understorey: Lilly Pilly, Sandpaper Fig, Red Ash, Red Cedar
 Shrublayer: Senna, Lilly Pilly
 Ground Cover: BL Paspalum, Juncus, False Bracken, Native Grape
Adjacent Vegetation Type: Riparian Rainforest
Survey Results:
 Striped Marsh Frog (*Limnodynastes peroni*) – 30 (w)
 Graceful Tree Frog (*Litoria gracilentata*) – 10 (w)
 Tyler’s Tree Frog (*Litoria tyleri*) – 4 (ob, w)
 Bleating Tree Frog (*Litoria dentata*) – 5 (w)
 Eastern Dwarf Frog (*Litoria fallax*) – 2 (w)
 Common Eastern Froglet (*Crinia signifera*) – 3 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): moderate
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): low
 Giant Barred Frog (*Mixophyes iteratus*): nil
General Comments: Suitable habitat for ephemeral species such as Green-thighed Frog.



Site No: 20 (1.45 km along Woolgoolga Creek Road near alignment)
Picture Orientation: 330°
E: 517055 **N:** 6668395
Land Tenure: State Forest
Waterbody Type: Ephemeral Creek
Dimensions: Pools (2-5m in length and 0.5-2m wide)
Hydrological Features: Natural with semi permanent pools
Water Visibility: 0.3m
Substrate: Gravel, Rock, Soil
Fringing Vegetation: Lichen, Moss, Basket Grass, Ferns (Maiden Hair Fern, Blechnum, Tree Fern), Vines (Native Grape)
Riparian Zone Width: 15m
Aquatic Vegetation Cover: n/a
Site Disturbance: Moderate (roads, pollution, fragmentation)
Surrounding Vegetation Type: Wet Sclerophyll Forest
Dominant Species
 Overstorey: Grey Gum, Flooded Gum, Grey Ironbark
 Midstorey: Grey Gum, Pink Bloodwood, Lilly Pilly
 Understorey: Lilly Pilly, various rainforest species
 Shrublayer: Lantana, native grape, rainforest species
 Ground Cover: Basket Grass, Maiden Hair Fern, Blechnum, Native Grape, Lantana
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 15 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): low
General Comments: Generally unlikely to have target species.



Site No: 21 (Woolgoolga Creek on the proposed alignment)
Picture Orientation: 010°
E: 516605 N: 6668683
Land Tenure: State Forest
Waterbody Type: Permanent Creek
Dimensions: Pools (10-80m in length and 2-5m wide)
Hydrological Features: Natural with permanent pools
Water Visibility: 1.0m
Substrate: Gravel, Soil
Fringing Vegetation: Rushes (Lomandra), Ferns (Blechnum, Maiden Hair Fern), Vines (Native Grape), Lantana
Riparian Zone Width: 10-40m
Aquatic Vegetation Cover: n/a
Site Disturbance: Low (weeds, fragmentation)
Surrounding Vegetation Type: Wet Sclerophyll Forest
Dominant Species
 Overstorey: Flooded Gum
 Midstorey: Brush Box, Lilly Pilly, Sandpaper Fig
 Understorey: Sandpaper Fig, Brush Box, Waterhousia
 Shrublayer: Sandpaper Fig, Native Grape, Lantana, Walking Stick Palm
 Ground Cover: Lomandra, Blechnum, Lantana
Adjacent Vegetation Type: Agriculture, Mixed Plantation
Survey Results:
 Tyler's Tree Frog (*Litoria tyleri*) – 30 (ob, w)
 Red-backed Toadlet (*Pseudophryne coriacea*) – 4 (w)
 Tusked Frog (*Adelotus brevis*) – 3 (w)
 Great Barred Frog (*Mixophyes fasciolatus*) – 8 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): nil
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): moderate
General Comments: Suitable habitat for creek dwelling species such as Giant Barred Frog.



Site No: 22 (Poundyard Creek - End of Newman's Road on alignment)
Picture Orientation: 300°
E: 516358 N: 6669986
Land Tenure: Private
Waterbody Type: Permanent Spring Fed Creek
Dimensions: Pools (1-15m in length and 1-3m wide)
Hydrological Features: Natural with permanent pools
Water Visibility: 2.0m
Substrate: Rock, gravel, sand and soil
Fringing Vegetation: Rushes (Lomandra), Ferns (Maiden Hair, Blechnum), Vines (Monkey Rope, Wait-A-While, Lawler, Native Grape)
Riparian Zone Width: 15m
Aquatic Vegetation Cover: n/a
Site Disturbance: Low (fragmentation)
Surrounding Vegetation Type: Rainforest
Dominant Species
 Overstorey: Strangler Fig, *Syzygium sp.*
 Midstorey: *Syzygium sp.*
 Understorey: Bangalow Palm, Sandpaper Figs, Rainforest Plants
 Shrublayer: Pittosporum, Walking Stick Palm
 Ground Cover: Lomandra, Monkey Rope, Lawler Vine, Wait-a-while, Native Grape
Adjacent Vegetation Type: Wet Sclerophyll Forest
Survey Results:
 Great Barred Frog (*Mixophyes fasciolatus*) – 9 (w)
 Tusked Frog (*Adelotus brevis*) – 4 (w)
 Eastern Dwarf Frog (*Litoria fallax*) – 26 (ob, w)
 Red-backed Toadlet (*Pseudophryne coriacea*) – 2 (w)
 At neighbouring farm dam Tyler's Tree Frog (*Litoria tyleri*) was also recorded.
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): low
 Giant Barred Frog (*Mixophyes iteratus*): moderate
General Comments: Limiting factor at this site for Giant Barred Frog may be fragmentation.



Site No: 23 (Palmer Road North)
Picture Orientation: 250°
E: 516472 **N:** 6670533
Land Tenure: Private
Waterbody Type: Dam
Dimensions: 0.06 ha
Hydrological Features: Artificial construction, permanent water
Water Visibility: 0.5m
Substrate: Soil
Fringing Vegetation: Cumbungi (Typha) and Lillies
Aquatic Vegetation Cover: 90%
Site Disturbance: Severe (Land clearing, roads, urban, fragmentation, banana plantation)
Surrounding Vegetation Type: Wet Sclerophyll Forest
Dominant Species
 Overstorey: Grey Gum, Tallowwood, Pink Bloodwood
 Midstorey: Grey Gum, Tallowwood
 Understorey: Brush Box, Lilly Pilly, Cheese Tree
 Shrublayer: *Acacia sp.*, Lantana
 Ground Cover: Bladley Grass, Kangaroo Grass, Lomandra
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Eastern Dwarf Frog (*Litoria fallax*) - >50 (ob, w)
 Tyler's Tree Frog (*Litoria tyleri*) - 3 (w)
 Bleating Tree Frog (*Litoria dentata*) - 2 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): low
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): moderate
General Comments: Site suitable for pond dwelling frogs.



Site No: 24 (Upper Little Arrawarra Gully)
Picture Orientation: 310°
E: 516376 **N:** 6672064
Land Tenure: State Forest
Waterbody Type: Semi Permanent Creek
Dimensions: Pools (2-7m in length and 0.3-3m wide)
Hydrological Features: Natural with semi permanent pools
Water Visibility: 1.2m
Substrate: Soil
Fringing Vegetation: Rushes (Lomandra), Grasses (Bladley Grass, Broad-leaved Paspalum), Ferns (Small Fishbone), Vines (Glocyene).
Riparian Zone Width: 5m
Aquatic Vegetation Cover: n/a
Site Disturbance: Low (Logging, vehicle trails)
Surrounding Vegetation Type: Dry Sclerophyll Forest
Dominant Species
 Overstorey: Grey Gum, Grey Ironbark, Tallowwood
 Midstorey: Brush Box, Tallowwood
 Understorey: Cheese Tree
 Shrublayer: Lantana, Cheese Tree
 Ground Cover: Lomandra, Bladley Grass, Broad-leaved Paspalum, Small Fishbone, Glocyene.
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Graceful Tree Frog (*Litoria gracilentia*) - 2 (w)
 Common Eastern Froglet (*Crinia signifera*) - 15 (ob, w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) - >100 (w)
 Tusked Frog (*Adelotus brevis*) - 1 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): low
 Giant Barred Frog (*Mixophyes iteratus*): nil
General Comments: Most suitable habitat for Green-thighed and Whirring Tree Frogs.



Site No: 25 (Northern tributary of Little Arrawarra Gully off Embankment Road)

Picture Orientation: 110°

E: 516490 **N:** 6672835

Land Tenure: State Forest

Waterbody Type: Ephemeral Drainage Line

Dimensions: Pools (1-5m in length and 0.5-2m wide)

Hydrological Features: Natural with semi permanent pools

Water Visibility: 0.2m

Substrate: Soil

Fringing Vegetation: Rushes (Juncus, Lomandra), Ferns (Bracken), Vines (Hard Leaf Creeper, Monkey Rope), Grasses (Basket Grass, Bladey Grass)

Riparian Zone Width: 5m

Aquatic Vegetation Cover: n/a

Site Disturbance: Low (logging, vehicle trails)

Surrounding Vegetation Type: Dry Sclerophyll Forest

Dominant Species

Overstorey: Grey Gum, Red Mahogany, Pink Bloodwood
 Midstorey: Grey Gum, Red Mahogany, Pink Bloodwood
 Understorey: Forest Oak, Brush Box, Swamp Box, Cheese Tree, Acacia
 Shrublayer: Cheese Tree, Lantana, Eucalypts
 Ground Cover: Lomandra, Juncus, Basket Grass, Bladey Grass, Bracken

Adjacent Vegetation Type: Dry Sclerophyll Forest

Survey Results:

Graceful Tree Frog (*Litoria gracilentia*) – 2 (w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) - >100 (ob, w)
 Tusked Frog (*Adelotus brevis*) – 1 (w)

Suitability For Target Species

Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): nil
 Giant Barred Frog (*Mixophyes iteratus*): nil

General Comments: Suitable habitat for ephemeral species such as Green-thighed Frog in the flood out depressions.



Site No: 26 (Middle Reaches of Little Arrawarra Gully)

Picture Orientation: 185°

E: 517299 **N:** 6672944

Land Tenure: State Forest

Waterbody Type: Semi Permanent Creek

Dimensions: Pools (5-20m in length and 1-7m wide)

Hydrological Features: Natural with permanent pools

Water Visibility: 0.3m

Substrate: Soil

Fringing Vegetation: Rushes (Lomandra), Ferns (False Bracken), Vines (Monkey Rope), Grasses (Basket Grass)

Riparian Zone Width: 10m

Aquatic Vegetation Cover: n/a

Site Disturbance: Low (logging, vehicle trails)

Surrounding Vegetation Type: Swamp Sclerophyll Forest

Dominant Species

Overstorey: Coastal Blackbutt, Red Mahogany
 Midstorey: Forest Red Gum, Weeping Bottlebrush
 Understorey: Weeping Bottlebrush, Lilly Pilly, Cheese Tree
 Shrublayer: Cheese Tree, Lantana, Lilly Pilly
 Ground Cover: Lomandra, Basket Grass, False Bracken

Adjacent Vegetation Type: Dry Sclerophyll Forest

Survey Results:

Common Eastern Froglet (*Crinia signifera*) – 13 (ob, w)
 Tusked Frog (*Adelotus brevis*) – 4 (w)
 Great Barred Frog (*Mixophyes fasciolatus*) – 8 (ob, w)
 Eastern Dwarf Frog (*Litoria fallax*) – 1 (w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 25 (w)
 Striped Marsh Frog (*Limnodynastes peroni*) – 3 (ob, w)

Suitability For Target Species

Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): moderate
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp*): moderate
 Giant Barred Frog (*Mixophyes iteratus*): low

General Comments: Suitable habitat for ephemeral species such as Green-thighed Frog in the flood out depressions.



Site No: 27 (Lower Little Arrawarra Gully)
Picture Orientation: 270°
E: 517495 **N:** 6673211
Land Tenure: State Forest
Waterbody Type: Permanent Creek
Dimensions: Pools (10-20m in length and 1.5-6m wide)
Hydrological Features: Natural with permanent pools
Water Visibility: 0.5m
Substrate: Soil
Fringing Vegetation: Sedges (Gahnia), Rushes (Lomandra), Ferns (Blechnum type), Vines (Monkey Rope), Grasses (Basket Grass)
Riparian Zone Width: 10m
Aquatic Vegetation Cover: n/a
Site Disturbance: Low (logging, vehicle trails)
Surrounding Vegetation Type: Swamp Sclerophyll Forest
Dominant Species
 Overstorey: Coastal Blackbutt, Red Mahogany
 Midstorey: Broad-leaved Paperbark, *Melaleuca styphelioides*, Red Bloodwood, Turpentine
 Understorey: Broad-leaved Paperbark, Cheese Tree, *Leptospermum sp.*
 Shrublayer: Cheese Tree, Doodenana, Lantana, Eucalypts, Sandpaper Fig
 Ground Cover: Lomandra, Baskett Grass, Blechnum Fern,
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Great Barred Frog (*Mixophyes fasciolatus*) – 4 (ob, w)
 Tusked Frog (*Adelotus brevis*) – 2 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp.*): low
 Giant Barred Frog (*Mixophyes iteratus*): low
General Comments: Suitable habitat for ephemeral and creek dwelling species such as Green-thighed and Giant Barred Frog.



Site No: 28 (Arrawarra Creek west side of Pacific Highway)
Picture Orientation: 280°
E: 517582 **N:** 6673909
Land Tenure: State Forest
Waterbody Type: Permanent Creek
Dimensions: Pool (20-50m in length and 1-3.5m wide)
Hydrological Features: Natural with permanent water
Water Visibility: 0.3m
Substrate: Soil
Fringing Vegetation: Rushes (Lomandra, Juncus)
Riparian Zone Width: 15m
Aquatic Vegetation Cover: 5% (Eel Grass)
Site Disturbance: Low (Logging, erosion)
Surrounding Vegetation Type: Wet Sclerophyll Forest
Dominant Species
 Overstorey: Coastal Blackbutt, Flooded Gum
 Midstorey: Turpentine, Coastal Blackbutt, Cheese Tree, Lilly Pilly
 Understorey: Water Gum, Lantana, Cheese Tree, Pittosporum, Eucalypts
 Shrublayer: Lantana, Water Gum, *Acacia sp.*, Monkey Rope
 Ground Cover: Lomandra, Basket Grass, Gahnia, Juncus
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Great Barred Frog (*Mixophyes fasciolatus*) – 8 (ob, w)
 Tusked Frog (*Adelotus brevis*) – 6 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): nil
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp.*): nil
 Giant Barred Frog (*Mixophyes iteratus*): low
General Comments: Most suitable habitat for Giant Barred Frog.



Site No: 29 (West Side of Pacific Highway 50m along Nash's Road)
Picture Orientation: 020°
E: 517590 N: 6674063
Land Tenure: State Forest
Waterbody Type: Ephemeral Depression
Dimensions: 0.0015 ha
Hydrological Features: Artificial construction from gravel road with ephemeral water body
Water Visibility: 0.1m
Substrate: Soil
Fringing Vegetation: Grass (Bladey, Paspalum, Giant Parramatta Grass)
Aquatic Vegetation Cover: n/a
Site Disturbance: Severe (recent logging, fragmentation, roads)
Surrounding Vegetation Type: Dry Sclerophyll Forest (Plantation)
Dominant Species
 Overstorey: Coastal Blackbutt
 Midstorey: Coastal Blackbutt, Grey Ironbark
 Understorey: Grey Ironbark, *Acacia sp.*, *Leptospermum sp.*
 Shrublayer: Lantana, Eucalypt regrowth, *Acacia sp.*
 Ground Cover: Bladey Grass, Paspalum, Giant Parramatta Grass
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Common Eastern Froglet (*Crinia signifera*) – 8 (w)
 Striped Marsh Frog (*Limnodynastes peroni*) – 2 (ob, w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp.*): nil
General Comments: Suitable only for Green-thighed Frog.



Site No: 30 (Lagoon 300m east of highway)
Picture Orientation: 150°
E: 517980 N: 6674204
Land Tenure: Crown
Waterbody Type: Lagoon
Dimensions: 0.18 ha
Hydrological Features: Natural permanent
Water Visibility: 0.6m
Substrate: Soil
Fringing Vegetation: Sedges (Eleocharis) and Lillies
Aquatic Vegetation Cover: 35%
Site Disturbance: Low (logging & vandalism)
Surrounding Vegetation Type: Dry Sclerophyll Forest
Dominant Species
 Overstorey: Coastal Blackbutt
 Midstorey: Coastal Blackbutt, Broad-leaved Paperbark
 Understorey: *Acacia sp.*, Geebung, Swamp Oak
 Shrublayer: *Leptospermum sp.*, Monkey Rope
 Ground Cover: Bladey Grass, Lomandra, Bracken Fern,
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results
 Eastern Dwarf Frog (*Litoria fallax*) – 120 (ob, w)
 Tyler's Tree Frog (*Litoria tyleri*) – 25 (ob, w)
 Peron's Tree Frog (*Litoria peronii*) – 10 (ob, w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): low
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp.*): moderate
General Comments: Aquatic vegetation considered too sparse for bell frogs. Nearby ephemeral areas may be used by Green-thighed Frog.



Site No: 31 (250m north Nash's Road on West Side of Pacific Highway)

Picture Orientation: 300°

E: 517671 **N:** 6674270

Land Tenure: State Forest – RTA Road Reserve

Waterbody Type: Paperbark Wetland

Dimensions: 0.4 ha

Hydrological Features: Natural with ephemeral water body

Water Visibility: 0.5m

Substrate: Soil

Fringing Vegetation: Sedges (*Eleocharis acuta*, *Baumea teretifolia*)

Aquatic Vegetation Cover: 85%

Site Disturbance: Low (Road, Pollution)

Surrounding Vegetation Type: Paperbark

Dominant Species

- Overstorey: Broad-leaved Paperbark
- Midstorey: Broad-leaved Paperbark, Swamp Box
- Understorey: Broad-leaved Paperbark, Swamp Box
- Shrublayer: Broad-leaved Paperbark, Swamp Box
- Ground Cover: Spikerush, *Baumea sp*, Kangaroo Grass, Paspalum

Adjacent Vegetation Type: Dry Sclerophyll Forest

- Eastern Dwarf Frog (*Litoria fallax*) – 5 (w)
- Graceful Tree Frog (*Litoria gracilentata*) – 12 (ob, w)
- Smooth Toadlet (*Uperoleia laevisgata*) – 1 (w)
- Red-backed Toadlet (*Pseudophyrne coriacea*) – 5 (w)
- Striped Marsh Frog (*Limnodynastes peroni*) – 2 (ob, w)
- Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 7 (w)
- Tyler's Tree Frog (*Litoria tyleri*) – 15 (w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): nil
- Green-thighed Frog (*Litoria brevipalmata*): low
- Wallum Froglet (*Crinia tinnula*): low
- Whirring Tree Frog (*Litoria revelata sp*): low

General Comments: Most suitable habitat for Wallum Froglet along the proposed alignment.



Site No: 32 (250m south of Arrawarra Beach Road)

Picture Orientation: 280°

E: 517810 **N:** 6674335

Land Tenure: RTA Road Reserve

Waterbody Type: Ephemeral Drainage Line

Dimensions: 0.02 ha

Hydrological Features: Natural with ephemeral water body

Water Visibility: 0.2m

Substrate: Soil

Fringing Vegetation: Sedges (*Baumea rubiginosa*), Ferns, Grass (Kangaroo, Bladey)

Aquatic Vegetation Cover: n/a

Site Disturbance: Moderate (road, fragmentation, clearing, pollution)

Surrounding Vegetation Type: Swamp Sclerophyll Forest

Dominant Species

- Overstorey: Forest Red Gum, Coastal Blackbutt
- Midstorey: Forest Red Gum, Broad-leaved Paperbark, Swamp Box
- Understorey: Cheese Tree, Swamp Box, *Melaleuca styloides*
- Shrublayer: Cheese Tree, Broad-leaved Paperbark, Coffee Bush
- Ground Cover: Bladey Grass, Kangaroo Grass, Lomandra

Adjacent Vegetation Type: Dry Sclerophyll Forest

Survey Results:

- Eastern Dwarf Frog (*Litoria fallax*) – 2 (w)
- Graceful Tree Frog (*Litoria gracilentata*) – 6 (ob, w)
- Common Eastern Froglet (*Crinia signifera*) – 15 (w)
- Smooth Toadlet (*Uperoleia laevisgata*) – 3 (w)
- Red-backed Toadlet (*Pseudophyrne coriacea*) – 20 (w)
- Striped Marsh Frog (*Limnodynastes peroni*) – >50 (ob, w)
- Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 20 (w)
- Tyler's Tree Frog (*Litoria tyleri*) – 1 (w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): nil
- Green-thighed Frog (*Litoria brevipalmata*): moderate
- Wallum Froglet (*Crinia tinnula*): low
- Whirring Tree Frog (*Litoria revelata sp*): nil

General Comments: Suitable for Green-thighed Frog.



Site No: 33 (100m north of Arrawarra Beach Road)
Picture Orientation: 355°
E: 517981 **N:** 6674698
Land Tenure: RTA Road Reserve
Waterbody Type: Ephemeral Depression
Dimensions: 0.03 ha
Hydrological Features: Artificial construction with ephemeral water body
Water Visibility: 0.2m
Substrate: Soil
Fringing Vegetation: Grass (Paspalum, Carpet)
Aquatic Vegetation Cover: n/a
Site Disturbance: Moderate (road, fragmentation, clearing, pollution)
Surrounding Vegetation Type: Dry Sclerophyll Forest
Dominant Species
 Overstorey: Coastal Blackbutt
 Midstorey: Coastal Blackbutt, Broad-leaved Paperbark, Black She-oak
 Understorey: Black She-oak, Swamp Box
 Shrublayer: *Leptospermum sp.*, *Acacia sp.*, Swamp Box, *Pultanea villosa*
 Ground Cover: Carpet Grass, Paspalum, Bladey Grass, Lomandra
Adjacent Vegetation Type: Swamp Sclerophyll Forest
Survey Results:
 Graceful Tree Frog (*Litoria gracilentata*) – 2 (w)
 Eastern Dwarf Frog (*Litoria fallax*) – 3 (ob, w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 2 (w)
 Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 20 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): low
 Wallum Froglet (*Crinia tinnula*): nil
 Whirring Tree Frog (*Litoria revelata sp.*): nil
General Comments: Unlikely for target species.

Site No: 34 (West Side of Pacific Highway Opposite Arrawarra Beach Road)
Picture Orientation: 200°
E: 517690 **N:** 6674727
Land Tenure: State Forest- Utilities
Waterbody Type: Ephemeral Drainage Line
Dimensions: 1.0 ha
Hydrological Features: Natural with ephemeral water body
Water Visibility: 0.6m
Substrate: Soil
Fringing Vegetation: Sedges (Lomandra), Grasses (Bladey Grass, *Entolasia stricta*)
Aquatic Vegetation Cover: n/a
Site Disturbance: Moderate (powerline, logging, fragmentation)
Surrounding Vegetation Type: Swamp Sclerophyll Forest
Dominant Species
 Overstorey: Red Mahogany
 Midstorey: Broad-leaved Paperbark
 Understorey: Black She-oak, Swamp Box, Broad-leaved Paperbark
 Shrublayer: *Leptospermum sp.*, Cheese Tree, Broad-leaved Paperbark
 Ground Cover: Bladey Grass, *Entolasia stricta*, Lomandra, various sedges and herbs
Adjacent Vegetation Type: Dry Sclerophyll Forest
Survey Results:
 Graceful Tree Frog (*Litoria gracilentata*) – 12 (ob,w)
 Common Eastern Froglet (*Crinia signifera*) – 30 (w)
 Rocket Frog (*Litoria nasuta*) – 2 (ob,w)
 Red-backed Toadlet (*Pseudophyrne coriacea*) – 5 (w)
 Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 10 (w)
Suitability For Target Species
 Green and Golden Bell Frog (*Litoria aurea*): nil
 Green-thighed Frog (*Litoria brevipalmata*): moderate
 Wallum Froglet (*Crinia tinnula*): low
 Whirring Tree Frog (*Litoria revelata sp.*): low
General Comments: One of the better sites for Green-thighed Frog.



Site No: 35 (Lagoon 1 km along Farm Trail in Wedding Bells State Forest)

Picture Orientation: 245°

E: 517065 **N:** 6675028

Land Tenure: State Forest

Waterbody Type: Lagoon

Dimensions: 3.6 ha

Hydrological Features: Natural permanent

Water Visibility: 0.8m

Substrate: Soil

Fringing Vegetation: Sedges (*Eleocharis sphacelata*) and Lillies

Aquatic Vegetation Cover: 15%

Site Disturbance: Low (erosion & vehicle trails)

Surrounding Vegetation Type: Dry Sclerophyll Forest

Dominant Species

- Overstorey: Coastal Blackbutt, Red Mahogany
- Midstorey: Coastal Blackbutt, Red Mahogany
- Understorey: *Acacia* sp, Broad-leaved Paperbark
- Shrublayer: *Leptospermum* sp, *Acacia* sp., Lantana
- Ground Cover: Bladey Grass, Kangaroo Grass, Lomandra

Adjacent Vegetation Type: Dry Sclerophyll Forest

Survey Results

- Stony Creek Frog (*Litoria lesueurii*) – 1 (ob)
- Rocket Frog (*Litoria nasuta*) - >100 (ob,w)
- Red Backed Toadlet (*Pseudophyrne coriacea*) – 1 (w)
- Eastern Dwarf Frog (*Litoria fallax*) – 35 (ob, w)
- Broad-palmed Frog (*Litoria latopalmeta*) – 15 (w)
- Pobblebonk (*Limnodynastes* sp) - >5 (w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): moderate
- Green-thighed Frog (*Litoria brevipalmata*): moderate
- Wallum Froglet (*Crinia tinnula*): nil
- Whirring Tree Frog (*Litoria revelata* sp): moderate

General Comments: Aquatic vegetation considered too sparse for bell frogs. Nearby ephemeral areas may be used by Green-thighed Frog.



Site No: 36 (West Side of Pacific Highway Opposite Darlington Park)

Picture Orientation: 010°

E: 517752 **N:** 6675079

Land Tenure: State Forest- Utilities

Waterbody Type: Ephemeral Drainage Line

Dimensions: 0.6 ha

Hydrological Features: Natural with ephemeral water body

Water Visibility: 0.5m

Substrate: Soil

Fringing Vegetation: Sedges (*Gahnia*, *Lomandra*)

Aquatic Vegetation Cover: n/a

Site Disturbance: Moderate (powerline, logging, fragmentation)

Surrounding Vegetation Type: Swamp Sclerophyll Forest

Dominant Species

- Overstorey: Forest Red Gum, Coastal Blackbutt, Broad-leaved Paperbark
- Midstorey: Broad-leaved Paperbark, White Mahogany, Swamp Box
- Understorey: Cheese Tree, Swamp Box, Broad-leaved Paperbark
- Shrublayer: *Leptospermum* sp, Broad-leaved Paperbark
- Ground Cover: Bladey Grass, Kangaroo Grass, *Gahnia*

Adjacent Vegetation Type: Dry Sclerophyll Forest

Survey Results:

- Graceful Tree Frog (*Litoria gracilentia*) – 7 (ob, w)
- Common Eastern Froglet (*Crinia signifera*) – 40 (ob, w)
- Red-backed Toadlet (*Pseudophyrne coriacea*) – >50 (w)
- Striped Marsh Frog (*Limnodynastes peroni*) – 6 (ob, w)

Suitability For Target Species

- Green and Golden Bell Frog (*Litoria aurea*): nil
- Green-thighed Frog (*Litoria brevipalmata*): moderate
- Wallum Froglet (*Crinia tinnula*): low
- Whirring Tree Frog (*Litoria revelata* sp): nil

General Comments: Suitable for Green-thighed Frog.



Site No: 37 (East Side of Pacific Highway Opposite Darlington Park)

Picture Orientation: 130°

E: 517964 **N:** 6675541

Land Tenure: Private

Waterbody Type: Series of Dams

Dimensions: 0.5 ha

Hydrological Features: Artificial construction with permanent water

Water Visibility: 0.7m

Substrate: Soil

Fringing Vegetation: Grasses (Paspalum and Carpet)

Aquatic Vegetation Cover: 35%

Site Disturbance: Severe (clearing, fragmentation, grazing)

Surrounding Vegetation Type: Agricultural

Dominant Species

Overstorey: Swamp Oak

Midstorey: Broad-leaved Paperbark

Understorey: Cabbage Palms, Callistemon sp.

Shrublayer: Swamp Oak

Ground Cover: Carpet Grass, Paspalum

Adjacent Vegetation Type: Dry Sclerophyll Forest

Survey Results:

Eastern Dwarf Frog (*Litoria fallax*) – 25 (ob, w)

Bleating Tree Frog (*Litoria dentata*) – 10 (w)

Rocket Frog (*Litoria nasuta*) – 3 (w)

Suitability For Target Species

Green and Golden Bell Frog (*Litoria aurea*): low

Green-thighed Frog (*Litoria brevipalmata*): low

Wallum Froglet (*Crinia tinnula*): nil

Whirring Tree Frog (*Litoria revelata* sp): low

General Comments: Generally unsuitable for target species.

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Supplementary Site One

Opposite Emerald Beach Turnoff

E: 517313 **N:** 6662885

Survey Results:

Common Eastern Froglet (*Crinia signifera*) – 10 (w)

Red-backed Toadlet (*Pseudophyrne coriacea*) – 15 (w)

Eastern Dwarf Frog (*Litoria fallax*) – 8 (w)

Striped Marsh Frog (*Limnodynastes peroni*) – 25 (w)

Supplementary Site Two

1 km South of Double Crossing Creek

E: 518560 **N:** 6665221

Survey Results:

Tyler's Tree Frog (*Litoria tyleri*) – 4 (w)

Eastern Dwarf Frog (*Litoria fallax*) – 25 (ob, w)

Striped Marsh Frog (*Limnodynastes peroni*) – 30 (ob, w)

Bleating Tree Frog (*Litoria dentata*) – 10 (w)

Smooth Toadlet (*Uperoleia laevisgata*) – 20 (w)

Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 1 (w)

Common Green Tree Frog (*Litoria caerulea*) – 2 (w)

Great Barred Frog (*Mixophyes fasciolatus*) – 2 (w)

Supplementary Site Three

0.2 km South of Double Crossing Creek

E: 518657 **N:** 6665765

Survey Results:

Graceful Tree Frog (*Litoria gracilentia*) – 3 (w)

Common Eastern Froglet (*Crinia signifera*) – 5 (w)

Smooth Toadlet (*Uperoleia laevisgata*) – 10 (w)

Red-backed Toadlet (*Pseudophyrne coriacea*) – 1 (w)

Striped Marsh Frog (*Limnodynastes peroni*) – >50 (ob, w)

Smooth Toadlet (*Uperoleia laevisgata*) – 20 (w)

Eastern Sign Bearing Froglet (*Crinia parinsignifera*) – 1 (w)

Common Green Tree Frog (*Litoria caerulea*) – 4 (w)

Supplementary Site Four

Powerline Easement 200m north of Embankment Road

E: 517622 **N:** 6673487

Survey Results:

Graceful Tree Frog (*Litoria gracilentia*) – 2 (w)

Common Eastern Froglet (*Crinia signifera*) – 50 (ob, w)

Smooth Toadlet (*Uperoleia laevisgata*) – 3 (w)

Red-backed Toadlet (*Pseudophyrne coriacea*) – >100 (w)

Striped Marsh Frog (*Limnodynastes peroni*) – 20 (ob, w)

APPENDIX TWO- ABIOTIC VARIABLES DURING THE SURVEY PERIOD

Table A. Abiotic variables recorded throughout the month of January 2006. Light shading denotes survey period. Data obtained from weather station 059040. Source: Bureau of Meteorology (2006).

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)	Direction of maximum wind gust	Speed of maximum wind gust (km/h)	3pm relative humidity (%)	3pm cloud amount (oktas)	3pm MSL pressure (hPa)
1/01/06	22.5	32.2	0	NNE	63	57	0	1012.3
2/01/06	20.5	27.6	0	S	54	63	7	1012.6
3/01/06	20.6	29	0			89	3	1005.4
4/01/06	22.7	24.8	2	S	37	65	7	1014.7
5/01/06	20.6	21.9	0	E	37	96	8	1013.2
6/01/06	19.9	22.9	118.8	SW	39	96	8	1009.8
7/01/06	20.8	25.6	72.8	SE	44	79	7	1013.2
8/01/06	20.4	26.1	29.2	ESE	50	77	7	1013.9
9/01/06	20.3	26.4	26.6	SW	37	88	6	1010.8
10/01/06	22.5	28	33	NE	41	80	4	1014.4
11/01/06	24.1	31	3.6	NNE	57	73	1	1011.2
12/01/06	22.8	27.7	13.4	NNE	26	84	1	1012.4
13/01/06	24	27.9	0	NE	28	83	8	1013
14/01/06	21.7	27.4	3.2	NNE	41	68	7	1012.6
15/01/06	20.9	28.7	0	ENE	31	69	5	1015
16/01/06	21.1	28.4	0.8	NE	37	68	5	1015.4
17/01/06	20.4	31	0	NNE	56	67	5	1009.5
18/01/06	22.1	25.6	3.8	S	39	74	7	1012.8
19/01/06	20.6	22.6	20.6	ESE	35	81	8	1018.2
20/01/06	20	26.5	40.2			73	7	1016.8
21/01/06	19.3	27.5	13.2	ENE	26	68	2	1013.8
22/01/06	18.8	27.8	0	E	26	64	2	1011.7
23/01/06	19.7	29.2	0	NE	48	71	1	1007.3
24/01/06	23.9	30.7	0	NE	39	74	1	1006.8
25/01/06	22	26.3	5.2	SSW	33	83	8	1015.6
26/01/06	20.2	28.6	0.2	E	26	62	1	1014
27/01/06	21.3	27.9	2.4	ENE	30	62	7	1011.4
28/01/06	19.2	27.8	0	ENE	28	52	1	1012.1
29/01/06	19.4	27.2	1	SE	33	68	7	1011.6
30/01/06	18.7	27.8	0	SW	30	68	1	1007.3
31/01/06	21.1	28.7	0	SSE	33	69	5	1007.5