17 Flora and fauna

This chapter details the flora and fauna species present within the study area and their status under relevant legislation. Impacts to flora and fauna species as a result of the Proposal are considered, as are management mitigation and measures proposed to ensure that identified ecological impacts are minimised.

17.1 Background and methodology

17.1.1 Background

Flora and fauna issues have been considered at each of the planning and development stages of the Sapphire to Woolgoolga Pacific Highway upgrade project, from the development and selection of the corridor and route options, through to the development and selection of the preferred route, and assessed by this environmental assessment. The following reports address flora and fauna issues:

- Sapphire to Woolgoolga Route Options Report, Ecological Assessment (Connell Wagner 2002).
- *Sapphire to Woolgoolga Supplementary Options Ecological Assessment* (Connell Wagner 2004).
- *Sapphire to Woolgoolga Fauna Investigations*, working paper 7a (Connell Wagner 2007).
- *Vegetation Survey of the Preferred Route for the Pacific Highway Upgrade between Sapphire and Woolgoolga*, working paper 7b (Ecos Environmental 2006).
- *Sapphire to Woolgoolga – Arrawarra Interchange Flora and Fauna*, working paper 7c (Connell Wagner 2007).
- Proposed Pacific Highway Upgrade between *Sapphire and Arrawarra – Targeted Frog Survey*, working paper 7d (Lewis Ecological Surveys 2006).

Potential impacts on biodiversity have been largely avoided as a result of the planning and preliminary assessment of impacts undertaken during the route options development process. Nevertheless, any proposed route within this region would have some impact on biodiversity. These potential impacts are discussed in the following sections.

17.1.2 Methodology

As part of the environmental assessment process, a number of ecological studies have been undertaken. These include separate fauna and flora studies (working papers 7a and 7b respectively), further flora assessment at Arrawarra (working paper 7c) and a frog survey (working paper 7d). All working papers are provided in Appendix F.

The flora assessment involved the following tasks:

- Review of previous vegetation mapping and reports incorporating the study area.
- Compilation of a list of threatened species potentially occurring in the study area.
- Field investigations comprising transects and quadrat surveys.
- Structural and floristic descriptions of vegetation communities, including species abundance
- Validation and modification of vegetation maps.
- Identification of threatened species, populations and communities listed under the NSW *Threatened Species Conservation Act, 1995* (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) potentially affected by the Proposal.
- Evaluating the impact of the Proposal on threatened species and communities in accordance with the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Climate Change 2005) and the *Significant Impact Guidelines – Matters of National Environmental Significance* (Department of Environment and Water Resources 2006).

The fauna assessment involved the following tasks:

- Development of a robust survey design in accordance with Department of Environment and Climate Change 2004 guidelines.
- Compilation of a list of threatened species potentially occurring in the study area.
- Surveys undertaken over four separate sessions during summer and autumn incorporating habitat searches, hair tubes, arboreal trapping, spotlighting, harp trapping, bat call detection, call playback, and bird census.
- Targeted surveys for threatened species known or having the potential to occur in the study area.
- Hollow-bearing tree survey.
- Aquatic habitat assessments.
- Specialist frog survey undertaken during optimal seasonal and weather conditions.
- Identification of threatened species, populations and communities listed under the NSW *Threatened Species Conservation Act, 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* potentially affected by the Proposal.
- Evaluating the impact of the Proposal on threatened species and communities in accordance with the draft Guidelines for *Threatened Species Assessment* (Department of Environment and Climate Change 2005) and the *Significant Impact Guidelines – Matters of National Environmental Significance* (Department of Environment and Water Resources 2006).

17.2 Existing ecological environment

The Proposal is situated in the NSW North Coast Bioregion, which is part of a zone known as the Macleay – McPherson overlap. The Macleay – McPherson overlap 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 eastern seaboard. The environmental characteristics allied with this overlap are associated with a highly diverse array of species (NPWS 1994).

With regard to vegetation, in the north of the bioregion soils derived from basalts, support sub-tropical and warm temperate rainforests, or wet sclerophyll forests, while in the south of the bioregion on the Barrington Plateau, cool temperate species are more common.

Forests occurring on soils derived from granites are mainly eucalypt vegetation communities. The dominant species include blackbutt (*Eucalyptus pilularis*), Sydney blue gum, spotted gum (*Eucalyptus maculata*), grey gum (*Eucalyptus punctata*), forest red gum (*Eucalyptus tereticornis*), red bloodwood (*Corymbia gummifera*), brush box (*Tristania conferta*) and white mahogany. Estuaries are dominated by mangrove communities and saltmarsh species.

With regard to significant flora and fauna, 202 flora species found in the bioregion are listed in the schedules of the *Threatened Species Conservation Act 1995* (NPWS 2001). Of these, 108 are endangered, 89 are vulnerable and 5 are considered extinct in the bioregion. 157 fauna species recorded in the North Coast Bioregion are listed in the schedules of the *Threatened Species Conservation Act 1995* (NSW NPWS 2001). Of these, 36 are listed as endangered and 121 are listed as vulnerable.

Of the bioregions in NSW, the North Coast Bioregion has the second highest area of conservation land. Land under conservation tenures occupy about 1,061,709 hectares or 18.65 per cent of the bioregion. National parks and nature reserves (under the *National Parks and Wildlife Act 1974*) make the greatest contribution to the area conserved. Other areas include world heritage areas, Aboriginal areas, historic sites and land under voluntary conservation agreements.

The Proposal has been described in terms of a southern upgrade section that includes duplication of the existing highway and introduction of local access roads, generally within or adjacent to the existing road reserve and a northern "bypass" section that includes new carriageways traversing private land and Wedding Bells State Forest to the west of the existing Pacific Highway. The vegetation in the upgrade section varies from cleared areas to regenerating vegetation and mature forest. In the bypass section, the private land consists of cleared areas, banana plantations and other crops and native forest. The northern part of the bypass section through the Wedding Bells State Forest would affect relatively intact areas of native forest.

17.2.1 Existing flora

The flora survey area included the footprint of the Proposal (refer Figures 7.2a to 7.2m) and up to 50 metres either side of the road centreline depending on the extent of native vegetation. A total of 479 plant species were recorded during the flora surveys, consisting of 411 native species and 68 naturalised or exotic species (refer Chapter 3 of the working paper 7b).

The two broad vegetation types occurring along the Proposal alignment are *Coastal Hills Moist Open Forest* (comprising five communities) and *Coastal Floodplain Forest* (comprising four communities). The *Coastal Hills Moist Open Forest* occurs on the hilly terrain adjoining the coastal floodplain, while the *Coastal Floodplain Forest* is the predominant vegetation type in the low-lying central part of the Proposal (refer Figures 17.1a to 17.1d). The Proposal also intersects a very small area of Estuarine Complex and a few small stands of Littoral Rainforest and Lowland Rainforest occurring in protected gullies.

The 12 vegetation communities identified along the Proposal are grouped under broad vegetation types in Table 17.1 below. These vegetation communities incorporate five endangered ecological communities listed in the *Threatened Species Conservation Act 1995* and recorded on or closely adjoining the proposed road footprint. No endangered ecological communities listed on the *Environment Protection and Biodiversity Conservation Act 1999* were recorded within the survey area.

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Refer Figures 17.1a to 17.1d

TABLE 17.1 VEGETATION COMMUNITIES PRESENT ALONG THE PROPOSED ROUTE

COMMUNITY (indicator species dominant or co-dominant)	ENDANGERED ECOLOGICAL COMMUNITY (*Threatened Species Conservation Act 1995*)
Rainforest	
Brush Box – Guioa – Native Olive Native Olive – Strangler Fig – Brush Cherry	Littoral Rainforest Lowland Rainforest on Floodplain
Coastal hills moist open forest	
Blackbutt Flooded Gum Grey Gum – Grey Ironbark Spotted Gum Narrow-leaved White Mahogany	
Coastal floodplain forest	
Red Mahogany Smooth-barked Apple Broad-leaved Paperbark / Swamp Mahogany Swamp Oak	Swamp Sclerophyll Forest on Floodplain Swamp Sclerophyll Forest on Floodplain Swamp Sclerophyll Forest on Floodplain Swamp Oak Floodplain Forest
Estuarine complex	
Swamp Oak – Saltwater Couch	Coastal Saltmarsh

Four threatened flora species listed under the *Threatened Species Conservation Act 1995* were recorded within the survey area. Two of these species are also listed under the *Environment Protection and Biodiversity Conservation Act 1999* (refer Table 17.2).

TABLE 17.2 THREATENED FLORA SPECIES IDENTIFIED WITHIN THE SURVEY AREA

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS[1]	
		TSC Act	EPBC Act
Marsdenia longiloba	Slender Marsdenia	E	V
Lindsaea incisa	–	E	–
Amorphospermum whitei	Rusty Plum	V	–
Quassia sp. Moonee Creek	Moonee Quassia	E	E

[1] E = endangered; V = vulnerable

17.2.2 Existing fauna

The fauna survey was undertaken within a corridor up to 500 metres either side of the centreline of the Proposal. Seven broad habitat types were identified in the vicinity of the Proposal: Dry Open Forest, Moist Open Forest, Rainforest, Swamp Sclerophyll Forest, Swamp Oak Floodplain Forest, Freshwater Wetland and Estuarine Wetland. The most common habitats were Dry Open Forest, Moist Open Forest and Swamp Sclerophyll Forest.

A total of 184 species, consisting of 12 reptiles, 22 amphibians, 44 mammals (16 bats) and 106 birds, were recorded during the surveys. This included 16 species listed as threatened under the *Threatened Species Conservation Act 1995* and one species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Four migratory bird species listed under the *Environment Protection and Biodiversity Conservation Act 1999* were also recorded (refer Table 17.3). The Department of Environment and Climate Change Atlas of NSW Wildlife and Department of Environment and Water Resources protected matters search tool indicate that additional threatened species to those recorded during the field surveys have the potential to occur in the habitats identified in proximity to the Proposal.

TABLE 17.3 THREATENED FAUNA SPECIES (INCLUDING MIGRATORY SPECIES) IDENTIFIED WITHIN THE SURVEY AREA

SCIENTIFIC NAME	COMMON NAME	CONSERVATION STATUS[1]	
		TSC Act	EPBC Act
Litoria brevipalmata	Green-thighed Frog	V	–
Crinia tinnula	Wallum Froglet	V	–
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	–
Coracina lineata	Barred-Cuckoo-shrike	V	–
Pandion heliaetus	Osprey	V	–
Ninox strenua	Powerful Owl	V	–
Cercartetus nanus	Eastern Pygmy-possum	V	–
Petaurus norfolcensis	Squirrel Glider	V	–
Petaurus australis	Yellow-bellied Glider	V	–
Pteropus poliocephalus	Grey-headed Flying-Fox	V	V
Myotis adversus	Large-footed Myotis	V	–
Miniopterus australis	Little Bent-wing Bat	V	–
Miniopterus schreibersii	East Bent-wing Bat	V	–
Scoteanax rueppellii	Greater Broad-nosed Bat	V	–
Syconycteris australis	Eastern Blossom Bat	V	–
Mormopterus norfolkensis	East Coast Freetail Bat	V	–
Haliaeetus leucogaster	White-bellied Sea-Eagle	–	M
Hirundapus caudacutus	White-throated Needletail	–	M
Monarcha melanopsis	Black-faced Monarch	–	M
Rhipidura rufifrons	Rufous Fantail	–	M

[1] M = migratory; V = vulnerable

All the threatened species are listed under the *Threatened Species Conservation Act 1995*, with only the Grey-headed Flying-fox also listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

With respect to fauna species, the Proposal has been referred to the Department of Environment and Water Resources based on potential impacts to matters of national environmental significance. The referral outlines the potential (minor) impact on the habitat of the Grey-headed Flying-fox and four migratory bird species (White-bellied Sea-Eagle, White-throated Needletail, Black-faced Monarch and Rufous Fantail).

Important fauna resources within the habitats identified include hollow-bearing trees, foraging resources such as winter-flowering tree species, and watercourses. Approximately 311 trees bearing hollows ranging in size from small (less than 10 centimetres) to large (greater than 30 centimetres) were recorded during field surveys. The survey for hollow-bearing trees extended approximately 25 metres either side of the proposed road centreline through the Wedding Bells State Forest. A large number of the hollow-bearing trees were recorded within a four kilometre section where the Proposal passes through Wedding Bells State Forest. The majority of the hollows in this section were associated with stags (dead standing trees), which had been ring-barked during past forestry management practices. Additional surveys within Wedding Bells State Forest adjacent to the Proposal were undertaken to compare the frequency of hollows within the area to be disturbed and other areas of the state forest. The surveys showed that there was a similar frequency of hollows between the areas.

Winter flowering trees species such as Broad-leaved Paperbark (*Melaleuca quinquenervia*) and Tallowwood (*Eucalyptus microcorys*) occur relatively commonly throughout the study area. A number of fauna species require winter-flowering plants to supply seasonal forage when the abundance of other food resources, such as insects, is low, or to coincide with migratory movements. As such, the presence or absence of winter-flowering species can be a limiting factor for a number of threatened species.

Watercourses within the study area such as Cunninghams Creek, Skinners Creek, Moonee Creek, Double Crossing Creek, Woolgoolga Creek and Arrawarra Creek provide habitat for aquatic species.

Threatened aquatic species

Two threatened fish species listed under the *Fisheries Management Act 1994* have a distribution encompassing or close to the study area, these are the Oxleyan Pygmy Perch and the Eastern Freshwater Cod.

Oxleyan Pygmy Perch are found almost exclusively in swamps, streams and lakes in coastal lowland banksia dominated heath ecosystems, characterised by waterbodies with low salinity and conductivity, and high organic content and acidity. The creeks and watercourses crossed by the Proposal do not include any areas of this habitat type.

The study 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. 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.

17.3 Potential impacts of the Proposal

17.3.1 General impacts

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

- Loss of native vegetation, including areas of endangered ecological community.
- Removal of threatened plants.
- 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.

Potential impacts on ecology have been minimised and avoided during the development of the concept design. The potential impact on native flora and fauna has been considered during the route investigation phase and subsequently through the refinement of the concept design of the Proposal. During this process a number of important measures to reduce and avoid potential impacts relating to key threatening processes have been built into the project design. The environmental management measures identified to avoid and / or minimise the impacts on ecology are detailed in Section 17.4 and the draft Statement of Commitments (refer Appendix A).

The main impact on flora would occur during the construction phase of the Proposal, while potential impacts on fauna could occur during both the construction and operation phases of the Proposal.

17.3.2 Potential flora impacts

Vegetation communities

Impacts on native vegetation communities would predominantly occur in the bypass section where the Proposal traverses forested private land and Wedding Bells State Forest. The upgrade section has typically fewer areas of native vegetation.

The area of each vegetation community that would be removed or disturbed by the Proposal is presented in Table 17.4 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 17.4 EXTENT OF VEGETATION REMOVAL BY VEGETATION TYPE

BROAD VEGETATION TYPE	COMMUNITY	ENDANGERED ECOLOGICAL COMMUNITY (TSC Act)	EXTENT OF LOSS (Ha)
Rainforest	Brush Box – Guioa – Native Olive	Littoral Rainforest	1.1
	Native Olive – Strangler Fig – Brush Cherry	Lowland Rainforest on Floodplain	1.0
Coastal hills moist open forest	Blackbutt	–	40.9
	Flooded Gum	–	5.3
	Grey Gum – Ironbark	–	8.7
	Spotted Gum	–	5.1
	Narrow-leaved White Mahogany	–	4.9
Coastal floodplain forest	Red Mahogany	Swamp Sclerophyll Forest	1.3
	Smooth-barked Apple	Swamp Sclerophyll Forest	0
	Broad-leaved Paperbark / Swamp Mahogany	Swamp Sclerophyll Forest	9.5
	Swamp Oak	Swamp Oak Floodplain Forest	5.3
Estuarine complex	Swamp Oak – Saltwater Couch	Coastal Saltmarsh	0
Total			**83.1**

The Proposal would result in the removal of approximately 83.1 hectares of native vegetation. The *Blackbutt Coastal Hills Moist Open Forest* community would incur the greatest loss, being approximately 40.9 hectares. This is the dominant community within the northern section where the Proposal traverses Wedding Bells State Forest. The dominant community on the low lying central section of the Proposal is *Paperbark – Swamp Mahogany Coastal Floodplain Forest*. This community would incur a loss of 9.5 hectares. The remaining communities would be affected to a lesser extent with two of the associations not likely to be affected at all.

Endangered ecological communities

Five endangered ecological communities listed under the *Threatened Species Conservation Act 1995* were recorded in the vicinity of the Proposal. No endangered ecological communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* were identified. While these communities are included to the extent of vegetation removal shown in Table 17.4 above, the extent of clearing for each community is presented separately in Table 17.5.

TABLE 17.5 EXTENT OF REMOVAL OF ENDANGERED ECOLOGICAL COMMUNITIES

ENDANGERED ECOLOGICAL COMMUNITY (TSC Act)	EXTENT OF LOSS (Ha)
Littoral Rainforest	1.1
Lowland Rainforest on Floodplain	1.0
Swamp Sclerophyll Forest on Coastal Floodplains	10.8
Swamp Oak Floodplain Forest	5.3
Coastal Saltmarsh	0
Total	**18.2**

The impact on endangered ecological communities listed under the *Threatened Species Conservation Act 1995* was assessed using the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation 2005). None of the endangered ecological communities recorded are considered likely to be significantly affected by the Proposal. A summary of the likely impacts is presented below with the full assessments provided in Appendix G of this report.

Littoral Rainforest

Small areas of Littoral Rainforest occur on the eastern and western side of the existing highway in the upgrade section of the Proposal at Sapphire Beach. Some areas of this community are degraded due to the adjacent cleared land and surrounding residential areas. This community would be affected by the Proposal (on the western side of the existing highway) at Sapphire Beach.

Littoral Rainforest occurs only on the coast and is found at locations in the NSW North Coast Bioregion, Sydney Basin Bioregion and South East Corner Bioregion. In total, it comprises less than one percent of the total area of rainforest in NSW. The largest known stand occurs in Iluka Nature Reserve, which is about 136 hectares in size (NPWS 2007).

Lowland Rainforest on Floodplain

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 affected by the Proposal. Approximately one hectare would be removed from a larger area of the community where the Proposal crosses Newmans Road.

On the NSW north coast Lowland Rainforest on Floodplain occurs only as small remnants in scattered localities, with less than 1000 hectares in total thought to remain (NPWS 2007).

Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest

Swamp Sclerophyll Forest is fairly common in the section of the Proposal between Sandy Beach and Moonee Beach. Within this section, the Proposal is largely contained within the existing road reserve extending slightly into adjoining properties at various locations. Much of the Swamp Sclerophyll Forest within the road reserve is young regrowth with moderate to high levels of common exotic species in the understorey.

Regrowth in the road reserve is often dominated by Swamp Oak, even though the adjacent swamp forest outside the road reserve is dominated by Broad-leaved Paperbark of Swamp Sclerophyll Forest. This phenomenon is commonly seen along roadsides where these species co-occur and may be the result of Swamp Oak colonising disturbed ground more readily. This change in species composition can create problems in determining the vegetation type; however, as both Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest are endangered ecological communities, it does not affect the determination of the conservation status of the vegetation. The Proposal would require the clearing of 10.8 hectares of Swamp Sclerophyll Forest and 5.3 hectares of Swamp Oak Floodplain Forest.

Both the Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest are fairly widespread on the coastal floodplain adjacent to the Proposal, although their extent has been greatly reduced by land clearing. The impact on these endangered ecological communities has been minimised by containing the development footprint predominantly within the current road reserve at the central and upgrade sections of the Proposal. Occurrences of these communities within the road reserve generally consist of regrowth in poorer condition than examples found on adjacent land including private land, Coffs Harbour City Council land and state forests land.

Coastal Saltmarsh

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. However, environmental measures to protect soil and water quality would be implemented to ensure no indirect impacts on this community as a result of construction activities.

In 1985 it was estimated that the total area of coastal saltmarsh in NSW was approximately 5700 hectares distributed in fragmented patches mostly less than 100 hectares. Since this estimate, further reduction and fragmentation has occurred (NSW Scientific Committee 2004).

Mitigation measures to minimise the area of clearing and disturbance to endangered ecological communities are outlined in Section 17.4.

Threatened flora species

The impact on threatened flora species was assessed using the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation 2005) for species listed under the *Threatened Species Conservation Act 1995* and the *Significant Impact Guidelines – Matters of National Environmental Significance* (Department of Environment and Water Resources 2006) for species listed under the *Environment Protection and Biodiversity Conservation Act 1999*. None of the threatened species recorded during surveys are considered likely to be significantly affected by the Proposal. A summary of the likely impacts is presented below with the full significance assessments provided in Appendix G of this report. Measures to minimise the impacts on these species are detailed in Section 17.4.

Slender Marsdenia

Slender Marsdenia (*Marsdenia longiloba*) is a slender vine, growing to five metres in height in moist open forest. The species is extremely rare and is listed as endangered under the *Threatened Species Conservation Act 1995* and vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*. A population consisting of 20 to 30 plants was identified on the eastern side of the existing highway north of Gaudrons Road at mid-Sapphire. This population extends over a distance of approximately 50 metres within Grey Gum-Grey Ironbark Forest, which is in good condition with few weeds.

The Proposal would not directly affect the population of Slender Marsdenia, which is located to the east of the existing highway. There are no proposed works in the immediate vicinity of the population. However, construction of the Gaudrons Road / Split Solitary Road interchange to the south would require measures to ensure that construction machinery and personnel are excluded from the area containing the threatened species (refer Section 17.4).

Lindsaea incisa

Lindsaea incisa is a small ground fern with slender erect fronds 10 to 20 centimetres long which arise from a rhizomatous root system. This species grows in heathy open forest grading into swamp sclerophyll forest on seasonally waterlogged or poorly drained sites. It is listed as endangered under the *Threatened Species Conservation Act 1995*. *Lindsaea incisa* was identified at a single location on the western side of the existing highway in Orara East State Forest south of Bucca Road. The plants

occur as a single patch approximately 30 metres west of the existing highway, occupying an area of approximately eight metres by two metres and consisting of 200 to 300 stems.

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*. While the Proposal would not directly affect the patch of *Lindsaea incisa*, construction of the proposed service road would require measures to ensure that construction machinery and personnel are excluded from the area containing the threatened species (refer Section 17.4).

Rusty Plum

Rusty Plum (*Amorphospermum whitei*) is a medium-sized tree with typical habitat consisting of gully rainforest or wet sclerophyll forest with a well developed rainforest understorey. It is listed as vulnerable under the *Threatened Species Conservation Act 1995*. Four individuals of this species are present at mid-Sapphire, eight individuals in the vicinity of Woolgoolga Creek, and one individual approximately 400 metres north of Woolgoolga Creek.

Eight of the 13 individuals identified could be affected by the Proposal. The eight individuals are made up of:

- Three individuals at mid-Sapphire, located on the western side of the existing highway. These individuals would require removal for the proposed northbound carriageway.
- Five of the eight individuals located at Woolgoolga Creek would be affected by the dual carriageways, associated embankments and construction access required for bridge construction.

Rusty Plum was recorded at several locations during the route options development phase of the proposed project. A large number of trees were recorded in the upper catchment of Woolgoolga Creek with other populations identified at Slaters Crossing Road, Bark Hut Creek and Moonee Creek. Survey work indicated that Rusty Plum is fairly widespread in rainforest and wet sclerophyll forests surrounding the study area. While this species is rare close to the coast due to clearing and development, it is reasonably common in the hinterland. To minimise the impact on this species, an investigation into the feasibility of relocating the species to suitable habitat on nearby land in secure tenure (in accordance with the Australian Network for Plant Conservation 2004 guidelines) would be undertaken (Section 17.4). It should be noted that this species has been successfully relocated on the Bonville Deviation Project south of Coffs Harbour.

Moonee Quassia

Moonee Quassia (*Quassia sp.* Moonee Creek) is a shrub to two metres high, which grows in wet sclerophyll forest and heathy open forest on sandstone and metasediment. It is listed as endangered under both the *Threatened Species Conservation Act 1995* and *Environment Protection and Biodiversity Conservation Act 1999*. Narrow-leaved Quassia was identified from one location in the vicinity of the road corridor, on the western side of the existing highway north of Wakelands Road. This population extends west from the road reserve for approximately 150 metres and contains approximately 70 plants, four of which are located within the road reserve.

The four plants within the road reserve are located approximately 15 metres from the construction footprint and would not be required to be removed for construction of the Proposal.

While this species has a relatively restricted distribution, from the Moonee Creek area to north-east of Grafton, a number of populations occur in state forests in the hinterland ranges including Wedding Bells, Orara East and Conglomerate state forests.

Typhonium sp

A *Typhonium* species without flowers was recorded in December 2005 on the eastern side of the proposed alignment, approximately 75 metres south of Newmans Road. This could be *Typhonium*

brownii, a relatively common species, or the endangered species *Typhonium* sp. *Aff. brownii*. These species can only be distinguished by their flowers, none of which were present despite surveys undertaken during the flowering period. In the absence of a conclusive identification, the principle of uncertainty has been applied and the population has been treated as being that of the *Threatened Species Conservation Act 1995* listed (endangered) *Typhonium* sp. *Aff. brownii* unless proven otherwise. The concept design was refined to minimise the potential impact on this species. These plants are located approximately 12 metres to the east of the proposed road footprint and measures to protect them during construction would be implemented unless subsequent surveys identify them as the common *Typhonium brownii* species (Section 17.4).

Other threatened species

In addition to the naturally occurring threatened species described above, two non-indigenous (not native to the study area) threatened species were recorded during the survey. Rough-shelled Bush Nut (*Macadamia tetraphylla*) is listed as threatened under the *Threatened Species Conservation Act 1995 and Environment Protection* and *Biodiversity Conservation Act 1999* and is indigenous to the Richmond-Tweed region. One planted tree was recorded in the grounds of the old forestry station on Woolgoolga Creek Road and one wild growing juvenile was recorded in a wet sclerophyll gully near Bark Hut Road. Neither of these plants is expected to be affected by the Proposal.

A single juvenile of Red Bopple Nut (*Hicksbeachia pinnatifolia*), which is listed as threatened under the *Threatened Species Conservation Act 1995*, was recorded at the old forestry station on Woolgoolga Creek Road in an area of planted rainforest that included other non-indigenous natives. This plant occurs to the north of the road footprint and would not be affected by the Proposal.

Suitable habitat exists for the Swamp Orchid (*Phaius australis*) within the Arrawarra interchange 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. To enable the presence or absence of this species to be confirmed and the potential impact quantified, surveys will be undertaken during the flowering period of September to October within the footprint of the Arrawarra interchange.

The Moonee Quassia (*Quassia sp.*) and Slender Marsdenia (*Marsdenia longiloba*) are included in the referral submitted to the Commonwealth Department of Environment and Water Resources. Mitigation measures in relation to threatened flora species affected by the Proposal are outlined in Section 17.4.

17.3.3 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.

Habitat removal

The broad habitat types present along the road corridor include moist open forest, rainforest, floodplain forest, estuarine complex 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, and creeks and drainage lines.

The area of each vegetation community that would be removed as a result of the Proposal is identified in Table 17.4 above. The greatest loss of hollow bearing trees would be within the moist open forest communities, with the highest density occurring within Wedding Bells State Forest. Approximately 154 hollow bearing trees would be removed during construction of the Proposal, with 84 of these located within Wedding Bells State Forest. While a large number of hollows were present within the road corridor, investigations identified that a similar density of hollow bearing trees occurs within adjacent areas of Wedding Bells State Forest, indicating that while this is a

valuable habitat resource it is not rare within the local area.

Winter-flowering species such as Broad-leaved Paperbark and Tallowwood occur within the moist open forest and swamp sclerophyll forest communities and removal of these habitats would reduce the availability of seasonal food sources for fauna species within the local area. While the Proposal would result in the loss of approximately 76 hectares of these communities, similar habitats containing winter flowering species are present within the local area. Moonee Beach Nature Reserve to the east of the existing highway (total area approximately 350 hectares) and Wedding Bells State Forest (total area approximately 5300 hectares) and Orara State Forest (total area approximately 4400 hectares) to the west contain extensive areas of similar habitats within the local area.

Other habitat features that would be affected by the Proposal, such as fallen timber and leaf litter, dense understorey vegetation, and open grassy understorey vegetation, are also present within the local area on private land, Moonee Beach and Sherwood nature reserves, and Wedding Bells and Orara East state forests.

Not all habitat within the footprint of the Proposal would be removed. Some fauna species can utilise man-made structures as habitat, such as microchiropteran bats which are known to utilise bridges and culverts for roosting. Within the study area several microchiropteran species were recorded in the vicinity of man-made structures such as the existing culverts and bridges of the Pacific Highway. The majority of these structures would not be affected by the Proposal and many new structures would be introduced, which may create new habitat for microchiropteran species. The NSW Roads and Traffic Authority (RTA) will undertake surveys for threatened bat species to identify any roosting bats prior to the demolition of existing highway bridges. The surveys will include bridge inspections by a qualified ecologist to identify any roosting bats. If found, any bats would be moved and relocated in accordance with a protocol to be developed in consultation with the Department of Environment and Climate Change (refer Section 17.4).

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 can be problematic when it creates areas of native vegetation, which become too small to support viable populations of native flora and fauna. This may lead to the fragmented area becoming weed infested and degraded and utilised by aggressive fauna species suited to edge environments such as the introduced Noisy Miner (*Manorina malanocephala*).

The southern and central sections of the Proposal, comprising mainly duplication of the existing carriageway and access roads, pass through a mosaic landscape consisting of residential, rural residential, agricultural and cleared land, as well as patches of remnant bushland of various sizes. Due to the already fragmented nature of the landscape and the presence of the existing highway, the Proposal would not cause additional isolation or fragmentation of any substantial areas of remnant bushland.

The southern and central parts of the bypass section of the Proposal pass through a fragmented landscape similar to that of the upgrade section described above, with some fragmentation at the individual property level occurring as a result of the Proposal. The northern part of the bypass would pass through Wedding Bells State Forest and would create two large areas of native forest. An extensive area of state forest land would be located to the west of the Proposal with a smaller

but still substantial area of forested land located to the east of the Proposal. The potential impacts of habitat fragmentation on fauna are discussed below.

Edge effects were calculated for newly created corridors, generally for patches of vegetation larger than 100 metres by 100 metres. Approximately three kilometres of vegetation would be subject to newly created edge effects as a result of the Proposal. Based on edge effects occurring up to 50 metres from the road edge, approximately 18 hectares of vegetation would be subject to edge effects as a result of the Proposal (using a factor of 0.6 in accordance with the RTA's *Edge Effect Policy*).

Barriers to fauna movement

The bypass section has the potential to act as a barrier to ground dwelling and arboreal fauna movement within the local area. Barrier effects are greater for smaller ground dwelling animals, which are generally less mobile, such as reptiles and amphibians. However, these species are likely to use fauna underpasses, culverts and bridge openings where they exist to cross between areas of habitat separated by the Proposal.

Highly mobile species such as birds and bats are the least likely to be affected by physical barriers such as a highway as the majority of these species are able to fly across it. At locations such as Double Crossing Creek, where aquatic birds may be present, the proposed carriageway incorporates a bridge, which would allow these species to fly either over or under the proposed and existing bridges. The Proposal is unlikely to have an adverse impact on bird movements within the local area.

Mammals are the fauna group whose movements are most likely to be affected by the Proposal. Where ground dwelling mammals can gain access to the road reserve, they are likely to be repelled by the highway or in the absence of fauna underpasses or drainage culverts, would be unable to cross the highway without risk of being struck by a vehicle. To reduce the risk of vehicles colliding with fauna, fauna exclusion fencing would be established at the locations identified in Table 17.6 and shown in Figures 17.1a to 17.1d. The fauna exclusion fencing locations are indicative only and would be further refined during the detailed design process in consultation with the Department of Environment and Climate Change.

TABLE 17.6 APPROXIMATE LOCATIONS FOR FAUNA EXCLUSION FENCING [1]

APPROXIMATE CHAINAGE	DETAILS
9.060 km to 9.460 km	Fencing along both sides of the highway
10.220 km to 11.700 km	Fencing along both sides of the highway
12.400 km to 12.800 km	Fencing along eastern side of the highway
12.500 km to 12.800 km	Fencing along western side of the highway
14.000 km to 17.800 km	Fencing along both sides of the highway
19.100 km to 20.480 km	Fencing along eastern side of the highway
19.550 km to 20.350 km	Fencing along western side of the highway
21.650 km to 22.020 km	Fencing along western side of the highway
21.700 km to 22.100 km	Fencing along eastern side of the highway
24.700 km to 26.300 km	Fencing along the eastern side of the highway
24.770 km to 26.300 km	Fencing along the western side of the highway
26.600 km to 27.000 km	Fencing along both sides of the highway
28.550 km to 32.450 km	Fencing along both sides of the highway

1 Locations are indicative only and would be further refined during the detailed design process.

Arboreal mammals such as Sugar Gliders, Squirrel Gliders and Yellow-bellied Gliders can potentially glide over a physical barrier such as a highway, depending on the proximity of adjacent canopy trees. However, some species cannot glide more than approximately 60 metres, which makes a dual carriageway highway a potential barrier. The potential impact to arboreal fauna movement is likely to be greatest at the bypass section of the Proposal (within Wedding Bells

State Forest) where glider species have been recorded on both sides of the proposed highway alignment and where no barrier to fauna movement currently exists.

The potential impact of the Proposal on terrestrial fauna movement has been addressed in the concept design with the inclusion of facilities for fauna passage under bridge structures along the route as well as the incorporation of dedicated fauna underpasses and fauna friendly culverts at the locations shown in Figures 17.1a to 17.1d and Table 7.5. Within the bypass section where the alignment traverses Wedding Bells State Forest, purpose-designed structures would be incorporated to facilitate glider crossing over the highway. The location of these structures would be subject to further refinement in the detailed design stage and be introduced in consultation with the Department of Environment and Climate Change (refer Section 17.4).

The Department of Environment and Climate Change (then NSW National Parks and Wildlife Service (NPWS)) has identified wildlife corridors for the NSW North Coast and this includes two regional and a subregional wildlife corridors traversed by the Proposal (refer Figures 17.1a to 17.1d). These corridors are traversed by the existing highway, which does not currently incorporate fauna underpasses or specifically designed fauna friendly culverts. The new carriageway design allows for fauna passage in the vicinity of each identified corridor location.

Wildlife injury and mortality

The potential for wildlife injury or death would occur during both the construction and operation phases of the Proposal. 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 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. 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.

Operation of the Proposal introduces an increased risk of wildlife injury or mortality as a result of wildlife being struck by a vehicle. The risk is greatest for less mobile species, which may include small terrestrial mammals, reptiles and amphibians. The greater the distance fauna must travel across a road, the greater the risk of collision. The upgrade section would potentially result in an increased risk of road kill or injury because of the additional sections of road (additional carriageway and local access road) that must be crossed by fauna. To mitigate this risk fauna exclusion fencing, fauna underpasses and fauna friendly culverts (refer Figures 17.1a to 17.1d) have been included in the concept design at locations where the highway bisects relatively large areas of native vegetation where fauna are likely to cross and at known wildlife corridors. At two locations of the proposed fauna crossings, south of Maccues Road and south of Fiddaman Road, the local access road is in proximity to the highway. At these locations the local access road will also incorporate fauna friendly culverts.

The bypass section through Wedding Bells State Forest includes provision of fauna crossings approximately every 500 metres where topography permits. Exclusion fencing to direct fauna towards the fauna crossings would maximise the use of these structures by local fauna.

Threatened and migratory fauna species

Of the 184 species recorded during the fauna surveys, 16 are listed as threatened under the *Threatened Species Conservation Act 1995*, with one species also listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Four migratory bird species listed under the *Environment Protection and Biodiversity Conservation Act 1999* were also recorded. The Department of Environment and Climate Change Atlas of NSW Wildlife indicates a number of additional threatened species have the potential to occur in the locality. Based on the habitat requirements of these species, an assessment of the potential for these species to occur within the study area was undertaken. The resultant list of threatened species recorded or with the potential to occur in the study area is provided in Table 17.7.

TABLE 17.7 THREATENED FAUNA SPECIES RECORDED OR POTENTIALLY OCCURRING WITHIN THE STUDY AREA

SCIENTIFIC NAME	COMMON NAME	TSC Act [1]	EPBC Act [1]	OCCURRENCE
Reptiles				
Coeranoscincus reticulatus	Three-toed Snake-tooth Skink	V	V	Potential
Amphibians				
Litoria brevipalmata	Green-thighed Frog	V	–	Recorded
Crinia tinnula	Wallum Froglet	V	–	Recorded
Mixophyes iteratus	Giant Barred Frog	E	E	Potential
Litoria aurea	Green and Golden Bell Frog	E	V	Potential
Litoria olongburensis	Wallum Sedge Frog	V	V	Potential
Birds				
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	–	Recorded
Coracina lineata	Barred-Cuckoo-shrike	V	–	Recorded
Pandion heliaetus	Osprey	V	–	Recorded
Ninox strenua	Powerful Owl	V	–	Recorded
Cyclopsitta diophthalma coxeni	Coxen's Double-eyed Fig-Parrot	E	E	Potential
Monarcha leucotis	White-eared Monarch	V	–	Potential
Ptilinopus regina	Rose-crowned Fruit-Dove	V	–	Potential
Ptilinopus superbus	Superb Fruit-Dove	V	–	Potential
Turnix melanogaster	Black-breasted Button-quail	E	V	Potential
Erythrotriorchis radiatus	Red Goshawk	E	V	Potential
Lathamus discolor	Swift Parrot	E	E	Potential
Lophoictinia isura	Square-tailed Kite	V	–	Potential
Melanodryas cucullata	Hooded Robin	V	–	Potential
Xanthomyza phrygia	Regent Honeyeater	E	E	Potential
Tyto novaehollandiae	Masked Owl	V	–	Potential
Dromaius novaehollandiae	Emu	E2	–	Potential
Ephippiorhynchus asiaticus	Black-necked Stork	E	–	Potential
Irediparra gallinacea	Comb-crested Jacana	V	–	Potential
Stictonetta naevosa	Freckled Duck	V	–	Potential
Climacteris picumnus	Brown Treecreeper	V	–	Potential
Haliaeetus leucogaster	White-bellied Sea-Eagle	–	M	Recorded
Hirundapus caudacutus	White-throated Needletail	–	M	Recorded
Monarcha melanopsis	Black-faced Monarch	–	M	Recorded
Rhipidura rufifrons	Rufous Fantail	–	M	Recorded
Merops ornatus	Rainbow Bee-eater	–	M	Potential
Mammals				
Cercartetus nanus	Eastern Pygmy-possum	V	–	Recorded
Petaurus norfolcensis	Squirrel Glider	V	–	Recorded
Petaurus australis	Yellow-bellied Glider	V	–	Recorded
Pteropus poliocephalus	Grey-headed Flying-Fox	V	V	Recorded
Myotis adversus	Large-footed Myotis	V	–	Recorded
Miniopterus australis	Little Bent-wing Bat	V	–	Recorded
Miniopterus schreibersii	East Bent-wing Bat	V	–	Recorded
Scoteanax rueppellii	Greater Broad-nosed Bat	V	–	Recorded
Syconycteris australis	Eastern Blossom Bat	V	–	Recorded
Mormopterus norfolkensis	East Coast Freetail Bat	V	–	Recorded
Aepyprymnus rufescens	Rufous Bettong	V	–	Potential
Dasyurus maculatus	Spotted-tailed Quoll	V	E	Potential
Phascogale tapoatafa	Brush-tailed Phascogale	V	–	Potential
Phascolarctos cinereus	Koala	V	–	Potential
Potorous tridactylus	Long-nosed Potoroo	V	V	Potential
Planigale maculata	Common Planigale	V	–	Potential
Pseudomys oralis	Hastings River Mouse	E	E	Potential
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Potential
Chalinolobus nigrogriseus	Hoary Wattled Bat	V	–	Potential
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	–	Potential
Kerivoula papuensis	Golden-tipped Bat	V	–	Potential
Nyctophilus bifax	Eastern Long-eared Bat	V	–	Potential
Pteropus alecto	Black Flying-Fox	V	–	Potential
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	–	Potential
Vespadelus troughtoni	Eastern Cave Bat	V	–	Potential

[1] V= vulnerable; E = endangered; E2 = endangered population; M = migratory

Threatened species listed under the *Threatened Species Conservation Act 1995* and recorded or with the potential to occur in the study area, were assessed using the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Climate Change 2005). Threatened and migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* and recorded in the study area were assessed using the *Significant Impact Guidelines – Matters of National Environmental Significance* (Department of Environment and Water Resources 2006). A summary of the likely impacts on the species listed in Table 17.7 is presented below with full significance assessments provided in Appendix G. Measures to minimise the impacts on these species are detailed in Section 17.4.

None of the threatened species recorded or with the potential to occur are considered likely to be significantly affected by the Proposal, under either NSW or Commonwealth legislation.

Reptiles

Suitable habitat exists for one threatened reptile species, the Three-toed Snake-tooth Skink, which was not recorded during field surveys. While potential habitat exists for this species in the rainforest and moist open forest communities present, it is noted as being very uncommon south of Grafton (NPWS 2005). The Proposal would result in the clearing of approximately 2.1 hectares of the species preferred habitat. In relation to the potential habitat available for this species in the local area, the Proposal is not considered likely to affect this species at the local, regional or state level.

Amphibians

The Green-thighed Frog was recorded at Skinners Creek in Orara East State Forest approximately one kilometre west of the Proposal. The potential impact on this species is limited to the disturbance of small areas of potential habitat during construction and is not considered likely to affect this species at the local, regional or state level.

The Wallum Froglet was recorded outside the Proposal footprint, north of the Arrawarra interchange. Potential habitat for the Wallum Froglet occurs in heathland in the vicinity of the Proposal. A small area of potential habitat would be cleared for the Proposal but it is not considered likely to affect the habitat of this species at the local, regional or State level.

The creeks, dams, wetlands and ephemeral drainage lines within the vicinity of the Proposal provide potential habitat for three other threatened frog species: the Giant Barred Frog, Green and Golden Bell Frog and Wallum Sedge Frog. These species were not recorded during field surveys despite suitable weather conditions. A small area of low to moderate habitat for the Giant Barred Frog would be disturbed by the Proposal, with no impact on Lake Russell the potential habitat for the Green and Golden Bell Frog. Potential habitat for the Wallum Sedge Frog occurs in the vicinity of the Arrawarra interchange in areas of Broad-leaved Swamp Sclerophyll Forest dominated by a banksia understorey. The design of the interchange has avoided impacts to this community. As such, the Proposal is not considered likely to affect the habitat of these species at the local, regional or state level.

Birds

Four threatened bird species were recorded during field surveys: Glossy Black-Cockatoo, Barred-Cuckoo-shrike, Osprey and Powerful Owl.

The potential impact on the Glossy Black-Cockatoo relates to the loss of foraging habitat (approximately 81 hectares of various forest types) and the removal of large tree hollows. Approximately 154 hollow bearing trees would be removed, with approximately one third of these containing hollows of sufficient size to be potential nesting sites for this species. Foraging habitat and a similar density of hollow-bearing trees occurs within Wedding Bells State Forest. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect this species at the local, regional or state level.

The Barred-Cuckoo-shrike is a fruit-eating bird associated with rainforests, eucalypt forests and timbered watercourses. The main impact on this species would be the clearing of approximately 2.1 hectares of rainforest vegetation containing fruit trees used for foraging. The combined area of the Moonee Beach Nature Reserve (approximate area of 350 hectares), Sherwood Nature Reserve (approximate area of 1160 hectares), Wedding Bells State Forest (approximate area of 5000 hectares) and Orara East State Forest (approximate area of 4460 hectares) which are located in the local area, is approximately 10,970 hectares that contains rainforest vegetation containing fruit trees. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect this species at the local, regional or state level.

The Osprey is associated with waterbodies including coastal waters, inlets, lakes, estuaries, beaches, offshore islands and sometimes along inland rivers. The Osprey feeds on fish over clear open water and may nest on the ground, on sea cliffs or in trees. While the Proposal would have a negligible impact on the foraging habitat of this species, a large nest possibly belonging to an Osprey or a White-bellied Sea-Eagle was observed approximately 100 metres south of Wedding Bells State Forest (approximate Chainage 28.700 kilometres). The RTA will ensure that the nest is inspected prior to construction to determine if it is in use. This nest tree would be removed during construction and, if in use, relocated to a location determined by a wildlife specialist. The Proposal is not considered likely to affect this species at the local, regional or state level (refer Section 17.4).

The Powerful Owl is associated with a wide range of wet and dry forest types with a high density of prey and large tree hollows for shelter and breeding. The potential impact on this species is the removal of approximately 81 hectares of potential foraging habitat and the loss of tree hollows. The vast majority of the 154 tree hollows to be removed would be too small for the Powerful Owl. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect this species at the local, regional or state level.

Several other threatened bird species were identified as having the potential to occur within the Proposal area based on the presence of suitable habitat and database records (refer Table 17.7).

Five threatened bird species known to occur in the local area are found predominantly within rainforest habitats. They include Coxen's Double-eyed Fig-Parrot, White-eared Monarch, Rose-crowned Fruit-dove, Superb Fruit-dove and Black-breasted Button Quail. Some of these species may also utilise adjacent open forest communities. Construction of the Proposal would require the removal of approximately 2.1 hectares of rainforest, with parts of these communities already degraded. In relation to the potential habitat in the local area, the Proposal is not considered likely to affect these species at the local, regional or state level.

Seven threatened bird species that have previously been recorded in the local area utilise open forest habitats. They are Red Goshawk, Black Breasted Buzzard, Swift Parrot, Square-tailed Kite, Hooded Robin, Regent Honeyeater and Masked Owl. The Proposal would require the removal of approximately 81 hectares of open forest communities with 24 per cent of this in Wedding Bells State Forest. Open forest habitats are extensive in the local area, contained within Moonee Beach and Sherwood nature reserves and Wedding Bells and Orara East state forests. In relation to the potential habitat in the local area, the Proposal is not considered likely to affect these species at the local, regional or state level.

On the NSW North Coast, emus utilise open forests as well as more open habitats such as woodlands, coastal heath, wetlands, tea tree plantations and open farmland. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect this species at the local, regional or state level.

Three threatened bird species that have previously been recorded in the local area utilise wetlands, estuaries, lakes, billabongs or farm dams. They are Black Necked Stork, Comb Crested

Jacana and Freckled Duck. The Proposal would not affect any wetlands, estuarine habitats, lakes or billabongs. The Proposal would be in close proximity to estuarine habitat located east of Double Crossing Creek, and to a large lake, Lake Russell, to the west of the Proposal. In relation to the potential habitat in the local area, the Proposal is not considered likely to affect these species at the local, regional or state level.

The Brown Treecreeper occupies open woodlands, forest clearings and edges, and eucalypts along watercourses. The Proposal would not affect any open woodlands and would create some forest clearings. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect this species at the local, regional or state level.

Migratory birds

Four birds listed as migratory under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* were recorded during field surveys with an additional species considered to have the potential to occur. These birds are not listed under the NSW *Threatened Species Conservation Act 1995*.

None of the migratory species recorded or identified as having the potential to occur within the survey area are considered likely to be significantly affected by the Proposal, under Commonwealth legislation.

The White-bellied Sea-Eagle inhabits large rivers, fresh and saline lakes, reservoirs, estuaries and coastal seas. The Proposal would affect a very small area of potential hunting habitat for this species at locations where the proposed carriageways cross the major creeks along the proposed route. A large nest possibly belonging to a White-bellied Sea-Eagle or an Osprey was observed approximately 100 metres south of Wedding Bells State Forest (approximate Chainage 28.700 kilometres). The RTA will ensure that the nest is inspected prior to construction to determine if it is in use. This nest tree would be removed during construction and, if in use, relocated to a location determined by a wildlife specialist. The Proposal is not considered likely to affect this species at the local, regional or state level (refer Section 17.4).

The White-throated Needletail is an aerial bird that will occasionally roost in trees and feeds on flying insects, such as termites, ants, beetles and flies which it catches in flight. The Proposal would not affect foraging areas for this species and would have a negligible impact on roosting sites. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or state level.

The Black-faced Monarch occupies tangled understoreys of rainforest and eucalypt forest. The Proposal would require the removal of a combined area of approximately 78 hectares of eucalypt forest and rainforest communities. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or state level.

The Rufous Fantail occupies wet forests and less often open forests. The Proposal would require the removal of a combined area of approximately 83 hectares of open forest and rainforest communities, with only approximately two hectares of the preferred rainforest habitat to be removed. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that

contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or State level.

The Rainbow Bee-eater occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil such as sand-ridges, riverbanks, road-cuttings, sand-pits, and occasionally coastal cliffs. This species nest is a chamber a the end of a burrow tunnelled in flat or sloping ground or a cutting. The road cuttings in the study area may provide potential habitat for this species.

Mammals

The Grey-headed Flying-fox is listed as vulnerable under both NSW and Commonwealth legislation. It inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas. While camps are often located in gullies, close to water, in vegetation with a dense canopy, none were observed in the vicinity of the Proposal. The Grey-headed Flying-fox feeds on the nectar and pollen of native trees, and fruits of rainforest trees and vines.

The clearing of approximately 83 hectares of potential foraging habitat for this species represents a relatively minor impact for this species in the local area (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contain available foraging habitat for this species). There are no known roosting sites for this species located within the survey area that would be affected by the Proposal. The Proposal is not considered likely to affect this species at the local, regional or state level, under either NSW or Commonwealth legislation.

All other mammal species discussed below are listed under NSW legislation only.

The Eastern Pygmy-Possum is found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath. Pygmy-Possums feed mostly on the pollen and nectar and nest in small tree hollows, under bark, in old bird's nests and in the branch forks of tea-trees. The Proposal would affect this species through the clearing of foraging resources (approximately 81 hectares) and the loss of 154 hollow-bearing trees. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or state level.

The Squirrel Glider is associated with dry hardwood forest and woodlands. The presence of hollow bearing eucalypts is a critical habitat feature. The Proposal would affect this species through the clearing of foraging resources and the loss of 154 hollow-bearing trees, some of which would be suitable for this species. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or state level.

The Yellow-bellied Glider is restricted to tall mature forests, preferring productive tall open sclerophyll forests with a mosaic of tree species including some that flower in winter. Large hollows within mature trees are required for shelter, nesting and breeding. The potential impacts of the Proposal would be similar to those for the Squirrel Glider discussed above, these being loss of foraging resources and hollow bearing trees. The movement of glider species would be facilitated by the inclusion of glider crossing as part of the Proposal as discussed above.

The Large-footed Myotis occupies most habitat types including 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. While roosting is most commonly associated with caves, this species has been observed to roost in tree hollows, amongst vegetation, under bridges, in mines, tunnels and stormwater drains. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or state level.

The Little Bent-wing and Eastern Bent-wing Bats are associated with a range of forest types and can utilise man made structures such as bridges, culverts and drains for shelter and roosting. Both species breed in caves and forage for insects either above or below the tree canopy. The Proposal would have a relatively minor impact on the amount of available foraging habitat for the Little Bent-wing and Eastern Bent-wing Bats within the local area. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect these species at the local, regional or State level.

The Greater Broad-nosed Bat is associated with moist gullies in mature coastal forest or rainforest. This species forages along creek and river corridors preying on slow flying insects and roosts in tree hollows. The impact of the Proposal on foraging habitat for this species would be minor with a relatively small area of creek and river corridors to be disturbed by the Proposal. The main impact on this species would be the loss of potential roosting sites with 154 hollow bearing trees to be removed as a result of the Proposal. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or state level.

The Eastern Blossom Bat is a small nectar-eating bat that requires a combination of heathland and coastal rainforest. This species roosts in subtropical and littoral rainforests and forages on nectar producing plants in adjacent heathlands and paperbark swamps. The main impact of the Proposal for this species would be the clearing of approximately 2.1 hectares of rainforest habitat, which may contain potential roost sites. Foraging habitat would also be impacted with the removal of forest communities containing winter flowering species such as Broad-leaved Paperbark. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect this species at the local, regional or state level.

The East Coast Freetail Bat is associated with dry sclerophyll forest and woodland where it hunts for insects usually above the forest canopy. The East Coast Freetail Bat roosts mainly in tree hollows but will roost under bark or in man made structures. Approximately 81 hectares of dry sclerophyll forest would be removed. The potential impact on roosting habitat for this species would be the removal of 154 hollow-bearing trees. In relation to the available habitat in adjacent and surrounding areas (the Wedding Bells State Forest, Orara State Forest and the Moonee Nature Reserve are located in areas adjacent and surrounding the Proposal and have a combined area of approximately 10,970 hectares that contains available habitat for this species), the Proposal is not considered likely to affect this species at the local, regional or state level.

Several other threatened mammal species were identified as having the potential to occur within the survey area based on the presence of suitable habitat and database records (refer Table 17.7).

Several terrestrial threatened species may utilise the forest habitats present within the study area including Rufous Betong, Spotted-tailed Quoll, Brush-tailed Phascogale, Koala, Long-nosed Potoroo, Common Planigale and Hastings River Mouse. The potential impact on these species

would be an increase in the potential for collision with vehicles and the loss of foraging and shelter sites. The main impact on foraging and shelter sites would be within the larger more intact area of forest habitat within Wedding Bells State Forest. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect these species at the local, regional or state level.

Nine bat species may potentially utilise parts of the forest habitats within the study area. They include Large-eared Pied Bat, Hoary Wattled Bat, Eastern False Pipistrelle, Golden-tipped Bat, Eastern Long-eared Bat, Black Flying-fox, Yellow-bellied Sheathtail-bat and Eastern Cave Bat. The forest communities of the study area provide foraging habitat for these species, while hollow bearing trees provide potential roost sites for five species: Hoary Wattled Bat, Eastern False Pipistrelle, Eastern Long-eared Bat and Yellow-bellied Sheath-tailed Bat. In relation to the available habitat in adjacent and surrounding areas, the Proposal is not considered likely to affect these species at the local, regional or state level.

17.3.4 Potential aquatic fauna impacts

The creeks and watercourses crossed by the proposed route do not include any areas of the habitat type for the Oxleyan Pygmy Perch, and as such the Oxleyan Pygmy Perch and its habitat would not be affected by the Proposal.

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, therefore the Eastern Cod and its habitat would not be affected by the Proposal.

The Proposal would traverse several creeks and watercourses, which provide habitat for fish and other aquatic organisms. Potential impacts on aquatic habitats include overshadowing, pollution of waterways and changes to the hydrological regime. Potential water quality issues and mitigation measures are addressed in Chapter 18 of this environmental assessment. The greatest potential for impact on local waterways is during the construction phase of the Proposal, therefore, the adoption of best practice water quality control and protection measures would be implemented to minimise impact on aquatic habitats (refer Section 18.3).

The concept design for the Proposal has been developed so that the existing hydrological regime would generally be maintained through the use of culverts and bridges where required. Detailed design of culverts would provide fish friendly crossings at all of the fauna crossing locations identified in Table 7.5, so that barriers to fish passage are not created. In operation, runoff from the Proposal would be directed to detention basins to improve water quality before being discharged to drains and then to local waterways. The operational basins would be located in positions that would protect sensitive environmental areas from an unexpected spill from an incident.

17.3.5 Potential impacts on protected areas

Two conservation areas are present in close proximity to the Proposal, Moonee Beach Nature Reserve and Solitary Islands Marine Park. The northern section of Moonee Beach Nature Reserve is located immediately south of the residential area of Sandy Beach and extends from the coast to the existing highway. The proposed new carriageway would be located on the western side of the existing carriageway and would have no direct impact on the nature reserve.

Solitary Islands Marine Park covers an area of approximately 71,000 hectares off the Coffs Coast from Mutton Bird Island in the south to Plover Island in the north. Details of the defined boundary of the marine area are provided in Chapter 13. The marine area extends into the lower reaches of all coastal tributaries and in the vicinity of the Proposal; this includes Cunninghams Creek and Double Crossing Creek.

Potential impacts on the marine park and aquatic ecology would arise from removal of the existing bridges and construction of the new bridges at these locations. At Cunninghams Creek demolition of the existing bridge would require the removal of two rows of five piers from the creek, while at Double Crossing Creek demolition would require the removal of two rows of four piers. The proposed bridge structures for Cunninghams Creek have been designed to clear span the creek, as such there would be no pier or abutment structures located within the creek or the marine park.

At Double Crossing Creek, the bridges for the northbound and southbound highway carriageways have also been designed to clear span the creek. However, the northern abutment of the bridge over Double Crossing Creek for the northbound off-ramp to Graham Drive North has been designed at maximum span, however still falls slightly within the defined area of the marine park.

Potential impacts on the marine park and aquatic ecology from demolition and construction activities would primarily occur as a result to any changes to water quality. Potential impacts on water quality include siltation or contamination of the waterway. The removal of existing bridge piers from both creeks has the potential to have a localised minor impact on water quality in the short term which is readily reversible, and with the introduction of mitigation and management measures identified in the draft Statement of Commitments (refer Appendix A) the impacts would be considered negligible. During construction there is also the potential for materials such as oils, fuels and cement to be spilt or dropped into the creeks. The management and mitigation measures proposed to minimise these impacts are presented in Chapter 18 of this report.

The coastal saltmarsh endangered ecological community is located approximately 75 metres downstream from the southbound carriageway adjacent to Double Crossing Creek and would not be directly impacted by the proposed construction activities.

There would be no adverse impacts during operation, with the removal of piers from the creek beds having a potentially positive impact on water quality with reduced scour and associated sedimentation on the downstream side of the piers.

There are no State Environment Planning Policy (SEPP) 14 Wetlands or SEPP 26 Littoral Rainforests in the vicinity of the Proposal.

17.4 Proposed management measures

The potential impact on native flora and fauna has been considered during the route investigation phase and subsequently through the refinement of the concept design of the Proposal. During this process a number of important measures to reduce and avoid potential impacts have been built into the project design. Mitigation measures to minimise impacts on the local environment during construction and operation are detailed in the draft Statement of Commitments located at Appendix A and would be transferred to the construction environmental management plan.

Prior to construction, the RTA will establish contractual systems for the construction contractor to conduct construction phase inspections and monitor compliance with flora and fauna management measures. The construction environmental management plan (considering flora and fauna management measures) will be prepared prior to construction in consultation with relevant government departments and relevant Councils.

Management measures identified in sections 17.4.1 to 17.4.9 below are listed only once however some measures are relevant to more than one area.

17.4.1 Native Flora

Commitments identified (refer Appendix A) to manage identified impacts to native flora are:

(i) Threatened plants in proximity to the Proposal to be retained will be identified and protected during construction through exclusion fencing and education of construction workers through the site induction process.

(ii) The feasibility of relocating individuals of Rusty Plum (*Amorphospermum whitei*) and, if required, any individuals of the threatened *Typhonium sp.* directly affected by the Proposal to suitable habitat on nearby land in secure tenure will be investigated and resultant action determined on the basis of expert advice.

(iii) Surveys will be undertaken during the flowering period of the Typhonium species recorded in the vicinity of Newmans Road to determine whether individuals present are threatened species. If the species cannot be positively identified prior to construction, then precautionary measures to protect the species during construction (such as exclusion fencing) will be employed.

(iv) Surveys will be undertaken during the flowering period (September to October) of the Swamp Orchid (*Phaius australis*) within areas of suitable habitat (Swamp Sclerophyll Forest) within the Arrawarra Interchange area to determine the presence or absence of this species and (if present) to develop appropriate mitigation strategies.

17.4.2 Native fauna

Commitments identified (refer Appendix A) to manage identified impacts to native fauna are:

(i) A suitably qualified ecologist will undertake specific searches for native fauna immediately prior to clearing activities. Searches will include nests and large hollow-bearing trees and target habitats of hollow-dwelling species, koalas and frogs.

(ii) Fauna species found in areas to be cleared prior to clearing activities will be re-located into suitable habitat as close as possible to the area in which they were found.

(iii) Stands containing hollow-bearing trees will be cleared using a two stage clearing process with adjacent non-hollow-bearing trees to be cleared first.

(iv) Habitat features and resources for native fauna (such as hollow-bearing trees, hollow logs and bush rocks) will be distributed along the route of the Proposal where feasible and reasonable. Such relocation will be undertaken in a manner to limit damage to existing vegetation and will not occur in high condition remnant vegetation.

(v) Culverts identified in the environmental assessment as having a potential role in fauna crossing will be designed to facilitate fauna movements.

(vi) Waterway crossings will be designed to facilitate fish passage where appropriate and in consultation with relevant government agencies

(vii) Expert advice will be sought to assist in identifying the need and location for crossing points for glider populations. If required, and in consultation with relevant government agencies, the location and design of crossing points will be incorporated into the Proposal.

(viii) Bridges at Double Crossing Creek, Cunninghams Creek, Skinners Creek, Woolgoolga Creek and Arrawarra Creek will be designed to facilitate fauna movements.

(ix) Fauna exclusion fencing (eg. floppy-top fencing) will be erected along the Proposal at appropriate locations to direct fauna movement towards fauna-crossing structures.

(x) Water quality control measures will be installed as early as possible in the construction program and will be designed / selected to meet identified receiving water objectives to protect the habitats of threatened wetland birds.

(xi) Strategies will be developed to deal with incidents involving individual animals during construction activities in consultation with local Department of Environment and Climate Change officers, WIRES and / or other relevant local wildlife carer groups.

(xii) Surveys will be undertaken for threatened bat species to identify any roosting bats prior to the demolition of the existing highway bridges at Double Crossing, Skinners and Cunninghams Creeks and the existing Hoys Road bridge over Cunninghams Creek. The surveys will include bridge inspections by a suitably qualified ecologist to identify any roosting bats. If found, any bats will be moved and relocated following consultation with the Department of Environment and Climate Change.

(xiii) The large nest located approximately 100 metres south of the Wedding Bells State Forest boundary (approximate Chainage 28.700 kilometres) will be inspected to determine if it is being used by an Osprey or a White-bellied Sea Eagle. If in use, expert advice will be sought regarding the feasibility of translocation of the nest / tree.

17.4.3 Habitat removal and vegetation clearance

Despite efforts to minimise habitat removal through both route investigation phase and subsequently through the refinement of the concept design of the Proposal, vegetation clearance is inevitable. Commitments identified (refer Appendix A) to manage identified habitat removal and vegetation clearance impacts are:

(i) Where feasible and reasonable, nest boxes will be utilised to replace the removal of hollow-bearing trees. If used, nest boxes will be fixed to suitable retained vegetation and in a way that does not damage the tree.

(ii) Where feasible and reasonable, removal of frog habitat along drainage lines will not be undertaken during periods of wet weather.

(iii) The limits of clearing and other native vegetation disturbance will be clearly marked on relevant work plans and on site with temporary fencing installed prior to clearing.

17.4.4 Habitat fragmentation

The primary mechanism for reducing the incidence of habitat fragmentation and its subsequent impacts was achieved through the route investigation phase and subsequently through the refinement of the concept design of the Proposal. The subsequent refinement of the route and concept design of the Proposal has further considered habitat fragmentation and where possible disturbances remain on one side of a vegetation community so as to avoid additional fragmentation and increased length of edge effect.

In addition to the inclusion of fauna friendly culverts and bridge openings in the concept design to maintain connectivity between habitat areas straddling both sides of the highway, other proposed measures to mitigate the impacts of fragmentation include:

(i) Native and locally indigenous plants will be used in the landscaping and disturbed areas will be progressively revegetated.

(ii) Weeds in areas disturbed by construction activities will be managed for a minimum of two years after construction completion.

17.4.5 Barrier effects and impacts on wildlife corridors

The primary mechanism for mitigating the effects of barriers to wildlife movement is the incorporation of fauna movement features such as fauna underpasses into the concept design. The fauna movement features incorporated into the design comprise culvert structures, bridge openings, glider crossings and fauna-proof fencing. The combined drainage / fauna crossing culvert structures would be designed such that the structures will provide dry passage for fauna for the majority of the time.

Fauna exclusion fencing would be located alongside the highway where it borders areas of native vegetation and in the vicinity of fauna corridors, to guide animals to and through the movement structures and to prevent access onto the highway (refer Table 17.6).

17.4.6 Wildlife mortality

In relation to wildlife injury and mortality, fauna rescue and relocation procedures and procedures for clearing non-habitat and habitat trees are identified in various sections above. Additional measures proposed to manage wildlife injury and mortality are:

(i) Adjoining vegetation will be maintained to limit overhang of fences or other barriers.

(ii) Flora species used in landscaping will be selected such that wildlife is not attracted for feeding or other purposes.

17.4.7 Protected Areas

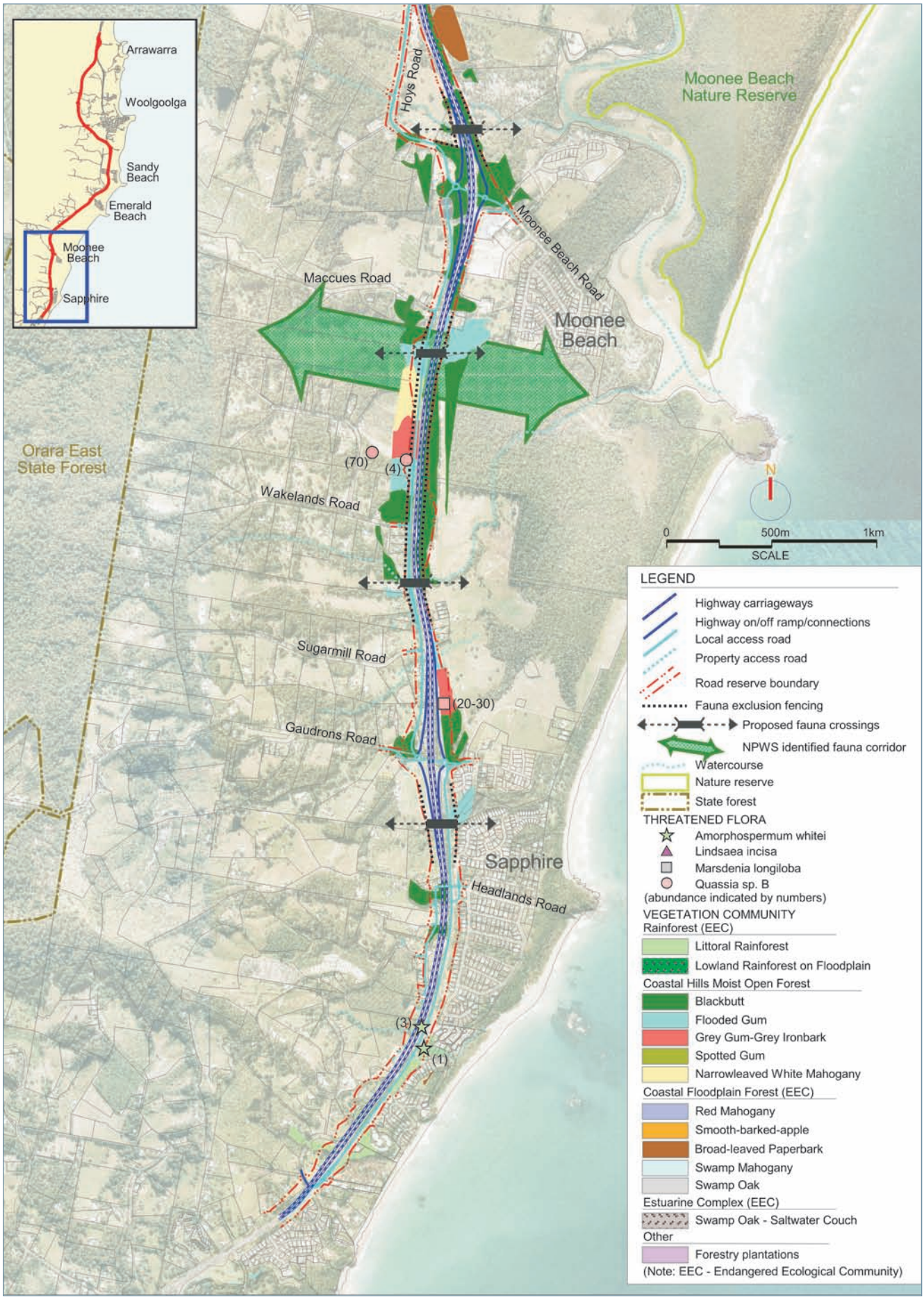
Mitigation measures proposed to minimise potential impacts on Solitary Island Marine Park arising from water quality impacts are identified in Chapter 18.

17.4.8 Monitoring

A monitoring program will be developed to allow the effectiveness of mitigation and offset measures to be assessed and allow for their modification if necessary. The program will be for a minimum of 12 months after construction completion.

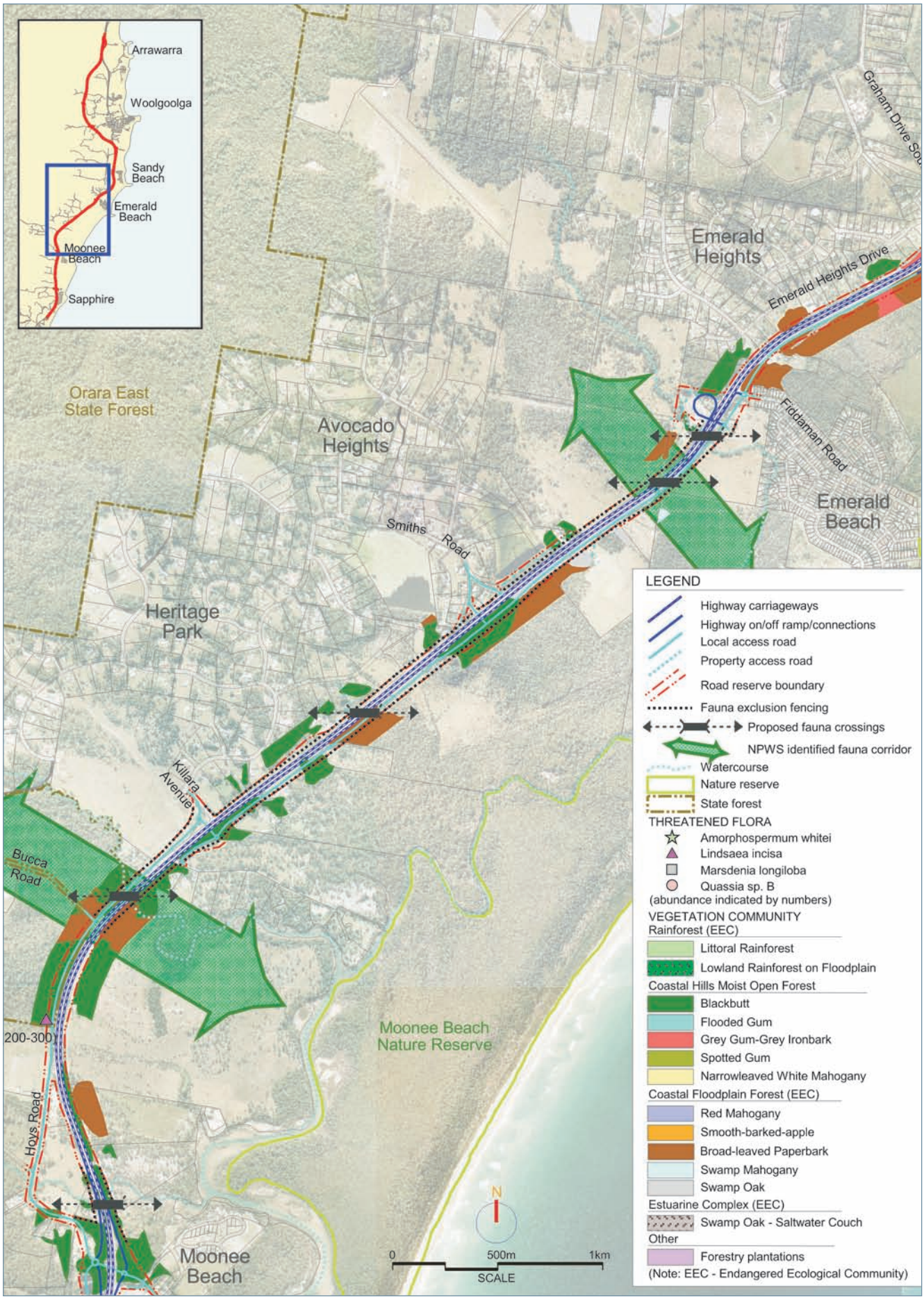
17.4.9 Compensatory habitat

Where route selection and road design cannot fully eliminate potential impacts on threatened flora species and ecologically endangered communities, compensatory habitat can be an appropriate form of mitigation. The purchase of land would partly compensate against the identified impacts of the Proposal on the threatened flora species and / or ecologically endangered communities. Therefore, a compensatory habitat (or other suitable offset) agreement will be developed in consultation with the Department of Environment and Climate Change.



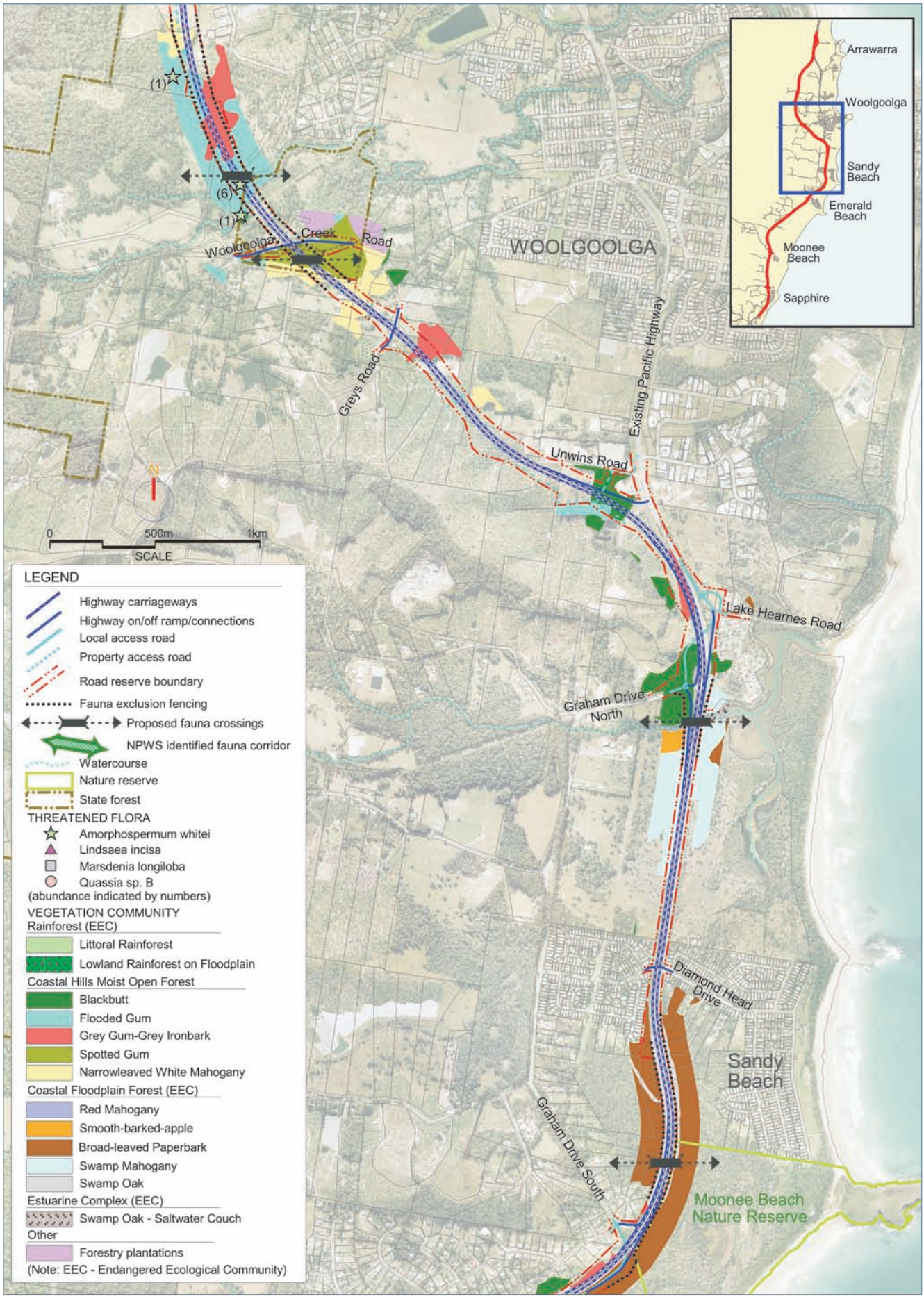
Source: Aerial photography 2005 (Roger Dwyer and Associates)

FIGURE 17.1a FLORA AND FAUNA (SAPPHIRE TO MOONEE BEACH)



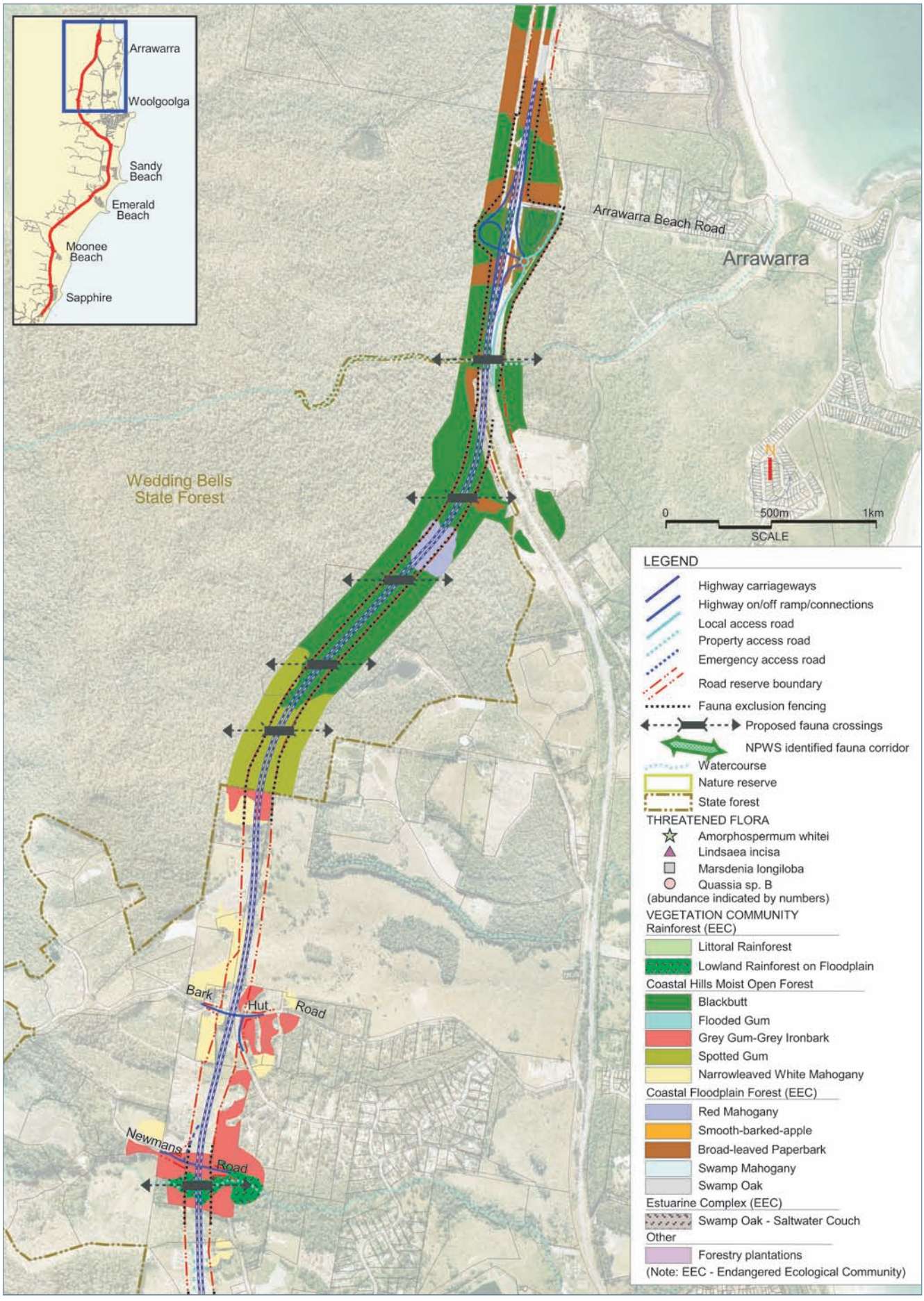
Source: Aerial photography 2005 (Roger Dwyer and Associates)

FIGURE 17.1b FLORA AND FAUNA (MOONEE BEACH TO EMERALD BEACH)



Source: Aerial photography 2005 (Roger Dwyer and Associates)

FIGURE 17.1c FLORA AND FAUNA (EMERALD BEACH TO WOOLGOOLGA)



Source: Aerial photography 2005 (Roger Dwyer and Associates)

FIGURE 17.1d FLORA AND FAUNA (WOOLGOOLGA TO ARRAWARRA)