

Chapter 10 Terrestrial ecology

This chapter considers the impact of the Proposal on terrestrial flora and fauna. Flora communities and fauna habitats in the study area are described, a condition assessment is provided, and the conservation significance and potential adverse impacts are identified. The significance of potential impacts, requirement for a Species Impact Statement and mitigation measures are assessed.

10.1 Method of assessment

The purpose of the terrestrial ecology investigations was to identify and assess the potential impacts of the Proposal on the existing terrestrial flora and fauna communities in the study area.

A literature review and database search of relevant published sources/records was initially conducted to identify the presence and distribution of threatened or endangered flora and fauna species, and ecological communities in and adjacent to the study area.

Field surveys were carried out between:

- 5 to 13 November 2001 (general surveys)
- 4 to 8 November 2002 (targeted surveys for *Acacia courtii* and Narrow-leaved Red Gum [*Eucalyptus seeana*])
- 16 and 17 March 2004 and 30 and 31 March 2004 (targeted surveys for the Green-thighed Frog [*Litoria brevipalmata*]).

These surveys employed a combination of flora and fauna habitat survey techniques during both daytime and night-time hours. Daytime investigations involved habitat assessment, avifauna surveys, reptile searches, dedicated frog surveys in areas of suitable habitat, and scat analysis. Nocturnal investigations included spotlighting surveys for mammals and other nocturnal fauna, use of call playback to detect owl species, surveys for microchiropteran bats using ultrasonic call detectors for echolocation, and nocturnal frog surveys. Incidental surveys of direct (sightings and call identification) and indirect (fauna remains, predator remains, scats, diggings and burrows) evidence was undertaken as well as consideration of anecdotal information from landowners and local residents.

Vegetation mapping was undertaken using a combination of aerial photographs (October 2000), the DEC Eastern Bushland Database, Hastings Council and Greater Taree City Council's vegetation mapping, and ground truthing of obtained maps. Flora surveys, general walked surveys, extensive random surveys, and targeted surveys for the threatened species, *Acacia courtii* and Narrow-leaved Red Gum and a number of other plants species of significance were carried out.

Eight Part Test assessments were undertaken as required under the EP&A Act in addition to Assessments of Significance required by the EPBC Act. This was to assess and identify threatened flora and fauna species, communities and populations that the Proposal may potentially impact. A conservation significance assessment was also undertaken evaluating the significance of the study area's terrestrial ecology at the national, state, regional and local geographic levels.

Details of the field investigations undertaken are presented in Working Paper No. 7.

10.2 Flora

The six main vegetation communities identified and recorded along the Proposal route are:

- Coastal Blackbutt Forest (dry open forest)
- Dry Tallowwood Forest (dry open forest)
- Swamp Forest (*Melaleuca* swamp)
- Sedgeland
- Flooded Gum Open Forest (moist Eucalypt)
- Cleared/Disturbed (cleared).

None of these communities are listed as Endangered Ecological Communities under the TSC Act or the EPBC Act. The distribution of these communities through the study area is presented on Figure 10-1A and Figure 10-1B and their key characteristics are discussed below.

10.2.1 Coastal Blackbutt Forest

Coastal Blackbutt Forest is widespread in the study area and is largely concentrated in the Lake section where native bushland associated with the Middle Brother National Park and the Middle Brother State Forest directly abuts the highway on the western side. Other large concentrations of this vegetation community exist immediately south of Kew and extend to the north of Herons Creek. The general condition of this vegetation community is moderate to good.

This vegetation community is a dry open forest dominated by Blackbutt. Other canopy species include She-oaks (*Allocasuarina* spp.), Bloodwoods (*Corymbia* spp.), Rough-barked Apple (*Angophora floribunda*), White Mahogany (*Eucalyptus acmenoides*), Smooth-barked Apple (*Angophora costata*) and Tallowwood (*Eucalyptus microcorys*) whose presence varies with topography and environmental conditions. Understoreys typically contain Christmas Bush (*Ceratopetalum gummiferum*), Grass Trees (*Xanthorrhoea* spp.), Gorse Bitter Pea (*Daviesia ulicifolia*), and Coffee Bush (*Breynia oblongifolia*) in an open shrub layer arrangement up to 5 m tall. Ground cover includes various herb and grass species such as Wattle Mat-rush (*Lomandra filiformis*), Threeawn Speargrass (*Aristida vagans*) and Molucca Bramble (*Rubus moluccanus*).

10.2.2 Dry Tallowwood Forest

Dry Tallowwood Forest is also widespread through the study area. This forest type is the second most common vegetation community that exists along the route of the Proposal. Concentrations are present in the Lake and Kew sections, and are generally in moderate to good condition.

This forest type belongs to the dry open forest category and is dominated by Tallowwood. Other canopy species include White Stringybark (*Eucalyptus globoidea*), Pink Bloodwood (*Corymbia intermedia*), Red Ironbark (*Eucalyptus fibrosa*) and Blackbutt (*Eucalyptus pilularis*). The understorey has a shrub layer to 3 m and consists of White Dogwood (*Ozothamnus diosmifolius*), Narrow-leaved Geebung (*Persoonia linearis*), Wattles (*Acacia* spp.) and *Leptospermum polygalifolium*. Ground cover includes Wild Tobacco Bush (*Solanum mauritianum*), False Sarsparilla (*Hardenbergia violacea*), Threeawn Speargrass, (Whiteroot) (*Pratia purpurascens*) and various other grass and herb species.

10.2.3 Swamp Forest

Swamp Forest is relatively uncommon in this region but is found scattered across the study area in small patches. The forest can be found in lowland depressions and along creeks and therefore subject to regular inundation.

The forest is dominated by Paperbarks (*Melaleuca* spp.) and contains at least one of these as the dominant species. The Swamp Oak (*Casuarina glauca*) and Swamp Mahogany (*Eucalyptus robusta*) may also be found as canopy species. Swamp Forests typically lack a shrub layer, however ground covers extending to 1 m in height include Harsh Ground Fern (*Hypolepis muelleri*), Swamp Water Fern (*Blechnum indicum*), *Lepyrodia scariosa* and *Baumea rubiginosa*.

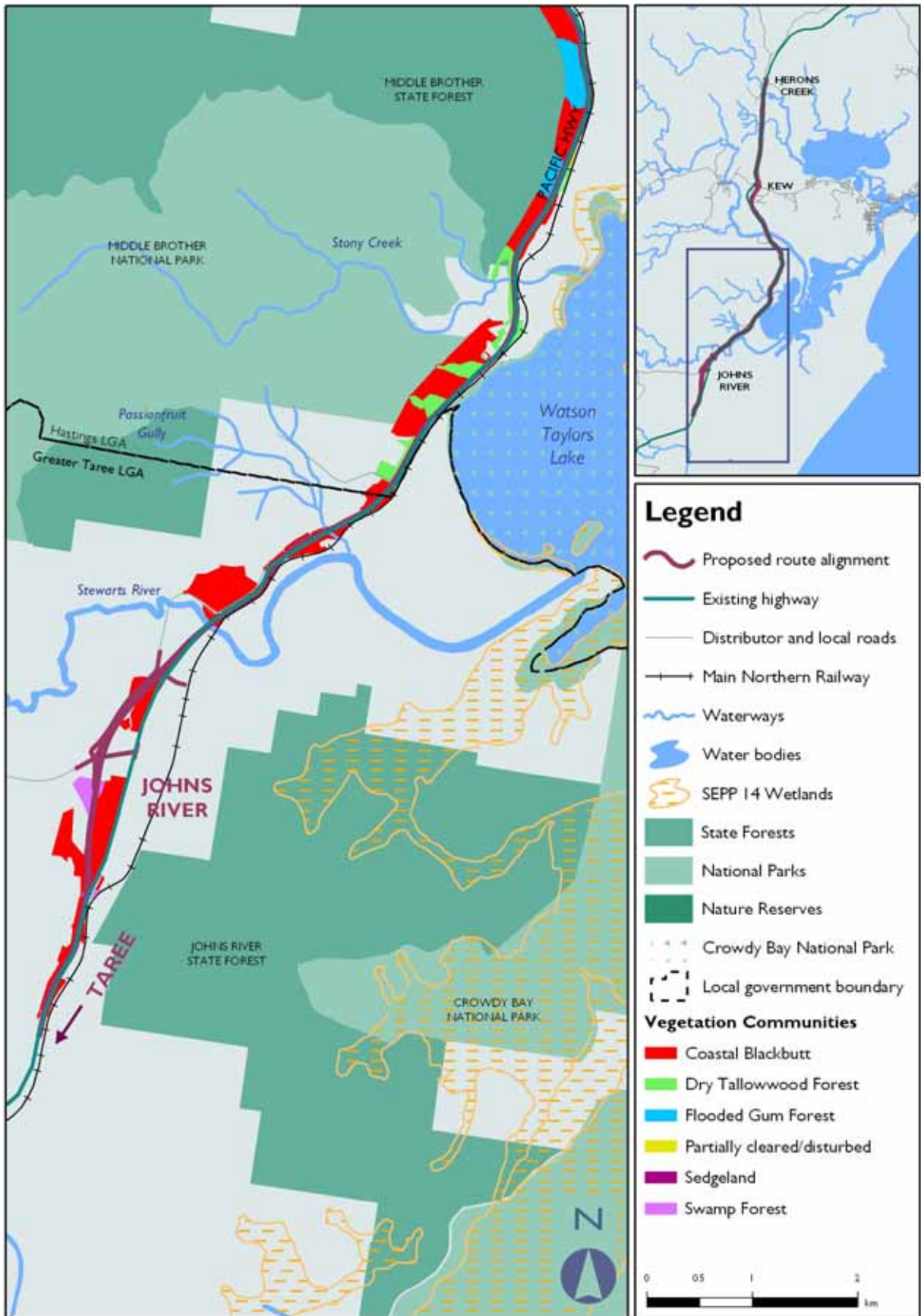


Figure 10-1A Vegetation communities (south)

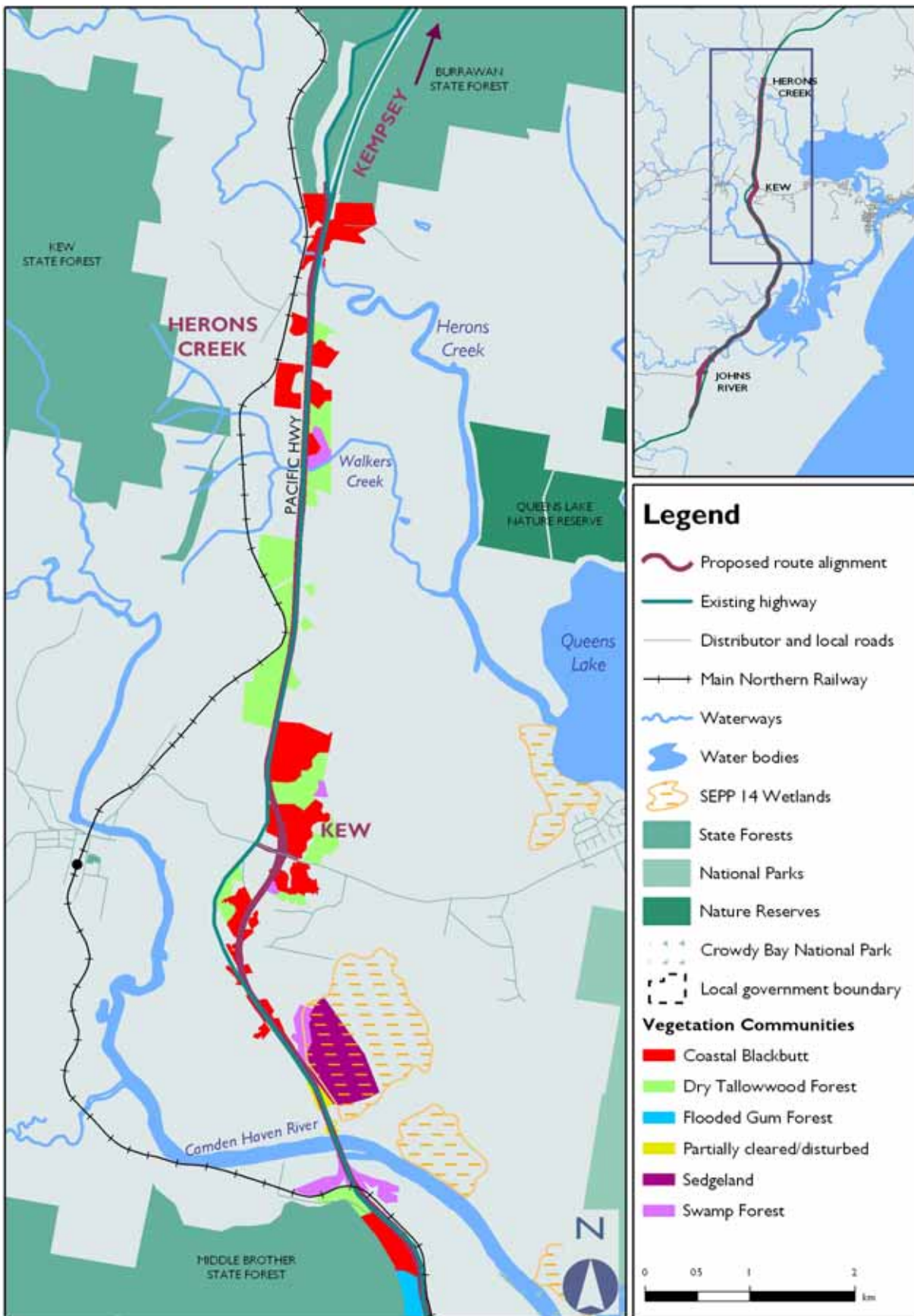


Figure 10-1B Vegetation communities (north)

10.2.4 Sedgeland

In the study area, this community is restricted to SEPP 14 wetland No. 544a (Sunnyvale Swamp). This sedgeland is in good condition and is located to the east of the highway between the Camden Haven River and Sunnyvale Road north. A raised embankment was constructed as part of the existing Highway alignment and will separate this community from the Proposal. The embankment has some sedgeland species present that have self-propagated.

Wetland species *Lepironia articulata* and *Baumea rubiginosa* dominate the sedgeland community.

10.2.5 Flooded Gum Open Forest

Flooded Gum Forest is found in the Lake sections in the Middle Brother National Park and Middle Brother State Forest that abuts the existing Pacific Highway and alignment of the Proposal. This type of forest is found in the moist protected valleys of the National Park and State Forest and is identified as being in moderate-good condition.

The forest is categorised as a tall wet sclerophyll forest being dominated by Flooded Gum (*Eucalyptus grandis*). Other canopy species include Blackbutt and Sydney Blue Gum (*Eucalyptus saligna*). The understorey consists of Red Bloodwood (*Corymbia gummifera*), Corkwood (*Duboisia myoporoides*), Narrow-leaved Palm Lily (*Cordyline stricta*), Bolwarra (*Eupomatia laurina*) and Lilly Pilly (*Acmena smithii*) in a tall, dense shrub layer up to 8 m tall. The ground cover layer includes ferns such as Rough Maidenhair Fern (*Adiantum hispidulum*), Prickly Rasp Fern (*Doodia aspera*) and *Cheilanthes sieberi* and is typically sparse. Vines are also common and include Whip Vine (*Flagellaria indica*), Lawyer Vine (*Smilax australis*), Sweet Sarsaparilla (*Smilax glycyphylla*) and Common Silkpod (*Parsonsia straminea*).

10.2.6 Cleared or disturbed land

Cleared or disturbed land is found throughout the study area and is particularly common alongside the existing highway. Land not covered by the above vegetation communities is either cleared and/or disturbed. The eastern side of the entire Lake section of the Proposal between the existing highway and the Main Northern Railway line is less than 50 m wide, and is degraded and highly weed infested.

This community comprises predominantly cleared grazing land supporting introduced pasture species and no longer represents natural vegetation communities. There may be scattered stands of native upper canopy, shrub layer and groundcover species, however the land usually contains a high proportion of noxious weed species.

10.2.7 Flora species of conservation concern

Threatened flora species are those listed on Schedules 1 (Endangered) and 2 (Vulnerable) of the TSC Act and in the EPBC Act. Threatened species include those considered to be of conservation concern due to restricted distributions or habitat requirements, significant population or distributional range declines, and where threats to the survival of species still prevail.

There are 33 species listed under the TSC Act that may be found in the local area and 15 may potentially exist in the study area. A total of 18 threatened species listed under the EPBC Act have potential habitat in the local area and 11 of these may be found in the study area. None of these threatened species were recorded during the surveys of the study area carried out during 2001 and 2002. Nonetheless, Eight Part Tests (NPWS 1996) were conducted for all threatened species with the potential to exist in the study area (see Working Paper No. 7).

The population of Narrow-leaved Red Gum in Taree LGA is listed as an Endangered Plant Population under Schedule 1 Part 2 of the TSC Act. While no Narrow-leaved Red Gum trees were recorded during the November 2001 and 2002 surveys of the study area, this species has been previously recorded within the vicinity of the study area. The Eight Part Test was used to determine the potential for the Proposal to have a significant impact on this population.

Consultation and consideration of the Rare or Threatened Australian Plant (ROTAP) species list (Briggs and Leigh 1995) was undertaken. The ROTAP list shows species that are presumed extinct, endangered, vulnerable, rare, or poorly known. The list is maintained by CSIRO however it does not grant any legislative protection to the species listed on it. There were no ROTAP species recorded during the surveys undertaken by Biosis Research.

SEPP 14 wetlands No. 544a (Sunnyvale Swamp) and No. 544c (Kew Swamp) exist within the study area immediately to the east of the highway. No areas of wetlands protected under SEPP 14 would be directly impacted in the study area by the Proposal. Works in areas protected by SEPP 14 require consent from Council and concurrence from DIPNR for the clearing, filling, draining and the construction of levees in mapped wetlands.

10.3 Fauna

10.3.1 Fauna habitats

The principal habitat types located within the study area are:

- open forest, woodlands, understorey vegetation
- tree hollows, fallen timber and bark
- rivers, creeks, drainage lines and wetlands
- cleared areas.

The habitats and species associations relevant to the study area are discussed below.

Open forest, woodland and understorey vegetation

Woodland habitat is found along most of the Proposal route. The Middle Brother National Park and Middle Brother State Forest contain the majority of woodland habitat in the study area. This habitat has been identified as being generally in good condition for fauna. Dense understorey habitat is most common adjacent to creek lines within the Lake section of the route but also occurs generally in the study area.

A large range of food and shelter is provided by woodland and open forest habitats. The upper canopy species (myrtaceous trees such as Eucalypts) are dominant in the study area and provide habitat for a number of species including birds and arboreal mammals. The canopy provides a variety of direct food resources such as foliage, nectar and exudates, and indirect food including arthropods.

Dense understorey and shrub vegetation is an important habitat for small birds including fairy-wrens and scrubwrens, reptiles, and ground dwelling mammals such as rodents and dunnarts. Dense understorey vegetation is found throughout the study area, however, it is more common within the sheltered gullies.

Tree hollows, fallen timber and bark

The field surveys identified a number of large trees exhibiting hollows. These hollows, fallen timber and bark are prolific in the woodlands and open forest of the study area, but can also be found wherever trees and other tall vegetation is present in cleared/disturbed areas.

The size of the hollow (diameter, height, depth), number of hollows, spacing and location per tree, and tree health dictate whether or not hollows would be utilised for habitat (Gibbons and Lindenmayer 2002). Hollows provide dens, mating and nesting habitat for a variety of local birds (Sulphur-crested Cockatoo [*Cacatua galerita*], Glossy Black-cockatoo [*Calyptorhynchus lathamii*], Powerful Owl [*Ninox strenua*], and Masked Owl [*Tyto novaehollandiae*]), arboreal mammals (Sugar Glider [*Petaurus breviceps*] and Greater Glider [*Petauroides volans*]) and forest-dwelling micro-bats (East Coast Freetail Bat [*Mormopterus norfolkensis*]).

Fallen branches and bark create moisture-retaining and sheltered microhabitats for a variety of terrestrial animals and are especially important as a refuge in times of drought and winter. They are found scattered throughout forested areas. Ground litter and debris is an important foraging medium for reptiles and hollows contained within larger logs can provide habitat for small to medium sized mammals (such as the threatened Spotted-tailed Quoll [*Dasyurus maculatus*]).

Rivers, creeks, drainage lines and wetlands

Larger creeks and rivers in the study area include the Stewarts River, Camden Haven River and Herons Creek. A number of named and unnamed small creeks, ephemeral waterways, and drainage lines exist in the study area, including Passionfruit Gully. These waterways provide resources for a range of terrestrial fauna. Habitats for terrestrial fauna, such as the Common Eastern Froglet (*Crinia signifera*) and Large-footed Myotis (*Myotis adversus*), are also provided in-stream, on riverbanks, in riparian corridors and in associated swamps and wetlands. Waterways supply habitat for a variety of aquatic fauna, which is discussed in detail in Chapter 11.

Heath, sedgeland and wetlands are found in wet depressions, alongside rivers and creeks, and in drainage lines within the entire study area. They provide optimal habitat for a number of invertebrate and vertebrate species such as amphibians, reptiles and small ground-dwelling mammals.

Major wetlands found adjacent to the route of the Proposal provide habitat for a range of species, such as the threatened Australasian Bittern (*Botaurus poiciloptilus*) and Black-necked Stork (*Ephippiorhynchus asiaticus*). The adjacent SEPP 14 wetlands are particularly significant. There are no Ramsar listed wetlands within the study area or that would be affected by the Proposal.

Cleared areas

Cleared land is found throughout the study area, especially along the route of the Proposal. Whilst cleared and disturbed areas do not represent natural vegetation, some native species that prefer the edge environments or ecotone habitats (such as Latham's Snipe [*Gallinago hardwickii*], wallabies and kangaroos) may occur within the disturbed land vegetation and microhabitat components. This vegetation type is most popular for introduced fauna species such as domestic animals and birds of prey often use these areas for hunting insects and introduced rodents.

Foraging and shelter resources for some bird and arboreal mammal species may be provided in small isolated stands of highly modified vegetation or scattered isolated trees in pasture areas. However, their isolated nature and disturbed condition renders them of little value for most hollow-dependent fauna species. Farm dams in the study area provide habitat and resources for a variety of amphibian and waterbird species. The dams of most value in this respect include those with some emergent wetland vegetation (such as Broadleaf Cumbungi [*Typha orientalis*]) and other aquatic plant species, which provide both foraging and breeding habitat for these fauna species.

10.3.2 Native fauna recorded

Fauna species recorded during the surveys in the study area were compiled with reference to past studies and are discussed in detail in Working Paper No. 7. There were 90 species of vertebrate recorded in the surveys undertaken including 5 amphibians, 6 reptiles, 61 birds and 18 mammals.

Based on the DEC Atlas of NSW Wildlife and the DEH Protected Matters Search tool, there are 38 threatened fauna species listed under the TSC Act and 17 migratory listed species under the EPBC Act potentially occurring in the study area. A further 22 of the species are considered under both Acts and an additional 5 migratory species listed under the EPBC Act were identified during current surveys. Consequently Biosis Research determined the impacts

under Eight Part Tests and/or the EPBC Act Guidelines on Significance for a total of 44 fauna species. Six threatened species listed in the schedules of the TSC Act were recorded in the study area including two birds (Glossy Black-cockatoo and Black-necked Stork) and four species of bat (three microchiropterans and one megachiropteran).

Birds

Biosis Research identified 61 bird species while surveying the study area. The majority of bird species recorded in the study area are typically associated with the forest and woodland habitats. Most species are common and widespread in suitable habitat throughout NSW including the Yellow-tailed Black-cockatoo (*Calyptorhynchus funereus*), Black-faced Cuckoo-shrike (*Coracina novaehollandiae*), Eastern Whipbird (*Psophodes olivaceus*), Grey Fantail (*Rhipidura fuliginosa*), Welcome Swallow (*Hirundo neoxena*), Superb Fairy-wren (*Malurus cyaneus*), and New Holland Honeyeater (*Phylidonyris novaehollandiae*).

A number of waterbird species were recorded in the study area including the Australian Wood Duck (*Chenonetta jubata*), Cattle Egret (*Ardea ibis*), Purple Swamphen (*Porphyrio porphyrio*), Royal Spoonbill (*Platalea regia*) and two Herons. The Little Eagle (*Hieraaetus morphnoides*) and the Wedge-tailed Eagle (*Aquila audax*) were recorded and are likely to forage in the general area. Birds of particular importance include the Glossy Black-cockatoo that is listed as a vulnerable species under the TSC Act and the Black-necked Stork that is listed as endangered (TSC Act). There were 7 bird species recorded that were listed under the EPBC Act as migratory species, namely, the Australian Wood Duck, Cattle Egret, Rufous Fantail (*Rhipidura rufifrons*), Satin Flycatcher (*Myiagra cyanoleuca*), Brown Falcon (*Falco berigora*) and the above Eagles.

Additional threatened bird species were considered that have either been previously recorded or have the potential to occur within 10 km of the study area. The following threatened bird species were identified as having potential habitat throughout the study area, but were not directly observed during the surveys: Latham's Snipe, Swift Parrot (*Lathamus discolor*), Square-tailed Kite (*Lophoictinia isura*), Hooded Robin (*Melanodryas cucullata*), Satin Flycatcher, Barking Owl (*Ninox connivens*), Masked Owl, and Regent Honeyeater (*Xanthomyza phrygia*). Additional information on those threatened species identified to have potential habitat along segments of the Proposal route is discussed in Working Paper No. 7.

Mammals

Eighteen mammals were recorded in the study area and all were native apart from the introduced Fox (*Vulpes vulpes*).

Five arboreal mammals were observed during the surveys, including the Feathertail Glider (*Acrobates pygmaeus*), Common Ringtail Possum (*Pseudocheirus peregrinus*), Sugar Glider, Greater Glider and the Vulnerable listed (TSC Act and EPBC Act) Grey-headed Flying-fox (*Pteropus poliocephalus*). Other observed native mammals included the Eastern Grey Kangaroo (*Macropus giganteus*), Swamp Wallaby (*Wallabia bicolor*), Short-beaked Echidna (*Tachyglossus aculeatus*) and the Common Wombat (*Vombatus ursinus*). The calls of six microchiropteran bats were identified and recorded. This included three bats listed as Vulnerable under the TSC Act, namely, the East Coast Freetail Bat, Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Little Bent-wing Bat (*Miniopterus australis*).

Other threatened mammals listed under the TSC Act and/or the EPBC Act previously recorded or likely to have habitat within 10 km of the study area include the Rufous Bettong (*Aepyprymnus rufescens*), Eastern Pygmy-possum (*Cercartetus nanus*), Spotted-tailed Quoll, Common Bent-wing Bat (*Miniopterus schreibersii*), Yellow-bellied Glider (*Petaurus australis*), Squirrel Glider (*Petaurus norfolcensis*), Brush-tailed Phascogale (*Phascogale tapoatafa*), Koala (*Phascolarctos cinereus*), Common Planigale (*Planigale maculata*) and the Greater Broad-nosed Bat (*Scoteanax rueppellii*).

Reptiles

The six reptile species recorded in the study area are the Eastern Water Dragon (*Physignathus lesueurii*), Jacky Lizard (*Amphibolurus muricatus*), Diamond Python (*Morelia spilota spilota*), Eastern Blue-tongued Lizard (*Tiliqua scincoides*), Garden Skink (*Lampropholis guichenoti*) and an unidentified species of *Eulamprus*. No threatened species were recorded during the current surveys or in the previous surveys in the locality. Only three listed threatened species (TSC and EPBC Acts) of reptile were relevant to the Proposal and it was found that none had potential habitat within 10 km of the study area.

Amphibians

During the 2001 surveys of the study area, five amphibians were identified and none are listed as threatened under the TSC and EPBC Acts. These were the Eastern Dwarf Tree Frog (*Litoria fallax*), Common Eastern Froglet, Striped Marsh Frog (*Limnodynastes peronii*), Red-backed Toadlet (*Pseudophryne coriacea*), and Smooth Toadlet (*Uperoleia laevigata*).

Whilst not found during the targeted surveys carried out by Biosis in 2001, a search of the DEC Atlas of NSW Wildlife revealed that two specimens of the Vulnerable listed Green-thighed Frog were recorded in 1997 near the Eggbert Farm on the western side of the existing property. The frogs are particularly difficult to detect, however the land in the Herons Creek section is considered suitable as Green-thighed Frog habitat (Atlas of NSW Wildlife). Potential breeding sites for this species occur along the Herons Creek section including ponds, creeks and paddocks. Targeted surveys for Green-thighed Frog were conducted by Biosis on 16 and 17 March 2004 and 30 and 31 March 2004 following significant rainfall events (50 mm in a 24 hour period). These surveys focussed on the collection and identification of tadpoles and/or metamorphlings (juvenile frogs). No evidence of Green-thighed Frogs was recorded during the surveys.

10.3.3 Fauna species of conservation concern

In NSW, threatened fauna species are defined under Schedules 1 (Endangered) and 2 (Vulnerable) of the TSC Act and under the EPBC Act. These species include those that are considered of conservation concern because of restricted distributions or habitat requirements, significant population or distributional range declines, and where threats to the survival of species still prevail.

A total of 38 threatened and/or migratory fauna species of bird, mammal, reptile and amphibian are known to occur in the study area. The threatened species found during the 2001 surveys and others of particular concern are discussed in Working Paper No. 7. Five species of threatened fauna and seven migratory species were recorded in the study area. Table 10–1 lists the potential and recorded fauna occurring within the study area and their conservation status.

10.3.4 Endangered fauna populations

The Emu (*Dromaius novaehollandiae*) is listed as an endangered population in the NSW North Coast Bioregion. Records for this species are concentrated between Coffs Harbour and Ballina. It was considered that the Proposal would not impact on individuals of this population.

Table 10–1 Threatened and migratory species recorded, or that have potential habitat, in the study area

Classification	Fauna type	Species recorded in 2001/2002 site-specific surveys	Other species with potential habitat within 10 km of the study area
'Vulnerable' species (TSC Act and/or EPBC Act)	Birds	Glossy Black-cockatoo	Australasian Bittern Square-tailed Kite Hooded Robin Barking Owl Powerful Owl Painted Snipe (<i>Rostratula benghalensis</i>) Grass Owl (<i>Tyto capensis</i>) Masked Owl
	Mammals	East Coast Freetail Bat Grey-headed Flying-fox Eastern False Pipistrelle Little Bent-wing Bat Koala	Rufous Bettong Eastern Pygmy-possum Spotted-tailed Quoll Common Bent-wing Bat Yellow-bellied Glider Squirrel Glider Brush-tailed Phascogale Common Planigale Greater Broad-nosed Bat
	Amphibians	none	Green-thighed Frog
'Endangered' species (TSC Act and/or EPBC Act)	Birds	Black-necked Stork	Swift Parrot Regent Honeyeater
'Migratory' species (EPBC Act)	Birds	Little Eagle Wedge-tailed Eagle Australian Wood Duck Cattle Egret Brown Falcon Rufous Fantail Satin Flycatcher	Latham's Snipe White-bellied Sea-eagle (<i>Haliaeetus leucogaster</i>) Swift Parrot Black-faced Monarch (<i>Monarcha melanopsis</i>) Spectacled Monarch (<i>Monarcha trivirgatus</i>) Regent Honeyeater

10.4 Significance assessment

The Eight Part Test is a statutory mechanism that helps determine whether a proposed development activity or development has potential for a significant impact on threatened species, populations or ecological communities or their habitats. The results of this test are used to determine if a SIS is required. Alternatively, the outcomes of the Eight Part Test can be used for guidance to implement impact avoidance and mitigation measures that would avoid significant impacts on threatened species and negate the need for a SIS.

Eight Part Tests were carried out on 70 threatened flora and fauna species listed under the TSC and EPBC Acts. The outcome of the application of Eight Part Tests indicated that the Proposal is unlikely to adversely impact on any threatened flora or fauna species listed under the TSC Act.

10.5 Assessment of impacts

The principal potential impacts on native fauna and flora associated with the construction and operation of the Proposal are:

- disturbance, loss or change in habitat associated with vegetation clearing
- fragmentation and delineation of habitat
- introduction of barriers that impede wildlife passage
- wildlife mortality (i.e. road-kill)
- edge effects
- alteration to natural drainage regimes and water quality
- habitat creation and management.

10.5.1 Habitat removal/vegetation clearance

The alignment of new roads should aim to traverse already cleared or disturbed land, however, with a Proposal which involves approximately 17.2 km of duplication adjacent to the existing carriageway, some removal of native vegetation would be unavoidable. Where removal of native vegetation is required, the footprint of the road should be reduced to limit the clearing of native vegetation and habitats to the smallest area possible consistent with other design influences including safety. The preferred option has been selected so that limited vegetation clearing would occur. The area of each native vegetation community to be removed is shown in Table 10–2.

Much of the route of the Proposal would involve duplication of the existing highway and remove vegetation that is already highly disturbed. Other areas, such as the bypasses of Johns River and Kew, would impact upon sections of relatively intact vegetation and thus the vegetation removal would be more significant.

The total amount of vegetation to be cleared for the Proposal is approximately 64.3 ha. Approximately 25 ha of this vegetation is in the Lake section of the study area, of which 23 ha (92%) is located within the current road reserve. The majority of land to be cleared for the length of the Proposal is located within the current road reserve (59%) (see Table 10–2).

Approximately 1.5 ha of land would be cleared from the Middle Brother State Forest, 2.7 ha of Crown Land and no DEC estate (including National Park) land would be affected. The vegetation communities most affected would be the relatively intact segments along the routes of the proposed bypasses of Johns River and Kew. Approximately 14.7 ha of land would be cleared for the Johns River bypass and 15.6 ha for the bypass of Kew (see Working Paper No. 7).

Table 10–2 Area of each native vegetation community to be removed

Vegetation community	Vegetation to be cleared				Total vegetation cleared	
	Within existing road reserve		Outside existing road reserve			
Coastal Blackbutt	23.0 ha	53%	20.1 ha	47%	43.1 ha	67%
Dry Tallowood Forest	9.9 ha	77%	2.9 ha	23%	12.8 ha	20%
Flooded Gum Forest	3.2 ha	100%	0 ha	0%	3.2 ha	5%
Sedgeland	0 ha	0%	0 ha	0%	0 ha	0%
Swamp Forest	1.6 ha	31%	3.6 ha	69%	5.2 ha	8%
Total	37.7 ha	59%	26.6 ha	41%	64.3 ha	100%

Source: Biosis Research 2004

10.5.2 Impacts on threatened flora species

Vegetation affected by the proposed works would constitute a relatively small proportion of the vegetation communities in the study area with much of the vegetation likely to be removed already in poor to moderate condition. Whilst relevant in a local sense, it is unlikely to be significant in terms of the overall distribution and conservation status of protected flora species.

Fifteen threatened flora species listed under the TSC Act have been identified as having potential habitat within the study area. No threatened species were recorded during the 2001/2002 surveys performed for the study area. As potential habitat exists, Biosis Research conducted Eight Part Tests (under the TSC Act) for each of the threatened species, the results of which are detailed in Working Paper No. 7. Eleven threatened species also listed under the EPBC Act were considered according to the EPBC Act Administrative Guidelines of Significance.

It was concluded that, providing suitable mitigation measures are implemented in all phases of the Proposal, no significant impact to the threatened species would occur. Biosis Research also concluded that neither a Species Impact Statement (SIS) nor a referral to DEH is required.

An Endangered Plant Population of Narrow-leaved Red Gum has been previously recorded in the vicinity of the study area. No individuals of this population were recorded in the study area despite targeted surveys being undertaken. Potential habitat of woodland or swampy, sandy sites (Harden 2002) for the population is present in the study area and consequently an Eight Part Test was undertaken. As this Endangered Population is outside the study area, it would not be affected by the Proposal and, as a result, it was concluded that the Proposal is unlikely to significantly impact this Endangered Population.

10.5.3 Impacts on protected fauna species

The removal of habitats for native fauna species would generally be of relevance in the local area although, for most species, it is unlikely to be significant in terms of the regional conservation status of protected fauna species. Many of the protected fauna species in the area would be immediately affected by clearing native vegetation and habitats, although some species are likely to recolonise following rehabilitation.

Six threatened species listed under the TSC Act were recorded in the study area during the 2001/2002 surveys. Seven migratory species as listed under the EPBC Act were also recorded during the studies. A total of 81 threatened and migratory species listed under the TSC Act, EPBC Act or both were considered in the light of the Proposal. It was found that only 27 threatened species under the TSC Act have potential habitat within the study area (including the recorded species) and these were assessed with Eight Part Tests. Four threatened species and a further 13 migratory species were listed under the EPBC Act and were assessed according to the EPBC Significance Assessment requirements (see Working Paper No. 7 for assessment details).

Targeted surveys carried out for the Green-thighed Frog did not find any evidence of breeding activity (i.e. presence of tadpoles or metamorphlings) after heavy rainfall despite the potential habitat for this species.

It was concluded that, providing appropriate mitigation techniques are implemented during design, construction and operation phases, the proposed works would not have a significant impact on any species or populations listed on the TSC Act or the EPBC Act. Neither a SIS nor a referral to DEH was considered necessary.

10.5.4 Habitat fragmentation

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas. The fragmentation of habitats is of particular concern where the location and construction of the road creates fragments of native vegetation which either become degraded and weed infested or which are too small to support viable populations of native flora and fauna species, resulting in genetic isolation. Newly created habitat is often utilised by some species, although they are usually generalist and often aggressive species such as the Noisy Miner (*Manorina melanocephala*) (Loyn et al. 1993).

Apart from the loss of total habitat area, fragmentation of vegetation tracts can cause a variety of impacts including genetic isolation, barrier effects and edge effects. The latter two are discussed below. The severity of impacts is dependent on a number of factors including distance between fragments, local environmental conditions, species present and mitigation measures.

The Proposal would result in habitat fragmentation where the new highway deviates from the existing highway, namely along the route of the proposed bypasses of Johns River and Kew. Specifically, patches of intact vegetation to be fragmented by the Proposal include those areas on the proposed Johns River bypass south of Stewarts River Road and to the north and south of Ocean Drive at Kew. Mitigation measures to ameliorate habitat fragmentation are discussed in Section 10.6.

10.5.5 Edge effects

Habitat edges are transitional zones characterised by changeable light levels, noise levels, wind speed and temperature. These effects are termed 'edge effects' and can promote degradation of adjacent vegetation through changes in microclimate, hydrology, flora species composition, altered pattern and frequency of fire, exotic flora and fauna invasion, improved predator access, and an increase in sedimentation, tree death and rubbish and water pollution (Bali 2000). Effects are known not to affect both sides of the road and are likely to alter depending on whether vegetation is downslope, downwind or surrounded by more habitat.

The edge effects currently experienced by habitat fragments are expected to increase as a result of the Proposal. Table 10–3 provides an estimate of the area of vegetation communities currently experiencing edge effects, the amount that is likely to occur due to the Proposal and the net increase in area and proportion.

Table 10–3 Current and proposed edge effects and net change

Vegetation Community	Current edge effects	Proposal edge effects	Net change in edge effects	Percentage change in edge effects
Coastal Blackbutt	63.6 ha	85.6 ha	+22.0 ha	35%
Dry Tallowood Forest	25.7 ha	32.1 ha	+6.4 ha	25%
Flooded Gum Forest	4.7 ha	8.1 ha	+3.4 ha	72%
Sedgeland	0.2 ha	0.2 ha	+0.0 ha	0%
Swamp Forest	4.4 ha	6.2 ha	+1.8 ha	41%
Total	98.6 ha	132.2 ha	+33.6 ha	34%

Bali (2000) has concluded that on average, edge effects from a road extend 50 m into an area of bushland. On this basis, approximately 132.2 ha of native vegetation would be impacted through edge effects by the Proposal (see Table 10–3). The current Pacific Highway over the Proposal length has edge effects totalling 98.6 ha, resulting in a total net increase in edge effects of 33.6 ha (or 34%) (see Working Paper No. 7). The greatest extent of edge effects would occur in the Lake section (approximately 11.9 ha or 24.6%) where there is almost continuous vegetation along the western side of the highway.

Approximately 69.0 ha (52.2%) of vegetation which would be impacted by edge effects occurs within the proposed road reserve compared to 38.5% within the current narrower road reserve. DEC Estate would have 2.0 ha affected, State Forests 11.5 ha and there would be 8.7 ha of Crown Land affected by edge effects resulting from the Proposal. The remaining 41 ha (31%) of vegetation affected by edge effects would be located on privately-owned properties.

A range of impact amelioration and environmental management measures has been incorporated into the design of the Proposal to reduce the imposition of direct and indirect impacts on adjacent habitats. The RTA has adopted a policy of 'best practice' construction and management techniques. This policy includes minimal vegetation clearance consistent with design standards, the installation of water quality control ponds, management of water discharges, control of contaminants, control and removal of weeds, and intensive site and habitat rehabilitation programs. Although some adverse impacts on habitats immediately adjacent to the road corridor cannot be avoided, the proposed mitigation measures (see Section 10.6) and RTA's 'best practice' would reduce the occurrence and severity of such impacts.

10.5.6 Barrier formation

Roads have the potential to act as significant barriers to the movement of terrestrial and arboreal fauna. Barrier effects are greater for some species than others, particularly smaller, ground-dwelling species with low mobility such as reptiles and amphibians. However, most reptiles and amphibians are likely to use purpose-built fauna underpasses, suitable drainage culverts or bridge openings to maintain movement between habitat areas that would otherwise be severed by the highway.

Highly mobile species, such as birds, are least affected by barrier effects, though responses vary. Birds would generally be able to cross the Proposal route (for the most part) by flying across it. The highway would involve the construction of bridges across the Stewarts and Camden Haven Rivers, permitting wetland and aquatic birds to fly either over or under these bridges. Consequently the Proposal is unlikely to have an adverse impact upon bird movements.

Movement of mammalian fauna is most likely to be affected adversely by the Proposal. Terrestrial mammals would either be repelled by the roadway and unable to cross in the absence of fauna underpasses or suitable drainage culverts or struck by vehicles when trying to cross the road (if they can gain access to the road reserve). The Proposal has the potential to adversely impact upon the movement of terrestrial mammals through the creation of physical barriers that impede faunal movements between habitat areas and could isolate populations of species on each side of the highway.

The Proposal would physically impede and restrict wildlife movements through the landscape, however, proposed drainage structures (pipe culverts and RCBC) and bridge openings would facilitate safe wildlife movements (east-west) under the highway. The locations of these design structures are presented in Table 6.9.

10.5.7 Wildlife corridors

Wildlife corridors are retained or restored habitat that enhance the connectivity of wildlife populations in a linear formation. They are used as one of the primary means of overcoming the effects of fragmentation (Wilson and Lindenmayer 1995). The functions provided by wildlife corridors for conservation purposes include the provision of foraging area and cover for movement of fauna between vegetation fragments, reducing genetic isolation, allowing access to a range of habitats, linking populations to maintain migration and re-colonisation, providing refuge for disturbances such as fire and providing habitat.

Wildlife corridors are often categorised in terms of their connectivity. The first category is the 'structural connectivity', which describes the spatial characteristics of the corridor including the distance over which the corridor extends, the width, the number of gaps and the habitat nodes present. The second category is the 'functional connectivity', which describes the ability of fauna to move through the corridor and it includes the spatial continuity and factors such as behaviour of the species, the scale of the species' movements, and its response to the corridors habitat.

Mapping by the DEC has identified four key regional corridors (Scotts et al. 2000) along the Proposal route. These are South Brother Link, Kew Corridor, Bulls Ground/Queens Corridor, and Burrawan/Kew Corridor. Linkages, location and faunal relevance of each of these corridors is shown on Figures 10-2A and 10-2B and described in Table 10-4.

Table 10-4 Major wildlife corridors in the study area

Corridor name	Corridor location	Link provided	Significant fauna
South Brother Link	Johns River section	Johns River State Forest to South Brother	Dry Coastal Foothills Assemblage, includes: Bibron's Toadlet (<i>Pseudophryne bibronii</i>) Green-thighed Frog Brush Bronzewing (<i>Phaps elegans</i>) Brush-tailed Phascogale Common Planigale Squirrel Glider Rufous Bettong Broad-nosed Bat
Kew Corridor	Kew section	Laurieton/Camden Haven key habitat to Kew State Forest	Koala Glossy Black-cockatoo
Bulls Ground/Queens Corridor	Herons Creek section	State Forests and DEC Estate	Dry Coastal Foothills Assemblage (see above), and Moist Escarpment-Foothills Assemblage, includes: Glossy Black-cockatoo Powerful Owl Masked Owl Koala Yellow-bellied Glider East Coast Freetail Bat Grey-headed Flying-fox Little Bent-wing Bat Common Bent-wing Bat Little Forest Bat (<i>Vespadelus vulturnus</i>)
Burrawan/Kew Corridor	Herons Creek section	Kew State Forest to Burrawan State Forest	Moist Escarpment-Foothills assemblage (see above)

These corridors comprise regional and localised linkages between key habitats that occur along the Proposal route. Local corridors important in the study area include riparian vegetation belts along Stewarts River, Camden Haven River, Walkers Creek, and Herons Creek. As the current and proposed highway crosses these waterways by bridge, the riparian vegetation forms significant links between vegetation on either side of the highway. The Main Northern Railway line also crosses these waterways, although the railway line is not considered a significant barrier to fauna movement due to the infrequency of rail services.

There is currently little connectivity for fauna movements between the Middle Brother National Park and Watson Taylors Lake. This is primarily due to the physical barrier caused by the existing highway. This area of the Proposal route is likely to benefit from the introduction and/or upgrading of design features such as pipe and box culverts that could strengthen faunal connectivity between the Middle Brother National Park and Watson Taylors Lake.

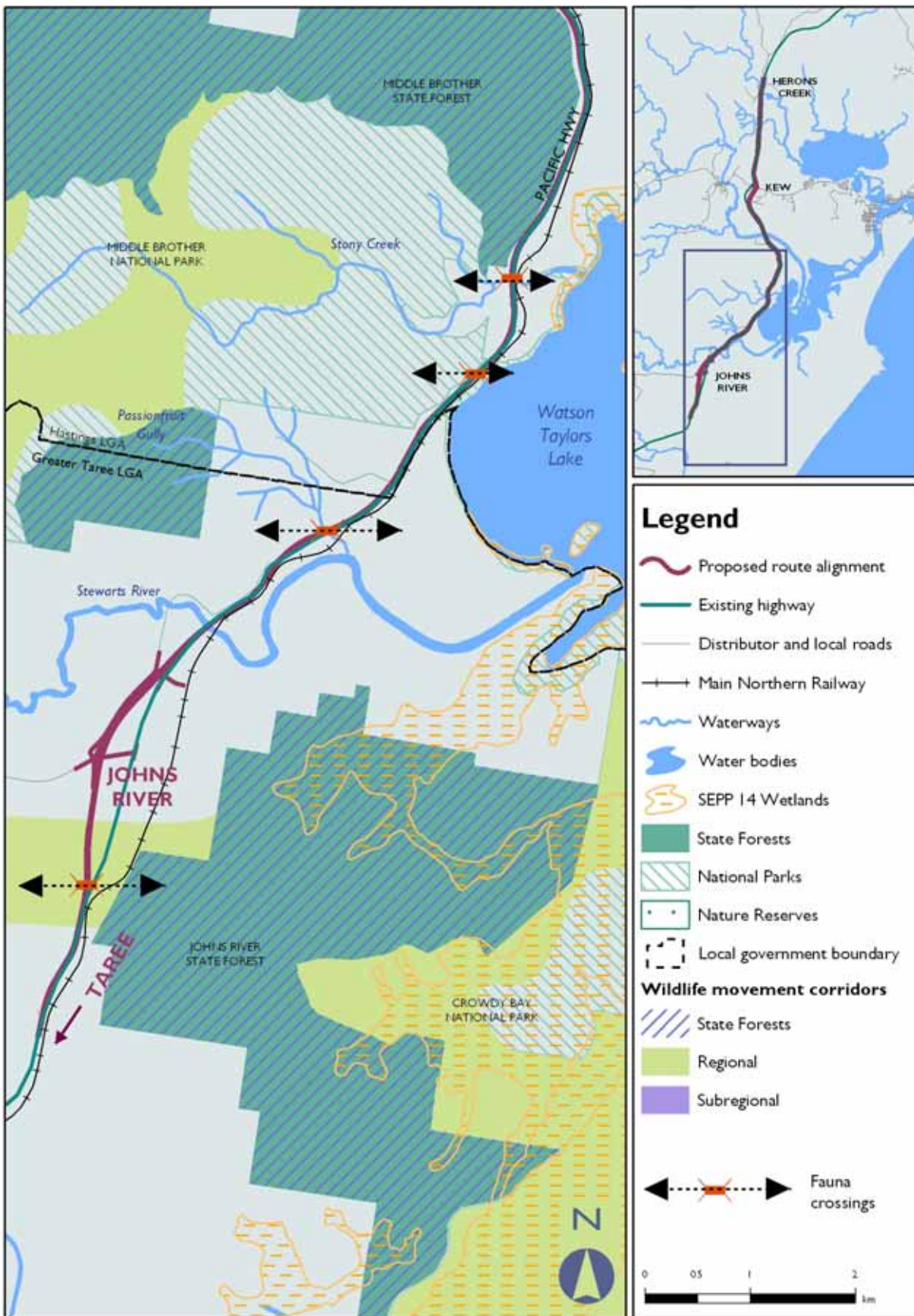


Figure 10-2A Wildlife movement corridors (south)

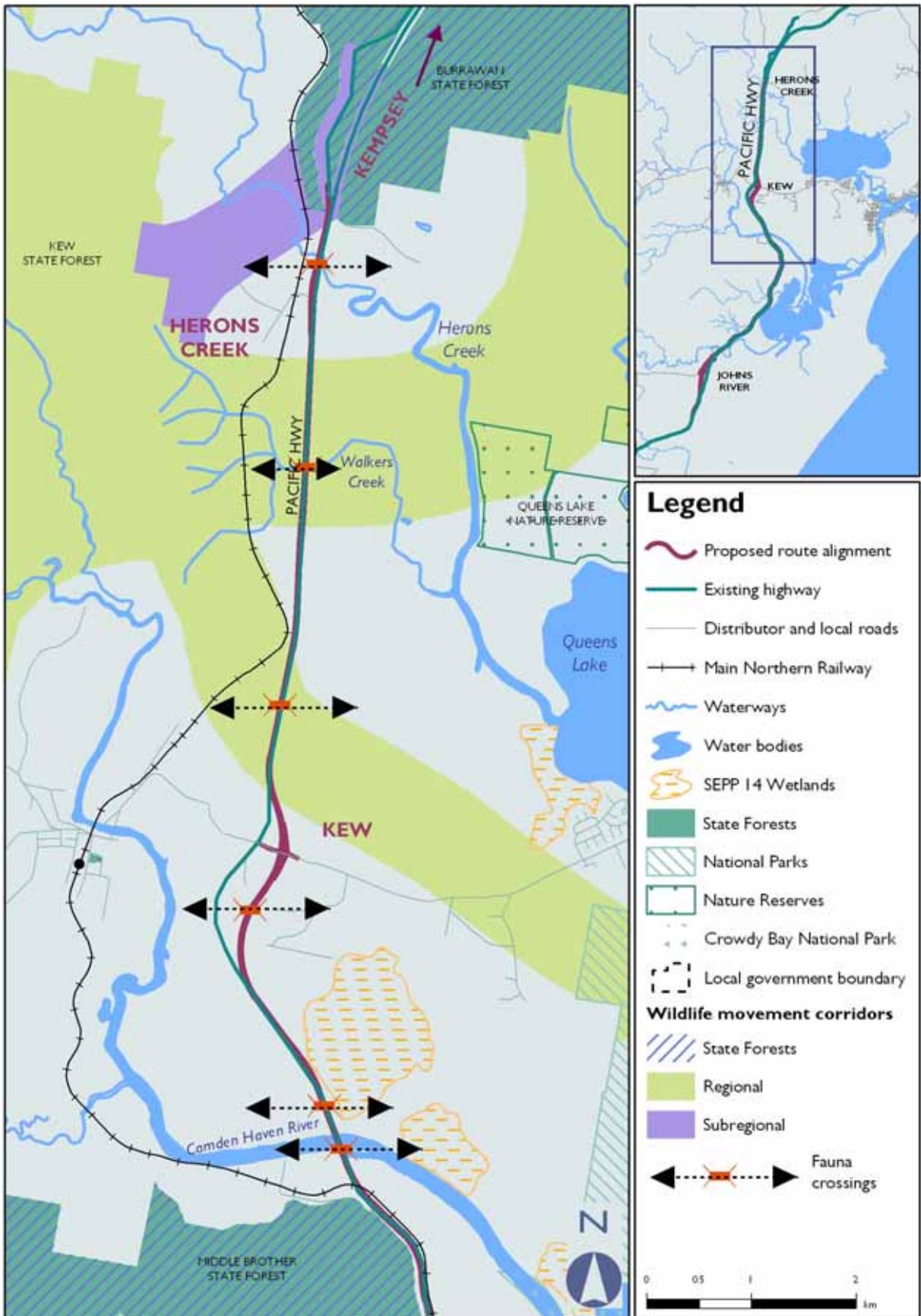


Figure 10-2B Wildlife movement corridors (north)

Vegetation in road reserves frequently forms important local corridors where communities have otherwise been cleared or highly modified. These corridors often allow local fauna movements, dispersion and migration by connecting to regional corridor networks. Road reserves are also utilised as habitat for many species adept at living in fringe environments.

While highways may not totally disrupt a corridor, they often act as a deterrent or increase mortality rates if appropriate mitigation is not provided. The potential for the Proposal to impose a barrier to faunal movement is of concern for the Koala, Yellow-bellied Glider, Squirrel Glider, and Brush-tailed Phascogale, as well as small mammals, reptiles and amphibians in general. Bridge openings and above-standard size drainage culverts are proposed to ameliorate impacts on wildlife corridors (see Table 6.9).

10.5.8 Wildlife mortality

Wildlife mortality due to collisions with vehicles is of particular concern for terrestrial species, including macropods, Koalas, small terrestrial mammals, reptiles and amphibians. Less mobile species are at the highest risk of mortality.

There are two primary means of fauna injury or death resulting from the construction and operation of highways. The first occurs during the initial phase of construction when vegetation in areas required for Proposal development is removed to expose soil substrates. This vegetation is habitat to many animals and injury or death of resident or visiting fauna may eventuate. Nocturnal fauna such as gliders and possums are also at risk as they shelter during the day and ground dwelling fauna such as snakes, lizards and small mammals are unable to travel large distances or at speeds fast enough to avoid clearing activities.

The second reason for fauna injury or death is road accidents. The likelihood for roadkill is proportional to the distance fauna must travel across the roads. Other road design factors influence the occurrence of road accidents such as the presence of embankments, slopes or walls. The RTA has policies and guidelines in place to reduce the incidence of fauna mortalities and a number of measures have been included in the design of the Proposal to reduce the likelihood of wildlife mortalities. These are discussed in Section 10.6.

10.5.9 Alteration of hydrologic regimes

Existing drainage patterns in the vicinity of the Proposal would generally be maintained by the use of traverse culverts beneath the roadway. Similarly, highway runoff would be directed to a network of temporary and permanent water quality treatment ponds prior to being discharged into local waterways. Native fauna are likely to use water quality treatment ponds following the completion of construction activities. The use of pond structures and the rehabilitation program are intended to ensure that hydrologic regimes are not adversely affected by the highway upgrade and that habitat and resources for native flora and fauna are provided in suitable locations. Further details are provided in Chapter 9.

10.5.10 National Parks, State Forests and SEPP 14 wetlands

The Proposal has the potential to affect the Middle Brother National Park, a number of State Forests, and two SEPP 14 wetlands located on the eastern side of the route, immediately north of the Camden Haven River crossing. The Proposal route has been selected to avoid direct contact with Middle Brother National Park and the two SEPP 14 wetlands (No. 544(a) and No. 544(c)) and, therefore, avoid any subsequent vegetation and habitat loss. The potential exists that, indirectly, erosion and sedimentation and highway runoff inflows may impact the water quality and aquatic biota of these wetlands. An embankment associated with a section of the former highway runs parallel to the eastern side of the existing highway between Stations 12800 and 13800, and separates the highway from SEPP 14 wetlands No. 544(a) and No. 544(c). This embankment would be retained during the operation of the Proposal. It is acknowledged that several culverts exist along this section of embankment to maintain transverse drainage flows. A temporary sedimentation basin is proposed to be

located on the eastern side of the highway between Stations 13000 and 13200 to capture and treat sediment-laden runoff during construction. This basin would be retained and converted into a permanent water quality control pond to capture and treat highway runoff during the operation of the Proposal. Diversion drainage would also be provided on both sides of the highway to control highway runoff during both construction and operation of the Proposal.

An area of 1.5 ha of land and habitat would be lost in the Middle Brother State Forest due to land acquisition, though this vegetation is currently susceptible to edge effects (see Working Paper No. 7). The clearance of habitat would be regulated by RTA policy and guidelines (see Section 10.6). Adequate safeguards and additional mitigation measures have been incorporated into the Proposal design to reduce the potential for direct and indirect environmental impacts (see Section 10.6).

10.6 Proposed mitigation measures

The RTA's *Road Development and Impact on Habitat Amelioration Measures* (RTA 1998) outlines policy principles with regard to the planning and construction of roads. Specifically the objectives of the RTA with regard to habitat amelioration in roads projects are:

- to avoid impacts on habitat through the planning process
- to minimise impacts on habitat through the planning process
- to mitigate impacts on habitat, through the use of a range of amelioration measures.

Consequently the principal form of mitigation incorporated into the Proposal is impact avoidance which would be achieved through:

- achievement of the Proposal largely by duplication of the existing highway
- location of the new carriageway primarily within the existing road reserve in areas of highway duplication
- location of the preferred option alignment to avoid direct disturbance to National Parks, Nature Reserves or SEPP 14 wetlands in the study area
- location of the Johns River and Kew bypasses through generally cleared and disturbed agricultural land rather than intact forest communities
- retaining the majority of existing bridges over waterways to limit the additional clearing and removal of riparian vegetation communities
- maximising the opportunities for the provision of fauna movement facilities to encourage fauna movement.

10.6.1 Habitat removal and vegetation clearance

Despite efforts to minimise the need for habitat removal through the design, some vegetation clearance is inevitable. The following measures would be implemented to ameliorate the possible impacts:

- restrict vegetation clearing to necessary areas only
- fence the area required to be cleared with highly visible temporary fencing in sensitive areas or flagging tape to prevent inadvertent clearance beyond what is required
- comply with relevant RTA guidelines for fauna rescue associated with road works that covers the felling of non-habitat and habitat trees
- in conjunction with DEC develop a plan to install nest boxes to replace removed tree hollows
- manage vegetation clearing to reduce the invasion of noxious weeds.

10.6.2 Native flora

Specific mitigation measures proposed to avoid or reduce the potential for adverse impacts on native flora (particularly threatened species) include:

- a detailed inspection of areas which are to be cleared or disturbed, to identify and collect or protect any individual threatened plant species present
- the collection and relocation of individual plants of conservation significance where appropriate when it is not possible to avoid them in the clearing and construction phases
- the collection of seeds or plant material from individual plant species of conservation significance (where appropriate) which are to be affected, and their propagation for use in replanting and rehabilitation programs (along the alignment or in relevant reserves, as advised by the DEC)
- the implementation of specific maintenance measures for propagated seedlings of relevant threatened plant species, as part of the rehabilitation and management program for the Proposal
- the protection and management of plant species of conservation significance which are to be retained along the route of the Proposal during construction such as protective fencing and maintenance and monitoring
- the avoidance of individual plants of threatened species where possible and the use of appropriate structures and design to enable individual plants to be retained
- the appropriate design of water quality ponds and stormwater discharge points along the Proposal route to prevent plants of conservation significance being affected by alterations to drainage and water discharge
- the treatment of water derived from the construction and operation of the road to avoid the discharge of contaminants or nutrients onto plant species of conservation significance or their habitats
- the provision of compensatory habitat as a means of offsetting adverse environmental impacts imposed by the Proposal. In this regard, the RTA, with agreement from DEC, has implemented a compensatory habitat package for the southern section of the upgrading of the Pacific Highway between Hexham and Port Macquarie, largely through the purchase of 553 ha of land at Mount Karuah (J O'Donnel [RTA], pers. comm., 8 June 2004).

10.6.3 Native fauna

Specific mitigation measures identified to avoid or reduce the potential for adverse impacts on native fauna (particularly threatened species) include:

- pre-clearing surveys of native vegetation, where required, to identify fauna individuals, species or populations requiring collection and relocation
- specific searches for fauna of particular concern immediately prior to clearing activities, such as Koalas, frog habitat, nests, large hollow-bearing trees and hollow-dwelling species - appropriate measures to deal with fauna species found prior to clearing activities would be incorporated in the CEMP
- the retention of habitat features and resources for native fauna (such as hollow-bearing trees and hollow logs) distributed along the route of the Proposal wherever possible,
- re-use of elements of potential value for native fauna (e.g. hollow-bearing trees, hollow logs, rocks) in suitable areas

- fauna-proof fencing (i.e. floppy-top fencing) specifically for terrestrial fauna such as Koalas to limit access opportunities for animals to the highway - fauna-proof fencing should be installed where structures facilitating fauna movements are located, such as RCBC and bridge openings
- design of bridge abutments at Stewarts River, Camden Haven River, Walkers Creek and Herons Creek to incorporate sufficient passage for wildlife movement along bank areas with appropriate contouring, landscaping and rehabilitation
- detailed design of all RCBC structures to include raised sections or varying floor heights so that fauna movements can continue during periods of moderate stream flow as well as appropriate treatments to facilitate and encourage animal use of the culverts and provide shelter and protection from predators
- the maintenance of communication with the local DEC officers, WIRES and/or other relevant local wildlife carer groups, to deal with individual animals during the construction phase of the Proposal.

Green-thighed Frog

Although this species was not recorded during the 2004 targeted surveys, previous sightings and the presence of suitable habitat at Herons Creek Road (south) is enough to warrant specific mitigation measures in this location. The breeding patterns of this species are highly variable and, therefore, if any potential existing breeding sites are to be disturbed by the Proposal, (e.g. ephemeral ponds and soaks, creeks, ditches in paddocks), other breeding wetlands should be constructed in accordance with expert DEC advice. This advice is likely to include wetlands being close to the impacted area, constructed as ephemeral (not always filled), at least 20 m long, 5 to 10 m wide and less than 1 m deep, with steep sides to maximise water volume and reduce evaporation, located on natural drainage lines where possible, with dense understorey vegetation planted and maintained around the wetlands and designed to remain flooded for over 60 days if located in the sun, and 100 days if shaded.

Koala

Koala habitat occurs along the length of the Proposal route. The occurrence of Koala feed trees (Coastal Blackbutt Forest and Dry Tallowwood Forest) are concentrated along the Kew bypass section of the Proposal route north of Ocean Drive. New or upgraded RCBC structures would be provided in these areas to maintain faunal connectivity between habitats on the eastern and western side of the highway.

10.6.4 Habitat fragmentation

The primary mechanism for reducing the incidence of habitat fragmentation and its subsequent impacts is appropriate design and route selection. The Proposal has considered habitat fragmentation and where possible disturbances remain on one side of a vegetation community which avoids creation of additional fragmentation and increased length of edge effect.

In addition to the inclusion of box culverts, RCBC structures and bridge openings in the concept design in order to maintain connectivity between habitat areas straddling both sides of the highway, other suggested measures to mitigate the impacts of fragmentation include:

- native and locally indigenous plants only should be used in the landscaping to reduce weed invasion into surrounding vegetation
- vegetation adjacent to the highway and within the road reserve should be managed to reduce invasion by weed species during construction.

10.6.5 Edge effects

As edge effects occur outside the direct development zone, efforts must be made to reduce possible impacts at their source. Possible mitigation methods include:

- using tagging of vegetation, visible temporary fencing in sensitive areas and other methods to minimise disturbance to habitat adjacent to construction
- minimising disturbance to stream banks and streambeds - this may be readily achieved with some bridges, but would not be possible in the case of culverts
- where possible, locating all ancillary building and works in cleared or otherwise disturbed areas, away from waterways and other sensitive areas
- avoiding the stockpiling of materials on adjacent vegetation
- managing construction activities to dispose of waste material and/or contaminants away from adjacent habitats
- implementing soil erosion and sedimentation control measures
- implementing a weed management strategy within the road reserve, and being especially diligent whilst revegetation is becoming established
- using indigenous local species for landscape plantings and revegetation.

10.6.6 Barrier effects and impacts to 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 Proposal design. The fauna movement features incorporated into the Proposal design comprise new and upgraded RCBC structures, bridge openings and fauna-proof fencing as detailed in Table 6-6 (refer to Chapter 6).

The design of the fauna movement features has been based on the regional continuity of habitat in the area, the size and location of habitat present on either side of the highway, the species likely to need or use fauna movement facilities, the current and possible future land uses on either side of the highway and the feasibility of construction with respect to engineering constraints.

Additionally, a number of other drainage structures included in the Proposal and not mentioned above may also function as fauna movement facilities for smaller fauna. Other fauna movement locations were not considered appropriate due to the lack of suitable habitat on at least one side of the preferred route, or because they do not provide connectivity within a wider regional context (see Working Paper No. 7).

Where required, fauna-proof fencing should be located on both sides of the highway (as close as practicable) to guide animals to and through the movement structures and to prevent access onto the highway.

10.6.7 Wildlife mortality

Mitigation measures proposed to reduce the incidence of wildlife injury and mortality include:

- reduction of the clearance and disturbance of fauna habitat (especially trees with hollows and shelter vegetation) prior to and during construction to the practical minimum – this includes temporary sites for ancillary construction activities and facilities such as stockpile locations (see Section 7.4)
- compliance with relevant RTA guidelines and policy during construction for fauna rescue, including procedures for clearing non-habitat and habitat trees, relocating rescued fauna and inclusion of wildlife specialists in the process

- reduce the risk of roadkill in the operational phase by designing barriers to prevent fauna access to highways by such species as Koalas - these are to be designed in conjunction with fauna movement facilities and therefore not reduce connectivity between habitats located either side of the highway
- prevent vegetation from hanging over barriers and encouraging wildlife to enter the highway corridor
- consider flora species used for landscaping so that wildlife are not attracted to them for feeding or other purposes (e.g. avoid using *Allocasuarina* species which are an attractive food source for Glossy Black-cockatoos)
- where safety and other considerations allow, include structures to allow fauna movement through traffic barriers located in median strips to allow continued passage should wildlife gain access to the road.

10.6.8 National Parks, State Forests and SEPP 14 wetlands

Mitigation measures proposed to reduce the impacts of clearance activities adjacent to the eastern edge of Middle Brother National Park and Middle Brother State Forest, and SEPP 14 wetlands No. 544(a) and No. 544(c), include:

- pre-clearing inspection of all vegetation in the vicinity of the highway corridor to avoid adverse impacts on native fauna species (particularly threatened species) and to identify and mark plant species of conservation significance
- appropriate collection and disposal of all weed material (if any) from the roadworks area
- collection and shredding of cleared, weed-free native plant material and its redistribution into appropriate areas of native vegetation
- implementation of a dedicated rehabilitation and replanting program utilising appropriate plant species as recommended by DEC
- continued maintenance of the embankment between the existing highway and SEPP 14 wetland No. 544(a)
- incorporation of appropriate drainage and water quality control measures into the Proposal design to control the ingress of sediment-laden and highway runoff during both construction and operation of the Proposal
- construction strictly within designated areas, especially adjacent to the Middle Brother National Park, to avoid any inadvertent encroachment or otherwise into the National Park.

10.7 Monitoring

Practical and cost effective post-construction monitoring should be conducted in order to detect changes to threatened species and their habitats as a result of the Proposal. Information obtained from the monitoring can then be used to assess impacts and to introduce or alter management strategies for amelioration of any potential adverse impacts. Monitoring programs should also include reviews of the efficacy of mitigation measures and allow for further improvement.

10.7.1 Flora

No threatened species of flora were recorded in the study area during the site-specific surveys of 2001 and 2002. A number of threatened flora species have potential habitat in the study area, however, construction and operational activities associated with the Proposal would not encroach upon these species. Consequently, no monitoring of flora species is considered necessary.

10.7.2 Fauna

Six species of fauna listed as threatened under the TSC Act and/or EPBC Act were recorded in the study area. A further seven migratory species as listed under the EPBC Act were recorded. Eight Part Tests for a further 26 threatened and migratory species were undertaken and it was concluded that no significant impact is expected.

Nonetheless two species are given special consideration:

- the Koala (the conservation and management of natural vegetation that provides habitat for Koalas is encouraged under SEPP 44 for Part 4 development but RTA observes as 'best practice') and may reside in the study area
- the Green-thighed Frog has been recorded previously in sections along the Proposal route and is particularly sensitive to changes in habitat.

This has led to fauna movement structures and fauna-proof fencing being incorporated into the design of the Proposal. Monitoring to evaluate the success of mitigation measures in relation to the Green-thighed Frog would be implemented.

Any required monitoring of fauna would be undertaken by a suitably qualified ecologist and would incorporate the recording of fauna populations, changes in population sizes and assessment of the cause of these changes (natural or otherwise). Water quality monitoring would also aid in assessment of the effects (see Chapter 9). Monitoring of the fauna movement structures and fauna-proof fencing should give an indication of the effectiveness of these measures and allow for improvements if needed.

10.8 Implications for ESD

10.8.1 Precautionary principle

The 'precautionary principle' requires that 'measures to prevent environmental degradation' be implemented 'where there are threats of serious or irreversible environmental damage', irrespective of 'full scientific certainty' regarding their efficacy in ameliorating adverse environmental impacts. The design of the preferred option includes a range of measures to limit or reduce potential adverse impacts on native biota and their habitats, some of which have not been rigorously evaluated in scientific terms. Notwithstanding this 'lack of scientific certainty', mitigation measures such as fauna movement facilities, fauna-proof fencing and the re-use of cleared native vegetation material would be implemented along the proposed bypass to limit or reduce adverse impacts on native biota and to contribute to the prevention of 'environmental degradation'.

10.8.2 Intergenerational equity

With the implementation of the nominated mitigation measures, no long-term adverse impacts are anticipated on flora and fauna resources that would lead to a significant reduction in their quality or quantity in the future. This approach to Proposal design, construction and monitoring is consistent with the principle of maintaining intergenerational equity.

10.8.3 Conservation of biological diversity

The design of the Proposal has had careful regard to the reduction in vegetated areas to be cleared and to the integration of features that would allow continued movement patterns for all fauna species in the localities shown on Figures 10-2A and 10-2B. The implementation of a comprehensive landscape strategy based on use of indigenous vegetation species and a range of mitigation measures (including the provision of compensatory habitat) before, during and after construction would assist in ensuring that biological diversity in the local area and region is maintained and, if possible, enhanced.

This approach to Proposal design, construction and monitoring is consistent with the longer-term conservation of biological diversity and the maintenance of ecological integrity.

10.8.4 Improved valuation and pricing of environmental resources

The consideration of environmental issues in the early stages of route development and route selection has assisted in achieving improved valuation and pricing of environmental resources as it ensures that these issues are given equal or more important consideration than other issues such as strategic planning and engineering. Measures to facilitate fauna movement across the reserve of the Proposal have been integrated into the concept design and included in estimates of total Proposal cost. The mitigation measures and monitoring proposed reflect this emphasis on protecting these resources and thus reinforce their environmental value.