11. Biodiversity

11.1 Assessment approach

Detailed biodiversity assessments for the proposed upgrade have been undertaken throughout the route selection (2001-2004) and environmental assessment and concept design (2004-2007) phases of the project. The terrestrial ecology and aquatic ecology studies undertaken during the route selection phase (Brown & Bali 2003; The Ecology Lab 2003) provided the basis for the subsequent environmental assessment – *Project Application Report Supporting Information – Biodiversity Assessment* (NSW Roads and Traffic Authority 2006a). Both phases included extensive desk-based assessment and comprehensive field survey.

Desktop studies on terrestrial ecology included a thorough literature and database review as well as aerial photographic interpretation. Fieldwork included a full range of in-depth studies such as vegetation traverses, quadrat surveys, habitat mapping, visual observation of the condition of terrestrial fauna habitat, and a detailed terrestrial vertebrate fauna survey. A full description of these studies and these results can be found in *Project Application Report – Supporting Information – Biodiversity Assessment* (NSW Roads and Traffic Authority 2006a).

The aquatic ecology study involved a review of existing information about the estuarine and freshwater environment of the area, including habitats, biota and the influence of human activities. This information was combined with fieldwork in the study area to assist in assessing the potential impacts of the proposed upgrade. A full description of these studies and their results can be found in the *Kempsey to Eungai Pacific Highway Upgrade Project Application Report – Supporting Information – Biodiversity Assessment* (NSW Roads and Traffic Authority 2006a).

Further targeted assessment addressing the Environmental Assessment requirements have been completed, the result of which are presented in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2.

The study area used for the ecological assessment of the proposed upgrade is defined as 1 kilometre each side of the proposed alignment as shown in Figure 11-1. The wider biological environment and the regional/landscape context of the proposed upgrade, was also examined.

This chapter summarises the biological impacts associated with the proposed upgrade. It discusses the terrestrial and aquatic flora and fauna assemblages and their habitats along the proposed upgrade and the potential impacts of road construction and operation on them. It summarises the proposed mitigation measures as well as the assessments of the significance of the impacts as required under the *Environmental Planning and Assessment Act 1979,* the *Threatened Species Conservation Act 1995* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

11.2 Study area context

11.2.1 Landscape context

A quantitative analysis of the landscape context of the proposed upgrade is presented in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2. The landscape context is the condition and nature of vegetation and habitats surrounding the study area. Many processes in a patch of vegetation are linked to processes in the surrounding landscape

(Lindenmayer & Burgman 2005). The quality (including the long-term survival) of vegetation is dependent on a suite of factors that influence the patch or stand, including its position in the vegetated landscape (Todd 2003). The landscape context analysis included assessment of patch size, vegetation cover in the landscape and distances between patches likely to be affected by the proposed upgrade to core areas of habitat.

The proposed upgrade occurs in a modified landscape, but generally the landscape contains a high proportion of remnant vegetation in large patches suitable to maintain significant populations of a range of biodiversity, including threatened species. The proposed upgrade will remove a significant amount of forest/woodland vegetation, the effects of which will be most significant at the local scale. However, at the wider landscape scale the impacts should not be significant. The patches that will be affected include large patches of vegetation that will continue to function as core areas of habitat, along with those that are smaller but are still functionally connected to core areas of habitat.

The proposed upgrade crosses areas of floodplain and native vegetation that contain a high diversity of species and vegetation communities, many of which are considered to be rare or threatened. These are described below.

11.2.2 Vegetation communities

Eleven native vegetation communities occur within the proposed upgrade study area (see Table 11-1 and Figure 11-1). Together these communities cover a total area of 5,090 hectares (55% of the study area). The remaining areas have been cleared of native vegetation or consist of plantation. The most extensive community is Blackbutt Dry Sclerophyll Forest, which covers an area of 2,494 hectares (27% of the study area).

Four communities are recognised as endangered under the *Threatened Species Conservation Act 1995*, totalling 1,468 hectares (16% of the study area). One additional community is considered regionally significant, with less than 15% of the known extent of the community present in conservation reserves (Regional Forest Agreement Monitoring Unit 2000). The condition of these communities is variable, ranging from highly disturbed with a high level of weed invasion to good quality.

Table 11-1 Vegetation communities within the study area

Vegetation community	Area occupied within study area (hectares)
Endangered ecological community[1]	
Freshwater Wetlands*	507
Swamp Sclerophyll Forest*	445
Swamp Oak Floodplain Forest*	397
River-flat Eucalypt Forest*	119
Less than 15% reserved	
Mahogany Dry Sclerophyll Forest*	14
Other	
Cleared	3,751
Blackbutt Dry Sclerophyll Forest*	2,494
Grey Gum/ Tallowwood Dry Sclerophyll Forest*	775

Vegetation community	Area occupied within study area (hectares)
Stringybark /Ironbark/ Bloodwood Dry Sclerophyll Forest*	165
Scribbly Gum Dry Sclerophyll Forest*	165
Plantation	24
Brush Box Turpentine Wet Sclerophyll Forest*	6
Riparian Oak Shrubland*	3
TOTAL	8,865

Notes
1. listed as an endangered ecological community under the Threatened Species Conservation Act 1995:
** Native community*

11.2.3 Terrestrial Fauna habitats

Four broad fauna habitat types were recorded within the study area, corresponding to the broad vegetation types: dry forest, wet swamp forest, wetlands and cleared/partially cleared agricultural lands. These are shown in Figure 11-2.

Within these broad habitat types a range of significant habitat features were identified including tree hollows and roosting resources, feeding resources including *Allocasuarina* suitable for the threatened Glossy Black-cockatoo and a range of breeding habitats suitable for threatened species of frog.

Vegetation and non-developed sites within the study area largely form part of a broad-scale corridor network covering much of Kempsey local government area (see Figure 11-3), based on the key habitats and corridors network determined by the Department of Environment and Conservation (Scotts 2003; Scotts et al. 2000a). Mapped key habitats[1] are areas of predicted high conservation value for forest fauna, and include many large areas of vegetated lands and important vegetation remnants. A framework of corridors has been mapped that provide connectivity between these areas across the landscape.

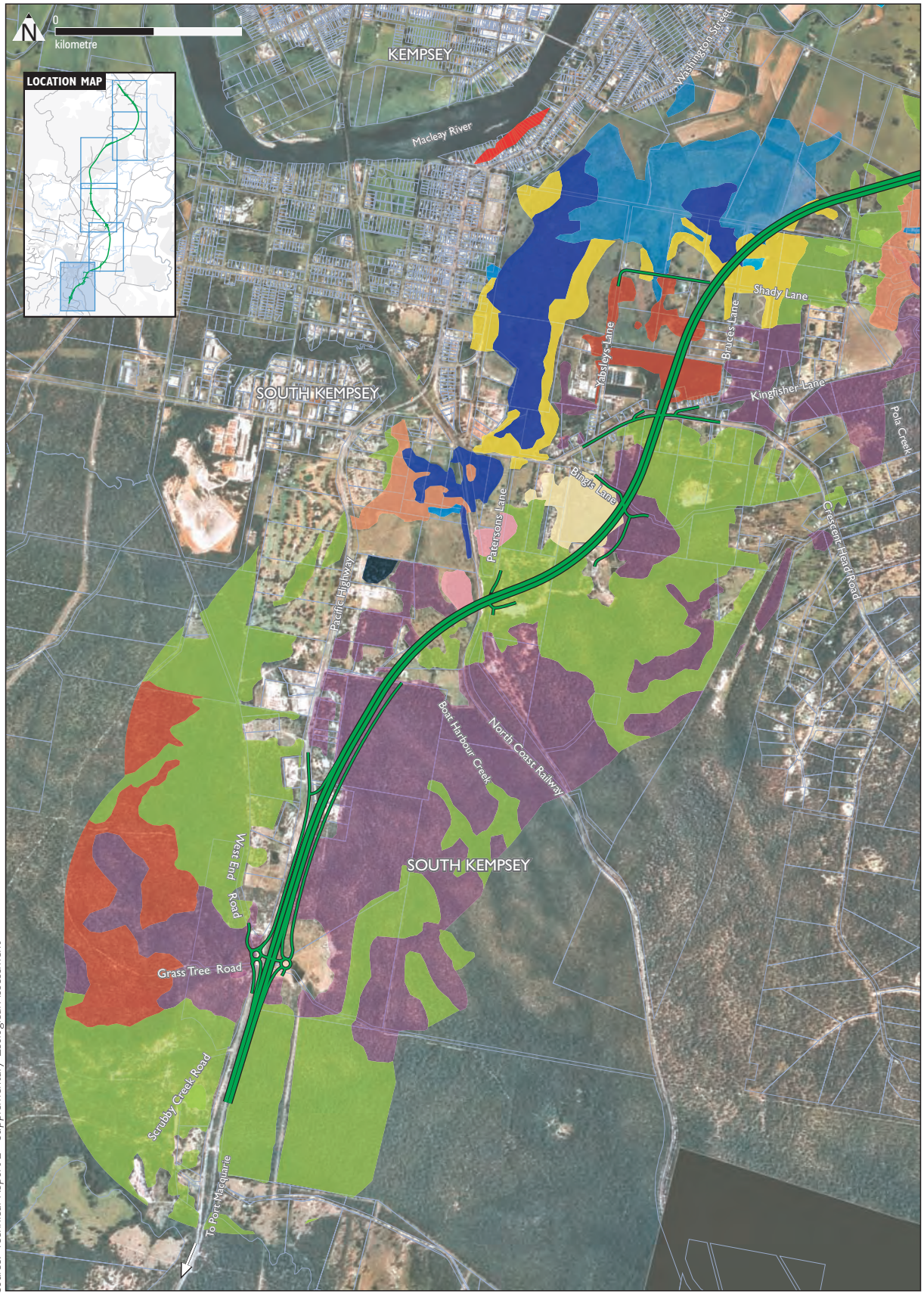
To the north of the study area a broad vegetation corridor includes Ngambaa Nature Reserve and Tamban State Forest and connects to coastal conservation reserves including Hat Head National Park. Focal species within the corridor network include the Koala and Brush-tailed Phascogale. Within the south of the study area connectivity is between reserves such as Kumbatine and Marie National Parks. Focal species within this corridor network include Yellow-bellied Glider and Brush-tailed Phascogale.

These corridor linkages are decided at the regional scale. However at the more localised scale, key habitats and corridors are also of importance reflecting more localised species considerations (Scotts, Drielsma & Kingma 2000b).

Aquatic habitats

The proposed upgrade crosses a number of creeks and waterways within the study area ranging in scale from small unnamed creeks with disconnected pools to the Macleay River. The likelihood of presence of fish and fish habitat are outlined in Table 11-2, ranging from "major fish habitat" in Class 1 waterways such as the Macleay River to "unlikely fish habitat" in Class 4 waterways (Fairfull and Witheridge 2003).

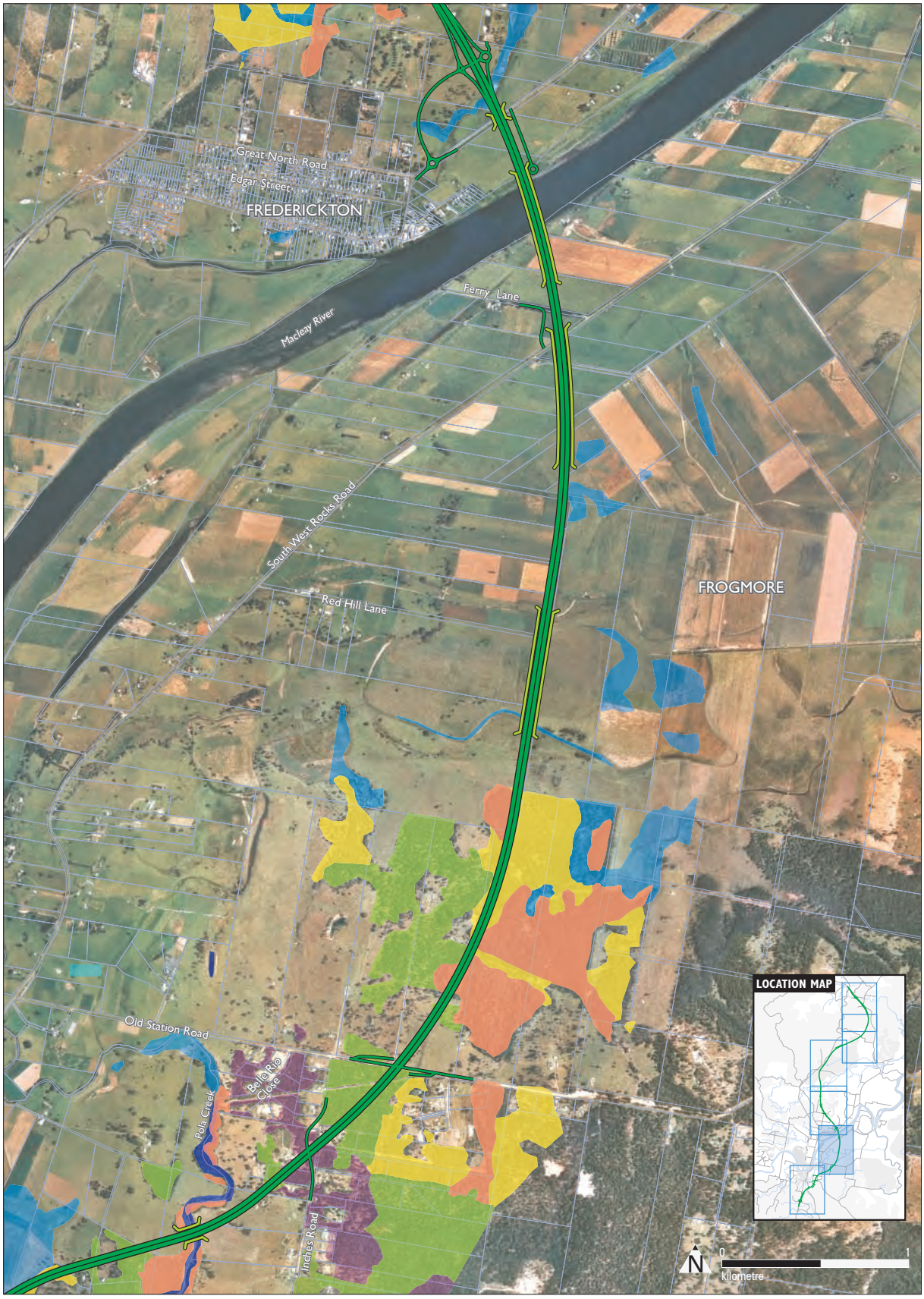
Figure 11-1a Vegetation communities within the study area



Source: *Technical Report 2 - Supplementary Ecological Assessment*

- The proposed upgrade
- Blackbutt - Scribbly Gum Dry Sclerophyll Forest
- Blackbutt - Dry Sclerophyll Forest
- Freshwater wetland (Lepironia Sedgeland)
- Freshwater wetland (Wet Meadows)
- Mahogany Dry Sclerophyll Forest
- River-flat Eucalyptus Forest
- Riparian Oak Shrubland
- Stringybark - Ironbark - Bloodwood Dry Sclerophyll Forest
- Swamp Oak Floodplain Forest
- Swamp Sclerophyll Forest
- Tallowwood - Grey Gum Dry Sclerophyll Forest

Figure 11-1b **Vegetation communities within the study area**



Source: *Technical Report 2 - Supplementary Ecological Assessment*

The proposed upgrade
Blackbutt - Dry Sclerophyll Forest
Freshwater wetland (Lepironia Sedgeland)
Freshwater Sedgeland (Wet Meadow)
Swamp Oak Floodplain Forest
Swamp Sclerophyll Forest
Tallowwood - Grey Gum Dry Sclerophyll Forest

Figure 11-1c **Vegetation communities within the study area**

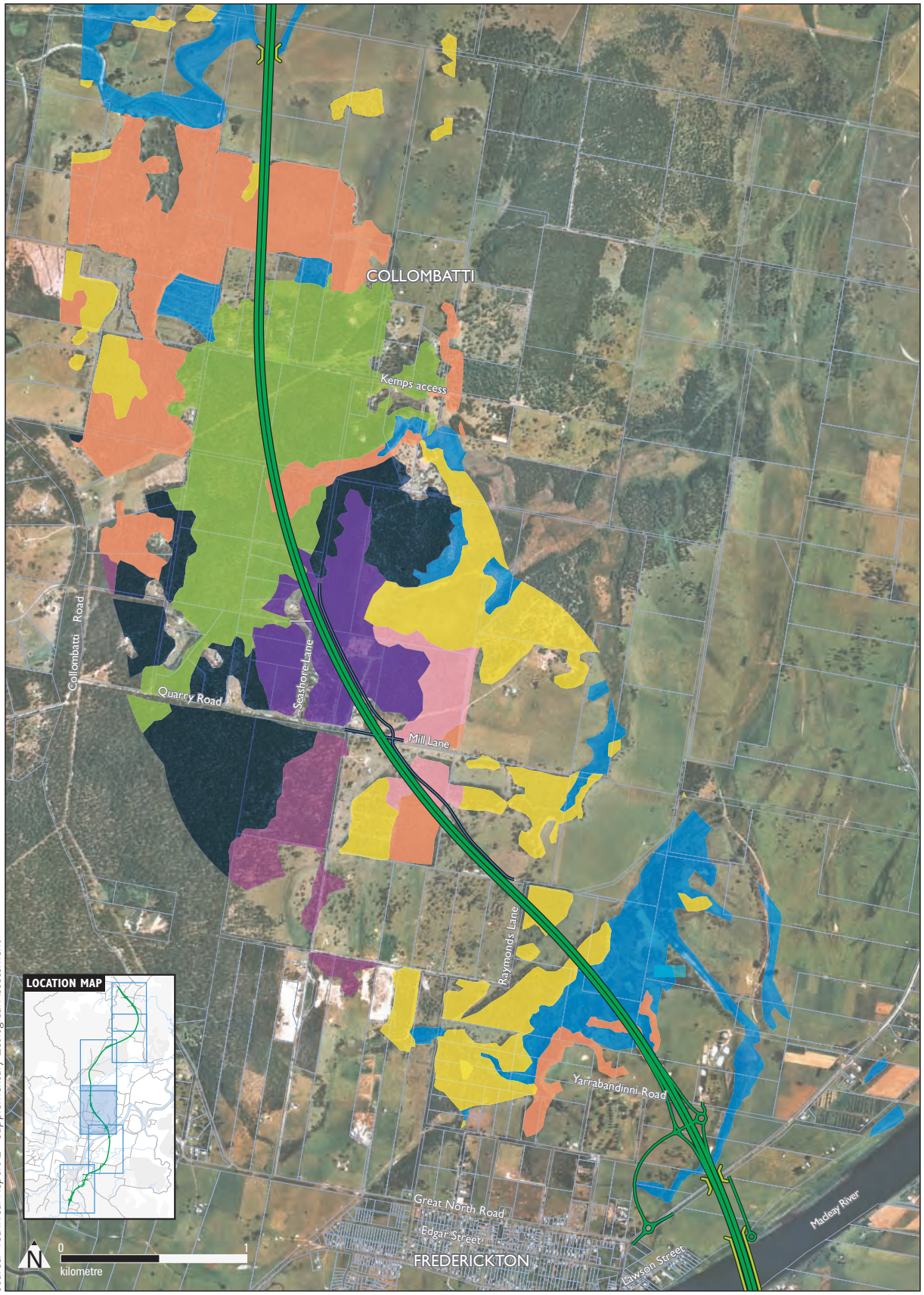
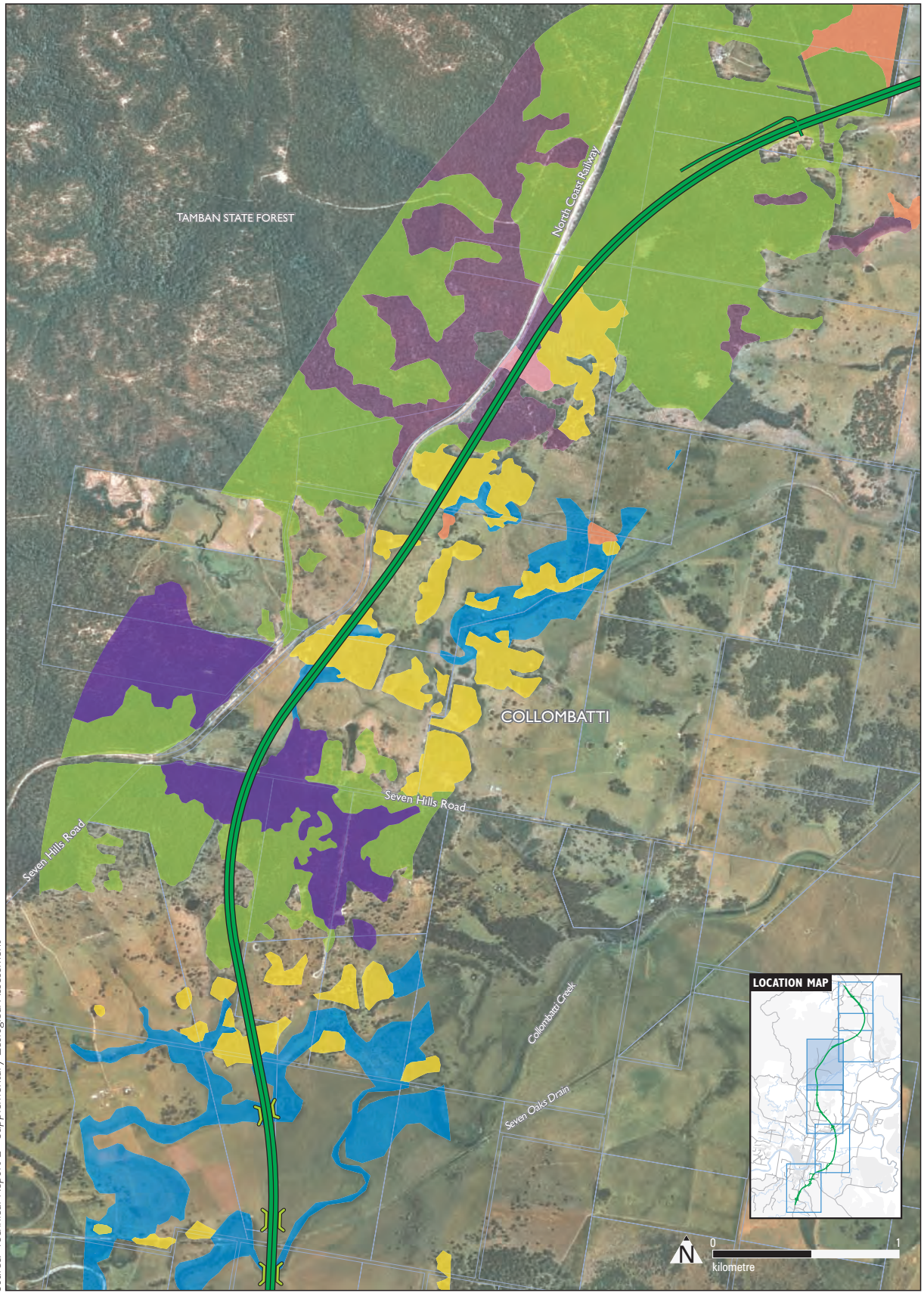
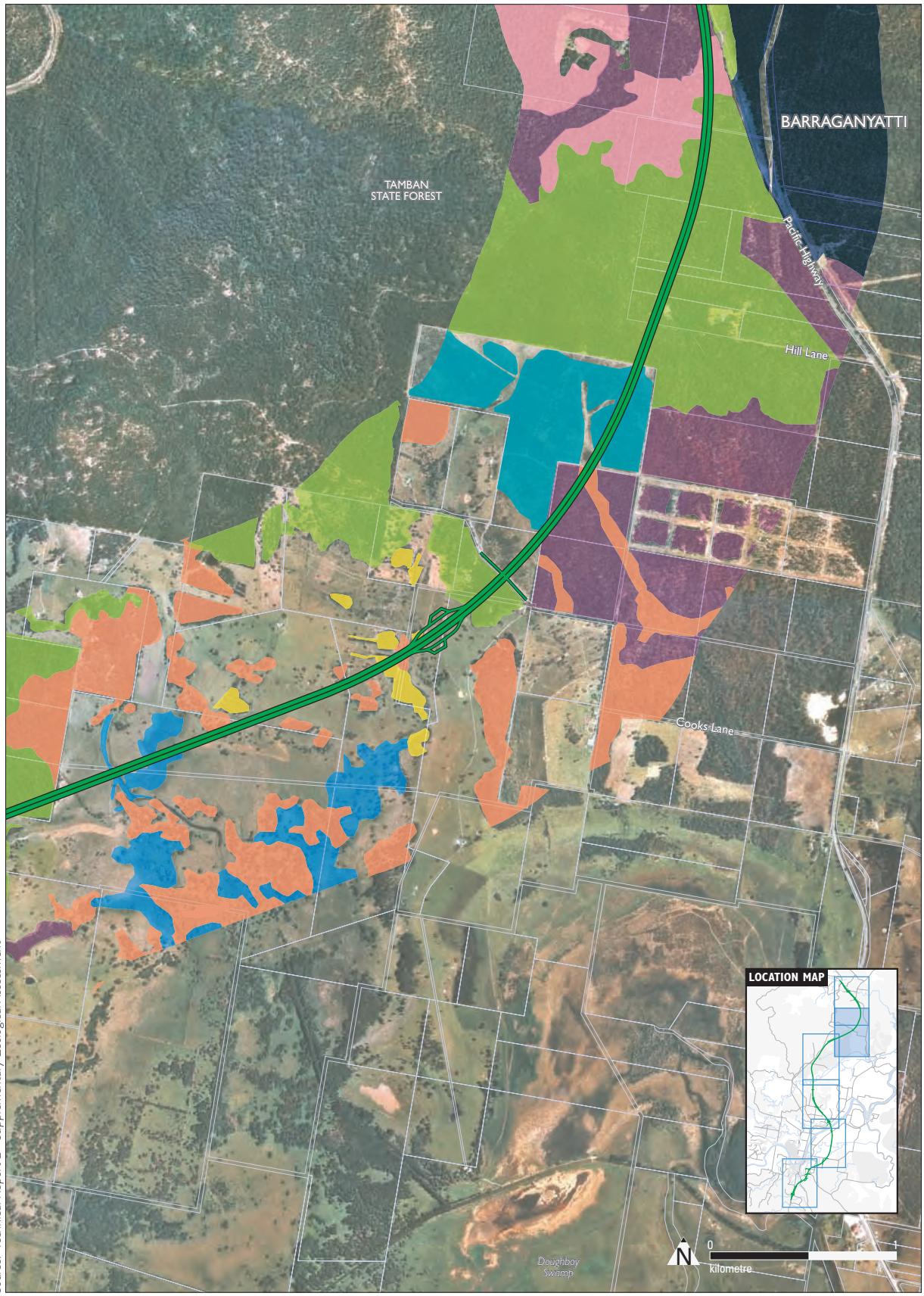


Figure 11-1d **Vegetation communities within the study area**



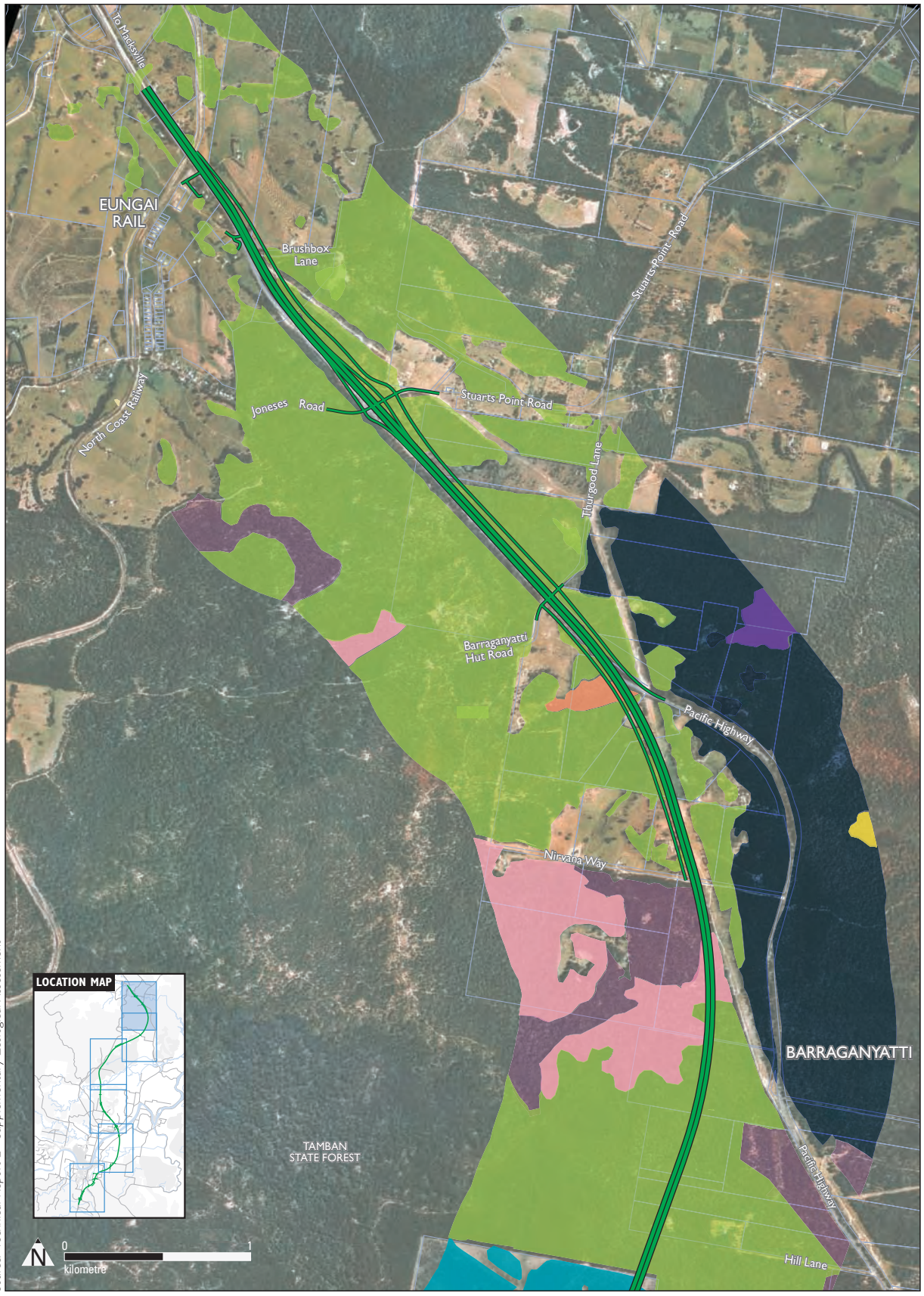
Source: Technical Report 2 - Supplementary Ecological Assessment

Figure 11-1e Vegetation communities within the study area



Source: Technical Report 2 - Supplementary Ecological Assessment

Figure 11-1f **Vegetation communities within the study area**



Source: Technical Report 2 - Supplementary Ecological Assessment

Figure 11-2 Fauna habitats within the study area

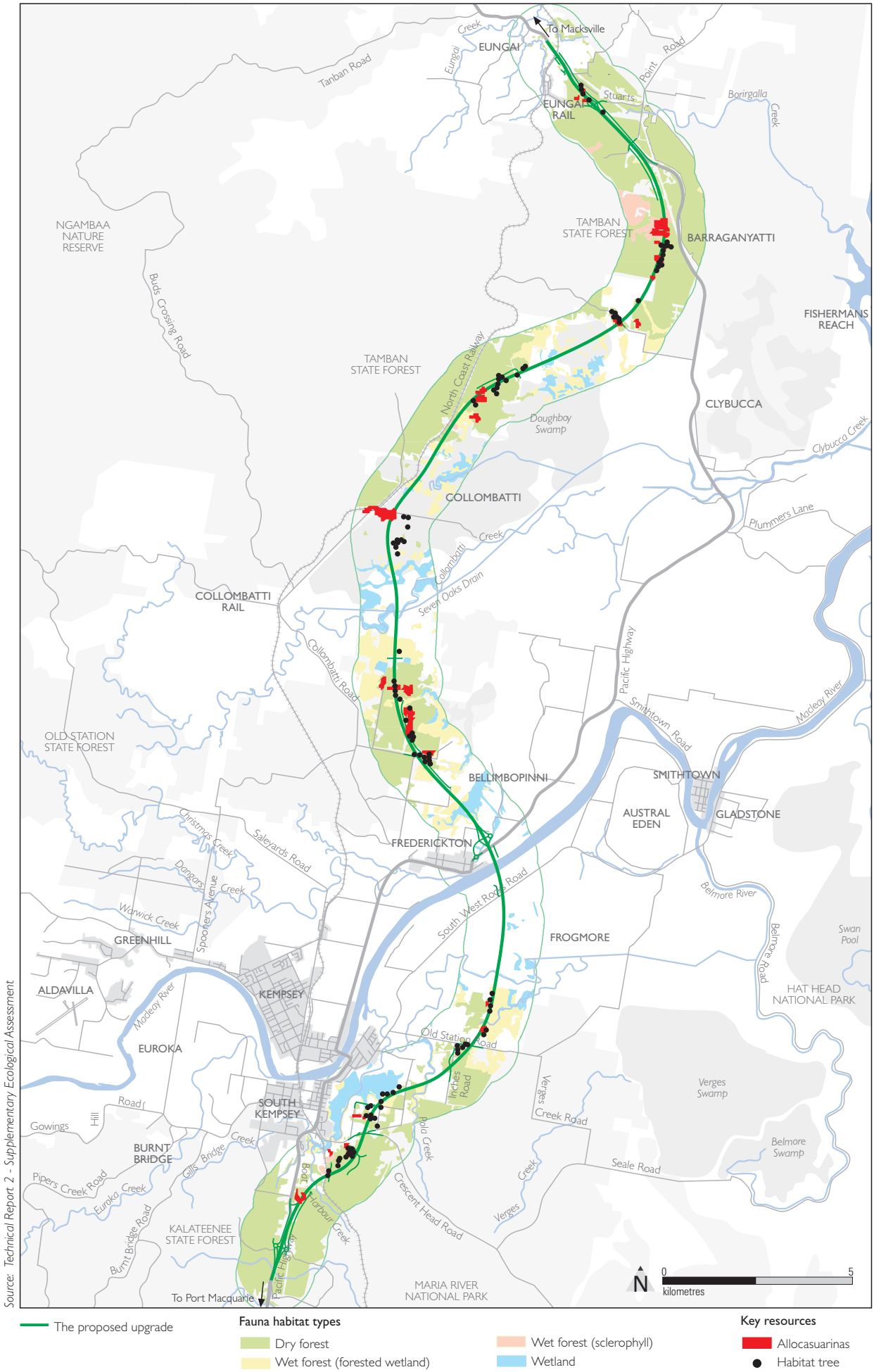
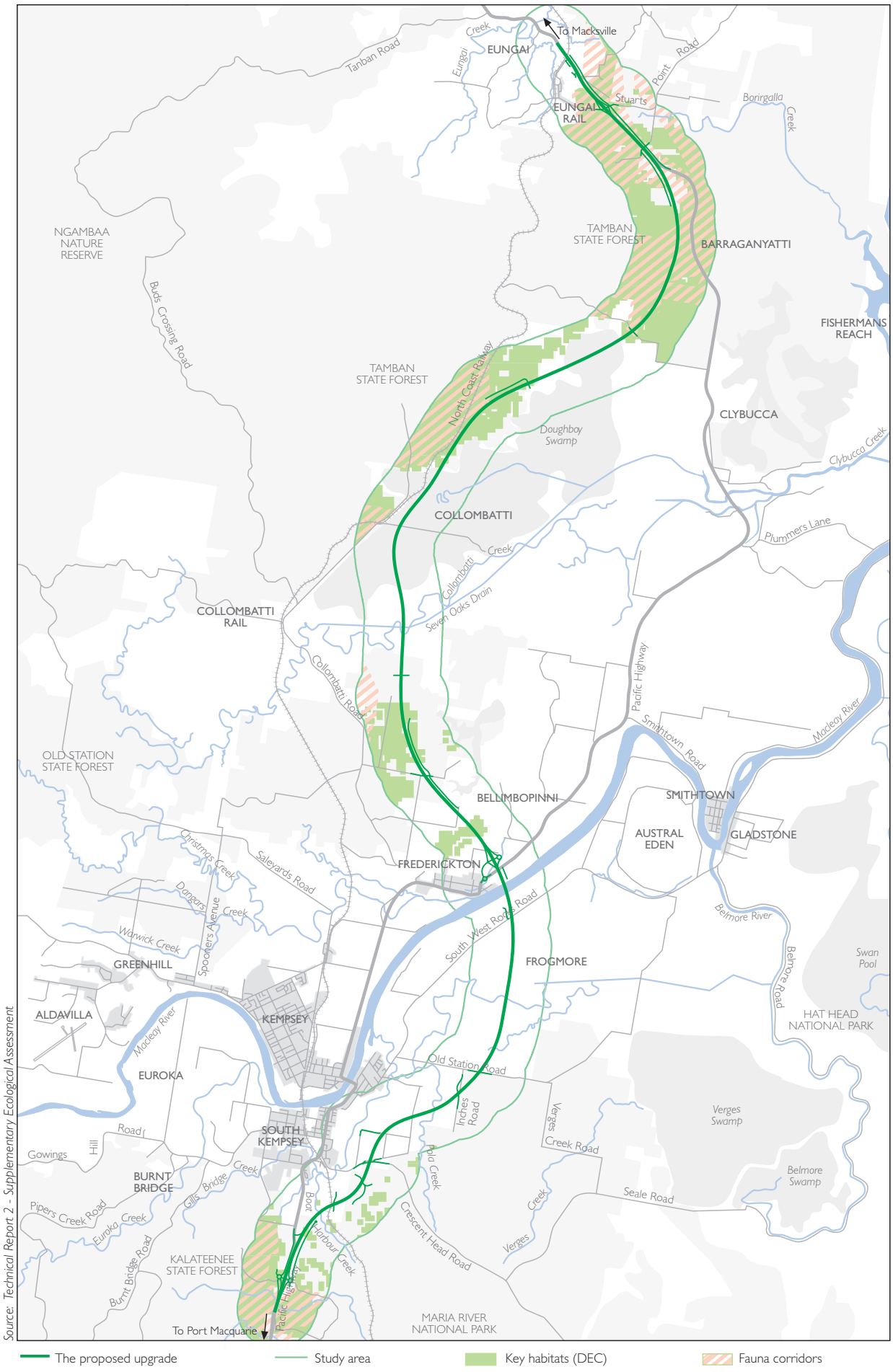


Figure 11-3 **Key habitats and corridors within the study area**



Source: Technical Report 2 - Supplementary Ecological Assessment

Table 11-2 **Waterways and likelihood of fish habitat**

Waterway	Waterway classification and fish habitat
Boat Harbour Creek	Class 2 – Moderate fish habitat
Unnamed tributary of Gills Bridge Creek	Class 3 – Minimal to unlikely fish habitat
Pola Creek	Class 2 – Moderate fish habitat
Frogmore (ephemeral drainage)	Class 4 – Unlikely fish habitat
Macleay River	Class 1 – Major fish habitat
Unnamed waterway north of Frederickton	Class 4 – Unlikely fish habitat
SEPP 14 wetland (No. 478)	Class 3 – Minimal fish habitat
Collombatti Creek	Class 2 – Moderate fish habitat
Unnamed waterways in Doughboy Swamp	Class 3 – Minimal to unlikely fish habitat
Barraganyatti Creek	Class 3 – Minimal fish habitat
Borirgalla Creek.	Class 2 – Moderate fish habitat

Source: NSW Roads and Traffic Authority (2006a)

1. *Note that the definition of Key Habitat used by the Department of Environment and Conservation differs from that used by the Roads and Traffic Authority in their Compensatory Habitat Guidelines.*

The locations of key waterways within the study area are shown in Figure 10-1 in Chapter 10 – *Hydrology and water management*.

One SEPP 14 Wetland lies within the study area, known as Collombatti Swamp (No. 478) (refer Figure 10-1). Clybucca Swamp and other SEPP 14 wetlands lie to the east of the construction corridor and study area, and to the north of the proposed upgrade. The boundary of Collombatti Swamp is located approximately 100 metres to the east of the construction corridor.

Maundia triglochinoides *(foreground)*

Source: NSW Roads and Traffic Authority (2006a)

11.2.4 Terrestrial flora

A total of 514 species of plant have been recorded within the study area including 104 introduced weeds. A large proportion of the proposed upgrade crosses low lying land and species commonly recorded are typical of floodplains and moist areas. Common families of plants recorded within the study area include Cyperaceae (sedges), Juncaceae (rushes), Myrtaceae (especially *Callistemon, Melaleuca* and *Eucalyptus* species), Asteraceae (daisies such as *Vernonia cinerea*), Fabaceae (wattles and peas including *Acacia* species) and Poaceae (grasses). Common species of weed include *Cinnamomum camphora* and *Lantana camara.*

A total of twelve (12) threatened species of plant listed under the *Threatened Species Conservation Act 1995* and/or the *Environment Protection and Biodiversity Conservation Act 1999* have been recorded or predicted to occur within 10 kilometres of the proposed upgrade corridor. Three of these species, *Arthraxon hispidus, Persicaria elatior* and *Maundia triglochinoides* have been recorded within the study area (Figure 11-4a to f) while the remainder are unlikely to occur based on the type of habitats present within the study area.

11.2.5 Terrestrial fauna

The number of animal species recorded during surveys of the study area was 211, comprising 17 amphibians, 15 reptiles, 47 mammals (seven introduced) and 129 birds (five introduced) (NSW Roads and Traffic Authority 2006a).

Twenty-three species (23) listed as threatened (Table 11-3) (*Threatened Species Conservation Act 1995* and *Environment Protection and Biodiversity Conservation Act 1999*) and twenty five

(25) species listed as migratory (*Environment Protection and Biodiversity Conservation Act 1999*) were recorded in the study area during surveys as part of the route selection studies and the project application report (NSW Roads and Traffic Authority 2006a).

Thirty-nine (39) threatened species of animal have been recorded or have the potential to occur within 10 kilometres of the proposed upgrade corridor based on database and literature searches of the area (NSW Roads and Traffic Authority 2006a). This number comprises three amphibians, 18 birds and 18 mammals. Of the 39 threatened species, all are listed under the *Threatened Species Conservation Act 1995* and seven (7) are also listed under the *Environment Protection and Biodiversity Conservation Act 1999*. Eighteen (18) of these species were recorded during surveys in the study area while a further four are likely to occur based on their habitat requirements and the presence of suitable habitat within the study area. These are listed in Table 11-3 and Figure 11-4a to f.

Table 11-3 Terrestrial fauna species of conservation significance during survey of the study area

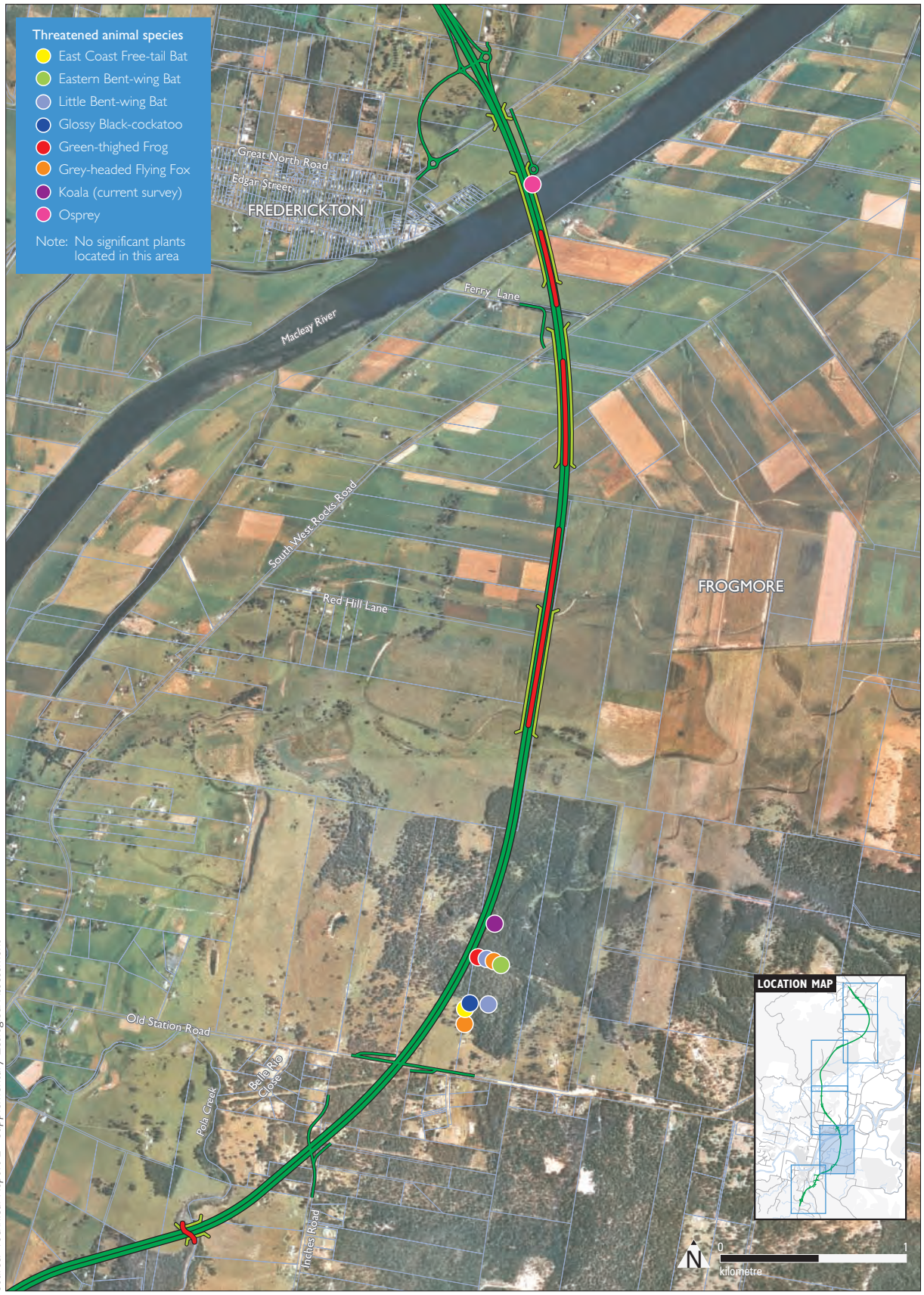
	Conservation significance/Listing	
Common Name (Scientific Name)	State[1]	National[2]
Amphibians		
Green Thighed Frog (*Litoria brevipalmata*)	V	
Birds		
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	V	
Black-necked Stork (*Ephippiorhynchus asiaticus*)	E	
Comb-crested Jacana (*Irediparra gallinacean*)	V	
Square-tailed Kite (*Lophoictinia isura*)	V	M
Powerful Owl (*Ninox strenua*)	V	
Osprey (*Pandion haliaetus*)	V	M
Masked Owl (*Tyto novaehollandiae*)	V	
Sooty Owl (*Tyto tenebricosa*)	V	
Mammals		
Hoary Wattled Bat (*Chalinolobus nigrogriseus*)	V	
Golden-tipped Bat (*Kerivoula papuensis*)	V	
Little Bent-wing Bat (*Miniopterus australis*)	V	
Eastern Bent-wing Bat (*Miniopterus schreibersii*)	V	C
Eastern Freetail-bat (*Mormopterus norfolcensis*)	V	
Large-footed Myotis (*Myotis adversus*)	V	
Yellow-bellied Glider (*Petaurus australis*)	V	
Squirrel Glider (*Petaurus norfolcensis*)	V	
Brush-tailed Phascogale (*Phascogale tapoatafa*)	V	
Koala (*Phascolarctos cinereus*)	V	
Common Planigale (*Planigale maculata*)	V	
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	V	
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V	

1. *listed under the Threatened Species Conservation Act 1995 – V = vulnerable, E = endangered*
2. *listed under the Environment Protection and Biodiversity Conservation Act 1999 – V = vulnerable, E = endangered, M = migratory, C = conservation dependent.*

Figure 11-4a **Location of significant plants and threatened animal species within the study area**

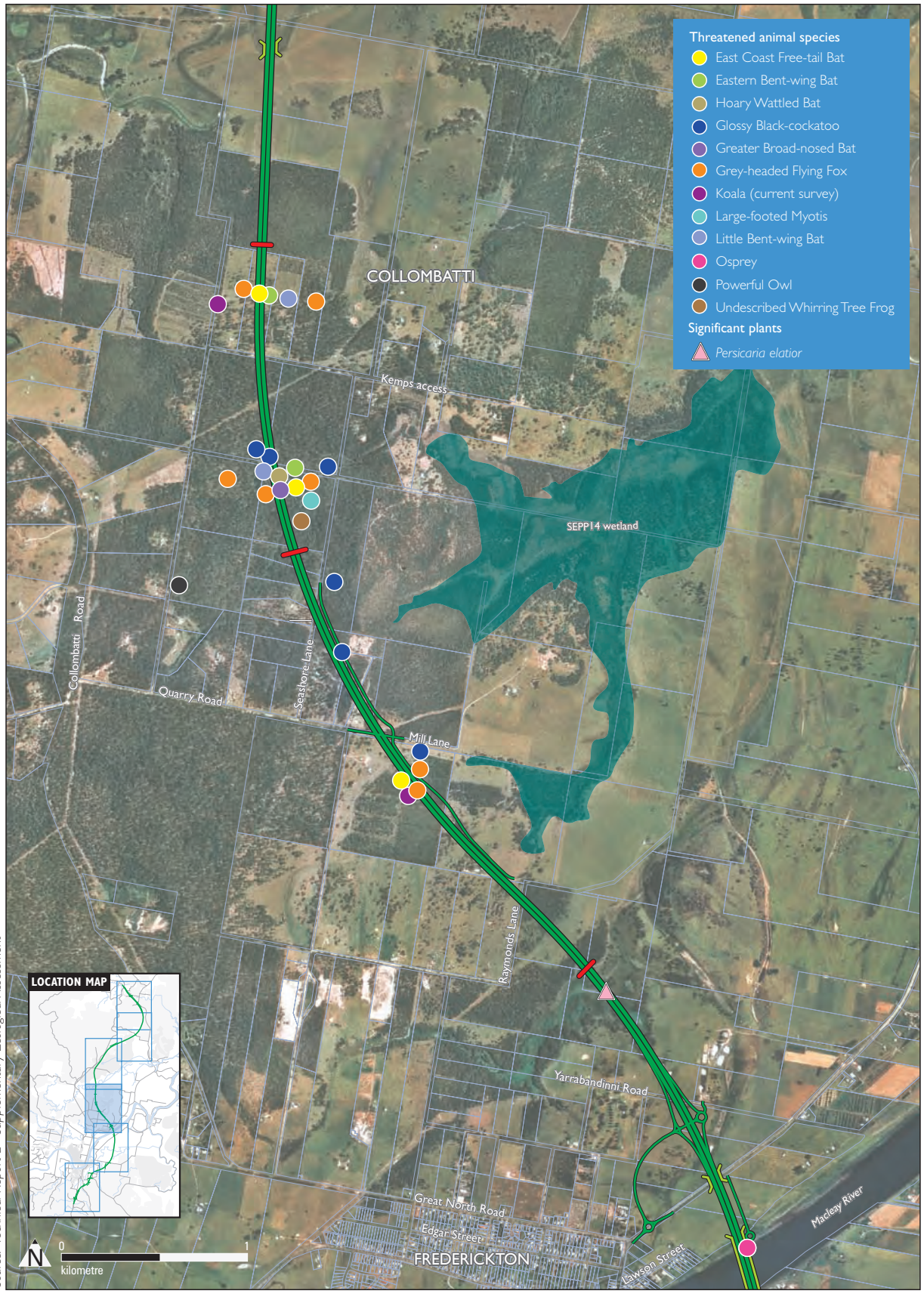
Source: Technical Report 2 - Supplementary Ecological Assessment

Figure 11-4b **Location of significant plants and threatened animal species within the study area**



Source: Technical Report 2 - Supplementary Ecological Assessment

Figure 11-4c Location of significant plants and threatened animal species within the study area



Source: Technical Report 2 - Supplementary Ecological Assessment

Figure 11-4d **Location of significant plants and threatened animal species within the study area**

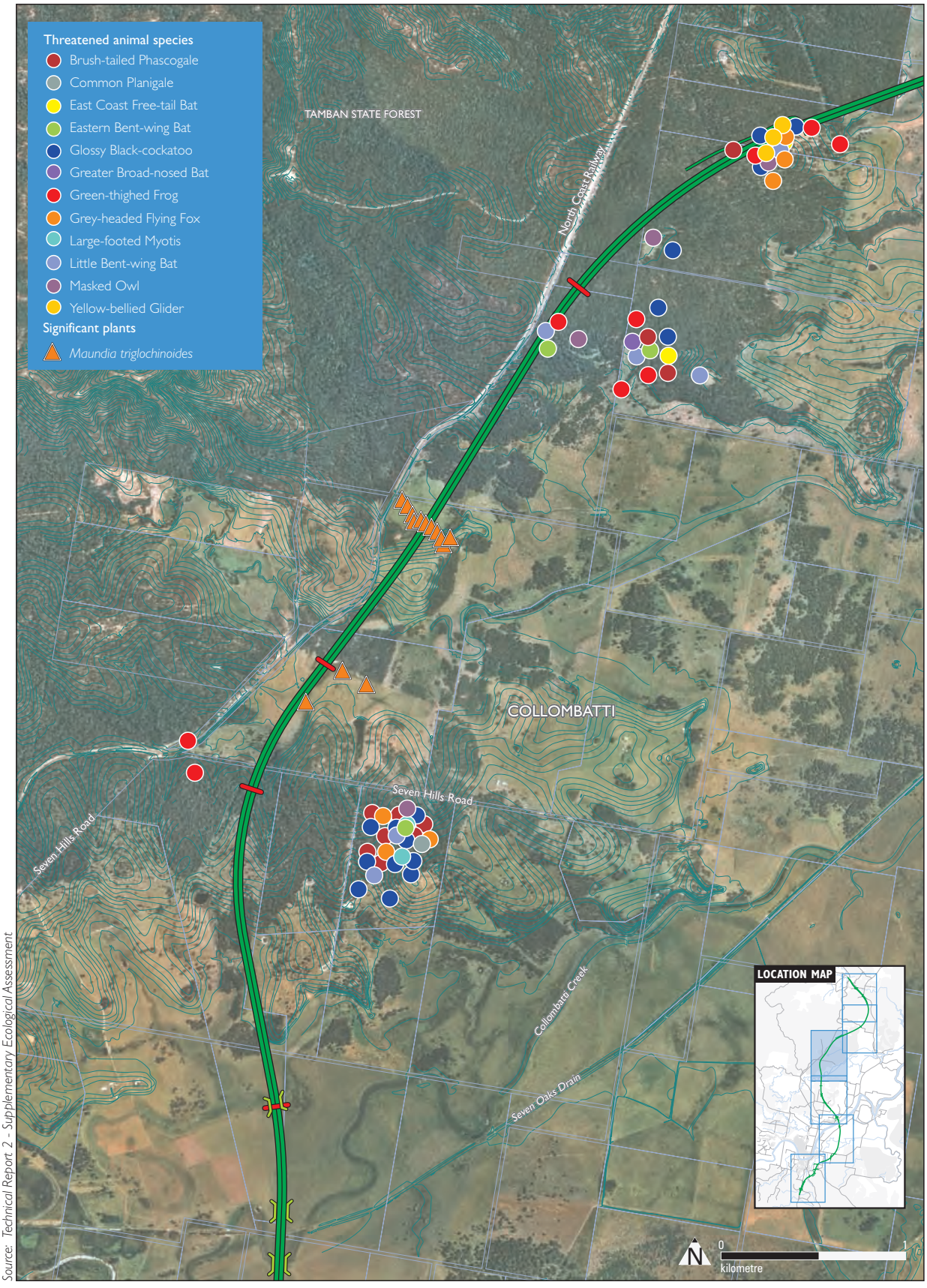
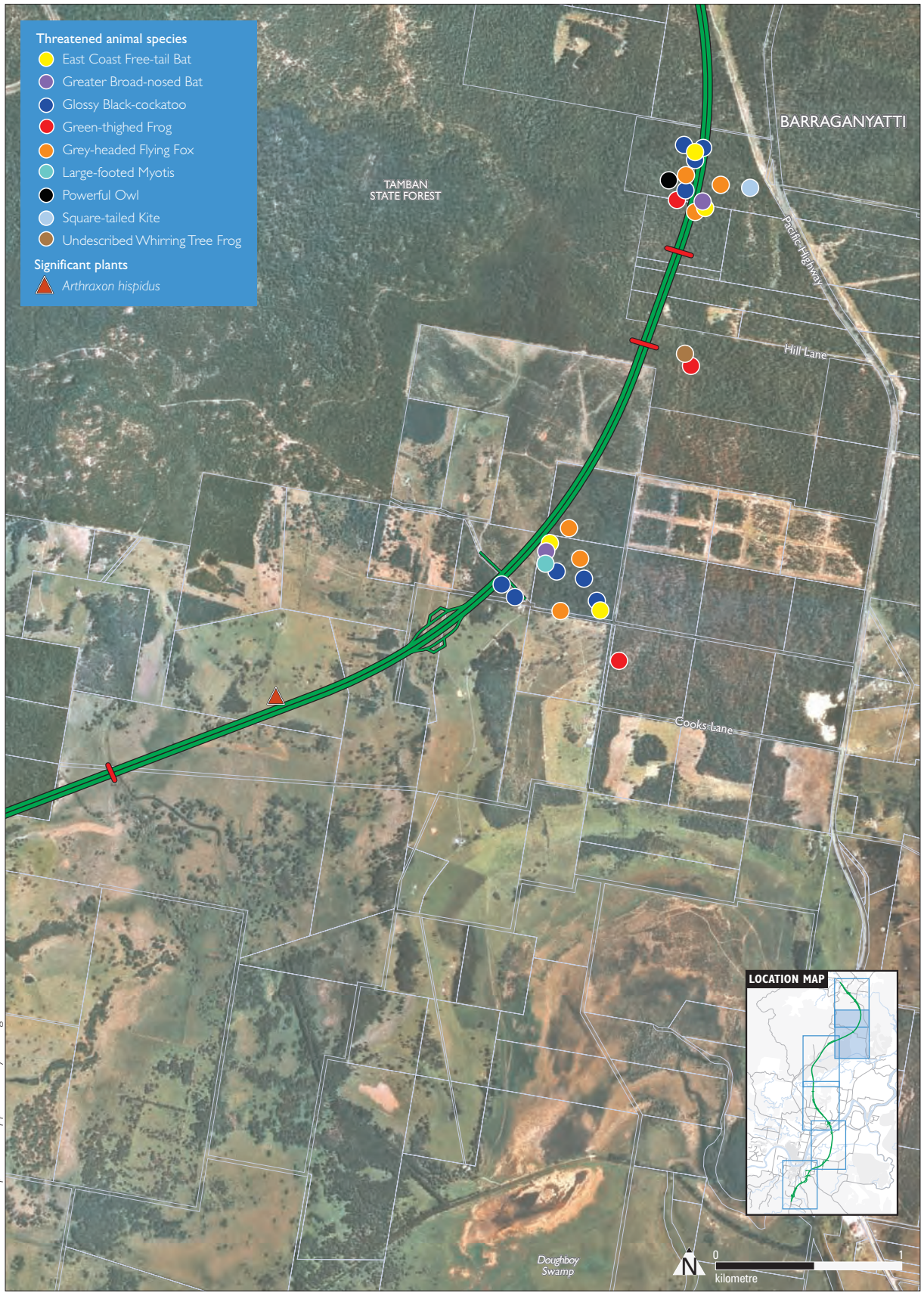


Figure 11-4e Location of significant plants and threatened animal species within the study area



Source: Technical Report 2 - Supplementary Ecological Assessment

Figure 11-4f Location of significant plants and threatened animal species within the study area

Source: Technical Report 2 - Supplementary Ecological Assessment

11.2.6 Aquatic flora and fauna

Fish and mobile invertebrate assemblages present in the waterbodies surveyed were typical of assemblages expected to be found in other similar creeks and waterbodies throughout the region. Therefore, the fish and mobile invertebrate assemblages within the creeks sampled were not considered to be unique to a particular area.

No threatened species as listed under the *Fisheries Management Act 1994* were recorded during survey of the study area. Searches of literature and the relevant databases (Department of Environment and Conservation 2005b) suggested it is unlikely any threatened species would commonly use habitats in the study area, however, it is possible that some of these threatened species may occasionally encroach upon the study area.

11.3 Impacts on biodiversity

11.3.1 Loss of native vegetation

The proposed upgrade would require the clearing of 286.5 hectares of native vegetation (Table 11-4). This figure is based on the extent of construction and includes 18 proposed ancillary areas, which are shown in Figure 7-1. Clearing for the road corridor would include four communities listed as endangered under the *Threatened Species Conservation Act 1995* as well as one that is regionally significant (Table 11-4).

Table 11-4 Vegetation communities cleared during construction

Vegetation community	Area occupied within study area (hectares)	Area cleared for road corridor (hectares)	Area cleared for ancillary areas (hectares)	Total clearing (hectares)	% removed from the study area
Blackbutt Dry Sclerophyll Forest	2,494	130.0	19.3	149.3	6.0
Grey gum/ tallowwood Dry Sclerophyll Forest	775	41.1	1.4	42.5	5.5
Freshwater wetlands[1]	507	14.5	0.0	14.5	2.9
Swamp Sclerophyll Forest[1]	445	17.4	0.0	17.4	3.9
Swamp Oak Floodplain Forest[1]	397	23.1	0.0	23.1	5.8
Stringybark /Ironbark/ Bloodwood Dry Sclerophyll Forest	165	2.5	1.3	3.8	2.3
Scribbly Gum Dry Sclerophyll Forest	165	12	3.4	15.4	9.3
River-flat Eucalypt Forest[1]	119	8.2	0.0	8.2	6.9
Plantation	24	6.8	<0.1	6.8	28.3
Mahogany Dry Sclerophyll Forest[2]	14	5.4	0.0	5.4	38.6
TOTAL	5,105	261.0	25.5	286.5	5.6

Notes

1. *Listed as an endangered ecological community under the Threatened Species Conservation Act 1995;*
2. *Regionally Significant, less than 15 per cent in conservation reserves.*

11.3.2 Loss of threatened species of plant

Three threatened species of plant were recorded within the study area: *Arthraxon hispidus*, *Maundia triglochinoides* and *Persicaria elatior*. The location of these plants in relation to the proposed upgrade corridor is shown in Figure 11-4a to f.

The construction of the proposed upgrade would remove approximately 10% of the northernmost population of *Maundia triglochinoides* and split the population in two. The proposed upgrade would affect approximately one third of the southern population in the study area (refer Figure 11-4a to f). A draft translocation plan has been developed to manage impacts on *Maundia triglochinoides* and is outlined in Section 11.4.

A single *Persicaria elatior* was recorded within a quadrat site in the northern section of the study area. Only one individual was recorded and would be removed during the construction of the proposed upgrade.

The proposed upgrade has been realigned to avoid impacts on *Arthraxon hispidus*.

11.3.3 Loss of fauna habitat

The proposed upgrade crosses three major fauna habitat types and would remove a total of 286.5 hectares of habitat (Table 11-5). Habitat clearing estimates include cut and fill as well as construction impacts and 18 ancilliary areas. Included in this figure are a number of important habitat resources such as habitat trees, tree hollows and feeding resources such as *Allocasuarina*. South of the Macleay River the proposed upgrade traverses largely cleared lands or follows the edges of remnants of vegetation, however, north of the Macleay River floodplain, the route bisects a number of intact remnants of vegetation.

Table 11-5 **Areas of habitat types to be removed and/or disturbed**

Habitat type	Area occupied within study area[1] (hectares)	Area cleared for road corridor (hectares)	Area cleared for ancillary areas (hectares)	Total clearing (hectares)	% removed from the study area
Dry Sclerophyll Forest	3,613	191	25.4	216.4	6.0
Wet Forest (Forested Wetlands)	842	40.5	0	40.5	4.8
Wet Forest (Sclerophyll)	119	8.2	0	8.2	6.9
Wetlands[2]	507	14.5	0	14.5	2.9
Plantation	24	6.8	0	6.8	28.3
TOTAL	**5,105**	**261**	**25.4**	**286.4**	**5.6**

Notes

1. *This figure does not include cleared lands and plantations that may be used by fauna on an occasional basis.*
2. *Includes Wet Meadows*

These habitats are likely to be used by a number of threatened species of animal on a regular basis for both foraging and breeding as evidenced by the high number of species recorded in the surveys. As such these habitats would be considered key habitat as defined by the Roads and Traffic Authority in their *Compensatory Habitat Policy and Guidelines* (NSW Roads and Traffic Authority 2001a). Habitat is likely to be lost for species including the Brush-tailed Phascogale, Koala, Glossy Black-cockatoo and Green-thighed Frog (NSW Roads and Traffic Authority 2006a). Details of the likely impacts on threatened species are provided in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2.

The project would remove approximately 121 hectares of key habitat as defined by Scotts (2003), mainly in the area of Tamban State Forest in the north of the proposed upgrade. This area consists of dry sclerophyll forest and provides significant foraging resources for the threatened Glossy Black-cockatoo as well as habitat for Brush-tailed Phascogales, large forest owls and microchiropteran bats.

11.3.4 Habitat fragmentation and barrier effects

Habitat fragmentation is the process of sub-dividing a continuous habitat into smaller isolated fragments (Andren 1994; Ford et al. 2001). Habitat fragmentation would increase the isolation of remnant vegetation and create barriers to the movements of small and sedentary fauna such as ground-dwelling mammals, reptiles and amphibians.

There would be a small amount of habitat fragmentation to the south of the Macleay River, although habitats and vegetation remnants in this area are already fragmented (see Figure 11-4a to f). North of the Macleay River the proposed upgrade would increase fragmentation in the Collombatti and Tamban State Forest areas. This is likely to fragment habitat for a number of species including the Koala, Brush-tailed Phascogale and Green-thighed Frog.

A quantitative assessment of the likely landscape-scale impacts of the proposed upgrade in terms of fragmentation and connectivity is presented in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2.

11.3.5 Edge effects

Edge effects are zones of changed environmental conditions (i.e. altered light levels, wind speed, temperature) occurring along the edges of habitat fragments. These new environmental conditions along the edges can promote the growth of different vegetation types (including weeds) and allow invasion by pest animals specialising in edge habitats.

Edge effects have been recorded at distances greater than 1,000 metres from the road surface (Forman et al. 2000), however in a comparison of edge effects in a variety of different habitat types, Bali (2000) estimated that average edge effects generally occur up to 50 metres away from the road edge.

Using the estimate of 50 metres proposed by Bali (2000) for potential edge effects, 159.9 hectares of vegetation, in addition to the vegetation removed, would be affected by new edge effects (Table 11-6). Section 11.4.6 discusses compensatory habitat for the proposed upgrade including compensation for edge effects on the basis of a ratio of 0.6:1 of the potentially edge affected area.

Table 11-6 Likely edge affected vegetation

Vegetation community	Area occupied within study area (hectares)	New edge affected area as a result of Proposal (hectares)
River-flat Eucalypt Forest[1,2]	119	4.7
Swamp Sclerophyll Forest[1,2]	445	10.7
Swamp Oak Floodplain Forest[1,2]	397	14.8
Freshwater wetlands[1,2]	507	9.7
Blackbutt Dry Sclerophyll Forest[2]	2,494	88.8
Scribbly Gum Dry Sclerophyll Forest[2]	165	7.6

Vegetation community	Area occupied within study area (hectares)	New edge affected area as a result of Proposal (hectares)
Mahogany Dry Sclerophyll Forest[2]	14	2.4
Stringybark /Ironbark/ Bloodwood Dry Sclerophyll Forest[2]	165	0.6
Grey gum/ tallowwood Dry Sclerophyll Forest[2]	775	18.6
Plantation	24	2.0
TOTAL	**5,105**	**159.9**

Notes

1. *Listed as endangered ecological communities under the Threatened Species Conservation Act 1995,*
2. *Considered to be key Habitat as defined under the RTA's Compensatory Habitat Policy and Guidelines (NSW Roads and Traffic Authority 2001a)*

11.3.6 Mortality

Fauna injury or death may occur during the construction phase when vegetation (and habitats) are cleared, and during the operation of the road as a result of collision with vehicles.

While some mobile species, such as birds, may be able to move away from the path of clearing, other species that are less mobile or those that are nocturnal and restricted to tree hollows may find it difficult to move rapidly over relatively large distances. Threatened species that may be affected by the clearing include microchiropteran bats and Brush-tailed Phascogales. The RTA has guidelines in place on the Pacific Highway that outline procedures to minimise fauna mortality during construction.

Mortality due to roadkill during operation has the potential to affect local fauna species at the sub-population level. In general, rates of roadkill mortality are likely to be directly proportional to the distance of native vegetation/fauna habitat crossed by the proposed upgrade (Forman et al. 2000) and factors such as the design of the road (e.g. raised or not, presence of walls and fences, fauna underpasses) also influence roadkill mortality.

11.3.7 Weeds

The construction of the road has the potential to introduce weeds into relatively intact areas of vegetation that are currently weed free. Nine of the weed species recorded within the study area are listed as Noxious within the Kempsey control area under the *Noxious Weeds Act 1997* (Table 11-7).

Table 11-7 Noxious weeds recorded in the study area

Common name	Scientific name	Weed control category
Bathurst Noogoora Californian Cockle burrs	Xanthium spp.	1
Bitou bush Boneseed	Chrysanthemoides monilifera	4
Blackberry	Rubus fruticosus (agg. spp.)	4
Chinese celtis	Celtis sinensis	3
Crofton weed	Ageratina adenophora	4
Giant Parramatta grass	Sporobolus fertilis syn. Sporobolus indicus var. major	4

Common name	Scientific name	Weed control category
Groundsel bush	Baccharis halimifolia	3
Lantana (Red flowered)	Lantana camara	4
Salvinia	Salvinia molesta	3

Notes

1. *Plants that pose a potentially serious threat to primary production or the environment and are not present in the State or are present only to a limited extent.*
3. *Plants that pose a serious threat to primary production or the environment of an area to which the order applies, are not widely distributed in the area and are likely to spread in the area or to another area.*
4. *Plants that pose a threat to primary production, the environment or human health, are widely distributed in an area to which the order applies and are likely to spread in the area or to another area.*

11.3.8 Changed hydrology

The positioning of road embankments and bridges is unlikely to impede or restrict the movement of water through the floodplain during flood events, and therefore is unlikely to alter the hydrology of the floodplain. Aquatic habitat is, therefore, unlikely to be lost due to the restriction of floodwaters.

However, a process that has been reported to affect water quality in the Lower Macleay River is the de-oxygenation of water on flood plains. In the lower Macleay Valley, floodwaters that are stored on the flood plains by levees and flood mitigation devices can become deprived of oxygen as grasses and plants decompose. When these floodwaters recede and enter the surrounding waterways, they can cause mortality of biota and possibly other effects such as avoidance of the area by aquatic organisms (as reported by Richardson 1980). It is unlikely, however, that the proposed upgrade would create any additional impacts above those experienced in the current situation. Impacts of changed hydrology are described further in *Chapter 10 – Hydrology and water management*.

Waterway crossings may also modify the natural hydrology of many of the creeks and rivers within the study area, which can ultimately affect the aquatic assemblages that use these areas (Fairfull and Witheridge 2003) if not managed properly. In general, impacts from these waterway crossings include:

- Excessive flow velocities, which can erode creek banks and lead to changes in water quality, as well as acting as a barrier to any fish movements in the creek.
- Modified water depths of the creek or river, again acting as a barrier to fish movement and loss of interconnectivity between pools.
- Increased water turbulence, which could lead to the avoidance of the area by various aquatic organisms.

11.3.9 Aquatic disturbance and fish passage

It is unlikely that any unique fish assemblages would be significantly affected by the actual proposed waterway crossings. Suitable habitat exists upstream and downstream of many of the watercourses crossed by the proposed upgrade. Given that the proposed crossings comply with NSW Fisheries guidelines, no long-term impacts from the proposed waterway crossings are expected on the fish and mobile invertebrate assemblages within the area. Also, no sensitive aquatic habitats such as seagrasses, mangroves or saltmarsh would be affected by the proposed works.

Barriers to fish passage from the installation of waterway crossings can occur temporarily (i.e. during construction) and/or over the long term where inappropriate structures are used. In addition to the potential impacts from the alteration of natural hydrology from waterway crossings, other impacts such as decreased light levels and debris blockage have the potential to affect fish passage (Fairfull and Witheridge 2003).

Although some of watercourses inspected during this study were classed as major to moderate fish habitat (see Table 11-2), it is expected that little to no impact would occur on fish passage given that all waterway crossings would comply with NSW Fisheries guidelines.

11.3.10 Commercial and recreational fishing

It is unlikely that the proposed upgrade would have any major impact on commercial or recreational fishing in the area. Commercial fishing in the Macleay River is concentrated in the lower reaches below the study area (NSW Roads and Traffic Authority 2006a). Given that there is similar habitat up and downstream of the proposed upgrade, minimal disturbance would be expected.

11.3.11 Cumulative impacts

The potential biodiversity impacts resulting from the proposed upgrade have been considered as a consequence of the construction and operation of the proposed upgrade within the existing environment. The incremental effect of multiple sources of impact (past, present and future) are referred to as cumulative impacts (Contant & Wiggins 1991; Council on Environmental Quality 1978) and provide an opportunity to consider the proposed upgrade within a strategic context. This is necessary so that impacts associated with the proposed upgrade and other activities within the region are examined collectively.

Cumulative impacts within the region are discussed in Section 21.2 and include other sections of the Pacific Highway upgrade, residential subdivisions and commercial developments.

The significance of the biodiversity impacts of the proposed upgrade are likely to be increased by biodiversity impacts from surrounding projects. These cumulative impacts will include a greater extent of clearing of native vegetation and habitats, including endangered ecological communities, as well as further fragmentation of habitat.

11.4 Management of impacts

Management of impacts on biodiversity have followed the general principle of, in order of preference:

- Avoiding impacts.
- Minimising impacts.
- Mitigating impacts.
- As a last resort, once the above options have been investigated, compensating for the residual impacts.

Impacts of the project on local flora and fauna have been avoided and minimised through the route selection process and through the development of the alignment of the proposed upgrade. Changes to the route and alignment that have been made in response to potential biological impacts include:

- The eastern sub-option was chosen which would avoid East Kempsey Swamp and potential impacts on a camp of the Grey-headed Flying-fox, which is listed as vulnerable

under both the *Threatened Species Conservation Act 1995* and the *Environment Protection and Biodiversity Conservation Act 1999*.

- The alignment immediately south of Seven Hills Road was moved to the west to avoid an area of mature *Allocasuarina* Forest that contained breeding habitat for the threatened Glossy Black-cockatoo as well as the Brush-tailed Phascogale.
- The alignment south of Cooks Lane was moved to the east to avoid a population of the threatened plant *Arthraxon hispidus*.

In order to further minimise and mitigate impacts on the ecological values of the site, the following mitigation measures are proposed to be implemented. Further details of mitigation measures are presented in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2.

11.4.1 Vegetation and habitat loss

Disturbance to areas of native vegetation and habitat would be unavoidable during the construction process. However, in order to avoid further disturbance to areas outside of those already identified, sensitive areas would be clearly identified during the construction process as 'no-go' areas. These would be marked on maps provided to contractors, as well as on the ground using parawebbing, tapes or signage. The adoption of these measures would limit the extent of habitat disturbance, prevent soil compaction and damage to trees/vegetation.

Where clearing of vegetation and fauna habitats take place, clearing protocols would be put in place. These protocols would include preparing an inventory of trees with hollows to be removed, checking hollow-bearing trees for the presence of bird nests and arboreal animals, such as possums, gliders and bats, prior to felling or pushing by a qualified ecologist pre clearing. A two stage clearing procedure would be developed, leaving habitat trees to the second stage to increase the possibility of fauna relocating. A qualified ecologist would relocate removed animals locally into nearby habitats. Suitable nest boxes or salvaged tree hollows would be provided in the nearby habitat areas for each relocated animal species as part of an overall nest box program developed between the RTA and the Department of Environment and Climate Change.

Revegetation of areas within the corridor of the proposed upgrade would be undertaken in such a way that it increases both the visual amenity and the habitat value of the areas. Revegetation of the areas would include:

- Planting of a range of locally occurring native shrubs, trees and groundcover plants (discussion would be held with the Department of Environment and Climate Change and regarding the choice of species, particularly in areas where the revegetation would be adjacent to existing patches of native vegetation, including endangered ecological communities).
- Increasing the overall vegetation cover within the study areas.
- Incorporation of existing natural vegetation where possible.
- Linking of bushland remnants, where possible.
- Maintenance of plantings through a landscaping plan included in the Construction Environmental Management Plan.
- Management of exotic weeds through a weed strategy as part of the Fauna and Flora Management Sub Plan.

These mitigation measures would be detailed in a Flora and Fauna Management Sub Plan as part of the overall project Construction Environmental Management Plan.

Green-thighed Frog habitat

In areas where known habitat for the threatened Green-thighed Frog would be disturbed, artificial habitat would be created within the road reserve during construction. This habitat would be designed to mimic the natural situation where breeding occurs within areas of impeded drainage close to sites of intact native vegetation. Important elements in the design include ensuring that some flood waters are retained for a suitable period of time (40 to 100 days) (Frank Lemckert, *personal communication*, 16 March 2007).

The pond designs would include the following features where possible and will be developed during the detailed design stage:

- Size: 20 metres diameter (core pond), but can be a series of potholes/ponds and larger flooded areas.
- Depth: variable depth to one metre.
- Shape: steep sides reducing evaporation and increasing water volumes.
- Length of time for inundation: of the order of 40 days for sunny site, 100 days for shaded site.
- Location: next to moist forest areas if possible.
- Vegetation: dense understorey vegetation or leaf litter.

Maundia triglochinoides translocation plan

A draft translocation plan for *Maundia triglochinoides* has been prepared (see Volume 2, Technical Report 2 – *Supplementary Ecological Assessment*.). The assessment of the suitability of this species for translocation concluded that with only 35 known populations of this species remaining, the protection and expansion of these populations is critical to the long-term survival of this species. However, the biology of *Maundia triglochinoides* is not well understood and past attempts at cultivation and translocation have been unsuccessful; as such the success of a translocation program is uncertain. The removal of plants for the proposed upgrade should be used as an opportunity for further research into the reproduction and propagation of this species and potential translocation techniques. It is recommended that any attempts at translocation focus strongly on experimentation of propagation techniques, monitoring and reporting of the methods and results.

11.4.2 Fragmentation, terrestrial barrier effects and road mortality

Fauna crossings

In order to reduce impacts of habitat fragmentation, fauna underpasses have been included in the design of the proposed upgrade where fauna corridors are present. In some cases structures would be combined (e.g. drainage and fauna passage). In other cases where drainage culverts/bridges are not required, a dedicated structure would be constructed. Proposed fauna crossings are identified in Figure 11-5.

The following was considered in proposing points within the proposed upgrade suitable for fauna crossing structures:

- Size and location of vegetation patches on both sides of the proposed upgrade and their suitability as fauna habitat.
- Species that are likely to need or use fauna crossing structures at each point.
- Feasibility of constructing a fauna crossing structure at that point due to engineering constraints.

- Regional connectivity within the local area based on the key habitats and corridors produced by the Department of Environment and Conservation (Scotts 2000, 2003).
- Available drainage structures.

Other drainage structures or stock crossing points may be used by fauna as crossing points, but would not include treatments to further facilitate the movement of animals (e.g. fauna fencing).

Fauna fencing would be provided at dedicated fauna underpasses as well as at key fauna crossing locations in order to guide animals to the crossing points. Fauna fencing would generally be standard floppy-top fencing, although in some areas the fencing may be modified for particular species including threatened frogs and the Bush-tailed Phascogale. The length of the fencing would be determined with reference to the extent of vegetation and habitat on either side of the road, but would generally extend at least 100 metres on either side of the crossing. Fauna underpass design, including provision of fauna fencing, would be progressed during detailed design in consultation with Department of Environment and Climate Change.

11.4.3 Changed hydrology

Measures have been identified and incorporated into the proposed upgrade to ensure that the positioning of road embankments and bridges does not greatly inhibit the movement and retention of floodwaters or the current drainage patterns (see *Chapter 10 – Hydrology and water management*).

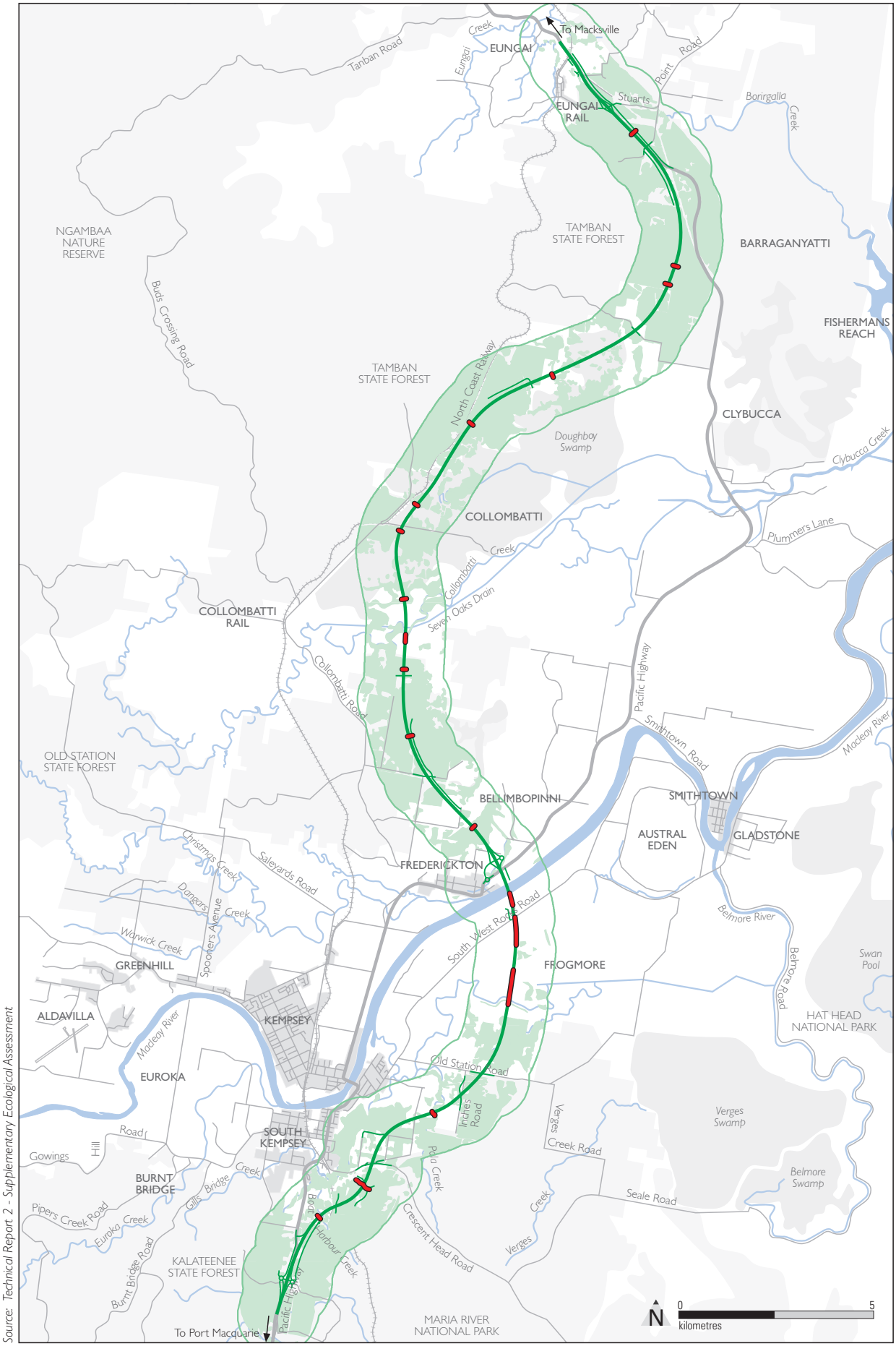
NSW Fisheries *Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003) would be used when designing waterway crossings for the project. The procedures set out in these guidelines will assist with the maintenance of the natural flow regime of all waterbodies impacted by the proposed upgrade. They also help with the mitigation of impacts associated with the potential loss of aquatic habitat, changes to normal waterflow patterns or depths and any increases in turbulence. NSW Department of Primary Industries (Fisheries) will be given the opportunity to review crossing designs.

11.4.4 Aquatic disturbance

Little aquatic disturbance within the study area is expected once construction of waterway crossings are completed. Damage to any aquatic habitat and riparian vegetation during construction would be minimised. Areas of riparian vegetation likely to be damaged or removed during construction would be replanted on completion of the works. In addition, appropriate erosion sediment control measures would be put in place around all proposed waterway crossings prior to construction to minimise water quality impacts on the waterways due to run-off from the construction site.

All waterway crossings would comply with NSW Fisheries *Fish Passage Requirements for Waterway Crossings* (Fairfull & Witheridge 2003). Specific measures cited in the guidelines include avoiding placement of bridge piers or foundations within the main channel (where practicable), maximising opportunities for the amount of light that penetrates under the bridge or within the culvert to encourage fish passage, and regular clearing of any debris that is blocking fish passage up and downstream.

Figure 11-5 **Proposed fauna crossing points**



Source: Technical Report 2 - Supplementary Ecological Assessment

11.4.5 Acid sulfate soils

The disturbance of acid sulfate soils on the project during construction needs to be carefully managed. This will be particularly so in the areas around East Frederickton, the floodplain of Collombatti Creek and the northern section of Doughboy Swamp, as well as in the proximity of the SEPP 14 Wetland (No. 478) north-west of Frederickton.

The disturbance to acid sulfate soils would be minimised by using construction techniques in these areas, which avoid disturbance of large areas of high potential acid sulfate soils. Further information on management of acid sulfate soils is provided in Section 12.3.4 and management of acid sulfate soils would be covered as part of the overall construction environmental management plan.

11.4.6 Compensatory habitat

'Compensatory habitat' is the provision of land containing one or more key habitats that are acquired and/or committed by a project proponent/land owner for the purpose of nature conservation, to make up for the loss or degradation of one or more key habitat(s). Loss or degradation of key habitat would result from land clearing and/or new edge effects on adjacent key habitat (NSW Roads and Traffic Authority 2001a).

'Key habitat' refers to the natural environment inhabited by native flora and/or fauna species, populations or ecological communities that are deemed to be of ecological significance (NSW Roads and Traffic Authority 2001a).

Where there is residual loss or degradation of key habitat after route selection, road design and determination of mitigation measures, compensation in the form of compensatory habitat, land rehabilitation and/or contribution to research can be employed.

Following consideration of the proposed mitigation measures for this project, it is concluded that the impacts relating to the clearing of native vegetation and fauna habitats would not be sufficiently mitigated and therefore compensatory habitat should be provided.

The project will include clearing of native vegetation (up to 286.5 hectares), all of which is considered key habitat due to its suitability as habitat for threatened species or its inclusion as part of an endangered ecological community. Based on the Roads and Traffic Authority's Compensatory Habitat Policy and Guidelines (NSW Roads and Traffic Authority 2001a), this area of clearing would be compensated with an area of habitat at least equal to the area being clearing. A further 94.7 hectares of newly edge-affected habitat would be compensated (on the basis that compensation for potential edge effects is calculated on the basis of a ratio of 0.6:1), making a total of 382 hectares. A compensatory package would be negotiated with the Department of Environment and Climate Change taking into consideration the types and location of habitats to be affected and the availability and suitability of potential compensatory habitat areas. The final package may include a range of compensatory measures including the provision of land, management measures and research initiatives.

Further details relating to compensatory habitat are provided in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2.

11.4.7 Summary of management measures

Standard and project-specific mitigation and management techniques for flora and fauna impacts arising from the construction and operation of the proposed upgrade are included in the draft Statement of Commitments for the proposed upgrade included in Appendix D and are summarised below.

Ecology

- Refine design and identify ancillary areas in light of biological knowledge and design constrains so as to avoid and minimise impacts to biodiversity.
- Maintain connectivity by providing fauna underpasses at key locations identified in the Project Application Report (NSW Roads and Traffic Authority 2006a).
- Follow the principles of Fish Friendly Waterway Crossings (Fairfull & Witheridge 2003) for the design and construction of waterway crossings.
- Design and construct artificial frog breeding ponds suitable for the Green-thighed Frog. Discussions should be held with recognised experts regarding current knowledge of breeding requirements in this species. These ponds should be considered experimental and an adaptive monitoring program should be put in place to determine their effectiveness.
- Finalise and implement the translocation plan for Maundia triglochinoides in consultation with the Department of Environment and Climate Change should translocation be considered a suitable option. The plan should include monitoring the effectiveness of the translocation.
- Prepare and implement a flora and fauna management sub-plan as part of the Construction Environmental Management Plan.
- Undertake ongoing management and monitoring of weed invasion through a weed management sub-plan as part of the Construction Environmental Management Plan.
- Prepare a comprehensive offset strategy and package for the proposed upgrade in consultation with relevant government authorities.
- Provide for ancillary areas in order to minimise the overall impact of the construction and avoid unnecessary vegetation and habitat removal.
- Pre-clear the disturbance areas, using a trained ecologist, prior to construction activities commencing in order to:
  - Mark the limits of clearing and install temporary fencing in sensitive areas (e.g. endangered ecological communities) to avoid unnecessary vegetation and habitat removal.
  - Collect native seed for use in the revegetation of disturbed areas.
  - Identify and place transportable habitat features such as large logs and boulders in adjacent retained areas to allow their continuation as potential fauna refuge sites.
  - Implement pre-clearing surveys for fauna including:
  - Identifying (by survey) and marking all habitat trees in the area to be cleared.
  - Leaving marked habitat trees and corridors of retained trees linking marked habitat trees with the nearest uncleared (secure) habitat areas standing after initial vegetation clearing for a period of at least 48 hours (to encourage animals to disperse into adjacent uncleared habitat).
  - After the 48 hour waiting period, felling standing habitat trees and corridors, commencing with the most distant trees from secure habitat.
  - Where possible, clearing should be undertaken in the spring to autumn period to facilitate survival of displaced animals.
  - If habitat trees are in short supply (<4 suitable trees per hectare) artificial nest sites (nest boxes) should be installed in adjacent (secure) habitat before clearing.
- Implement 'best practice' stormwater treatment measures to maximise:
- Onsite pollutant retention and removal.
- Infiltration and sub-surface discharge of stormwater.
- Achieve ANZECC Water Quality Guidelines (2000) for all water discharge into streams and creeks.
- Replace riparian vegetation disturbed by the project with appropriate endemic species to maintain creek bank stability.
- Rehabilitate areas within the road reserve that are not necessary for the operation of the road in a progressive manner as construction proceeds. This should include:
  - Planting of a range of locally occurring and sourced native shrubs, trees and groundcover plants.
  - Inclusion of logs, dead trees and stumps in the landscaping works.
  - Inclusion of foraging species, such as Allocasuarina for Glossy Black-cockatoos.
  - Incorporation of existing natural vegetation where possible.
  - Maintenance of plantings through a revegetation plan included in the Construction Environmental Management Plan.
- Implement an adaptive monitoring program for at least three years post construction, focussing on rehabilitated areas as well as mitigation strategies.

11.5 Significance of impacts

Projects assessed under Part 3A of the *EP&A Act* do not require the assessment of significance previously required under Section 5A of the Act (the Seven Part Test). Instead the assessment is based on the heads of consideration detailed in the draft *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation 2005b), indicating the significance of the impacts relative to the conservation importance of the habitat, individuals and populations likely to be affected.

Impacts are considered more significant if:

- Areas of high conservation value are affected.
- Individual animals and/or plants and/or subpopulations that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community.
- Habitat features that are likely to be affected by a proposal play an important role in maintaining the long-term viability of the species, population or ecological community.
- The impacts are likely to be long-term in duration.
- Impacts are likely to be permanent and irreversible.

Threatened biodiversity listed under the *Environment Protection and Biodiversity Conservation Act 1999* are assessed following the *Principal Significant Impact Guidelines* (Department of the Environment and Heritage 2006).

The proposed upgrade removes 286.5 hectares of native vegetation of which 63 hectares is listed as endangered ecological communities under the *Threatened Species Conservation Act 1995*. A further 159.9 hectares would be affected by edge effects (39.9 hectares endangered ecological communities).

A number of threatened species of plant and animal have been recorded along the route and individuals of these species may be affected by the proposed upgrade through the removal of habitat or the disturbance of individuals. However, the significance assessments (see Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2) indicate that the proposed upgrade is only likely to have a significant impact on three endangered ecological communities, one threatened plant and three threatened animals, namely:

- Swamp Oak Floodplain Forest.
- River Flat Eucalypt Forest.
- Swamp Sclerophyll Forest.
- Maundia triglochinoides.
- Green-thighed Frog.
- Glossy Black-cockatoo.
- Brush-tailed Phascogale.

Although the proposed mitigation measures would reduce the impact of the proposed upgrade on these species, they are unlikely to totally ameliorate the significance of the impact.

Under the draft *Guidelines for Threatened Species Assessment under Part 3A of the Environmental Planning and Assessment Act 1979*, the following thresholds need to be addressed:

Whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts will maintain or improve biodiversity values.

The term 'maintain or improve' is defined in the draft *Guidelines for Threatened Species Assessment under Part 3A* of the *Environmental Planning and Assessment Act 1979,* as: 'no net impact on threatened species or native vegetation' (Department of Environment and Conservation 2005b). The proposed upgrade will result in the loss of up to 286.5 hectares of vegetation and habitat within the local area, including 63 hectares of endangered ecological communities. A further 159.9 hectares of vegetation and habitat will be subject to new edge effects. The project route and concept design has been undertaken to avoid and minimise impacts on vegetation, including endangered ecological communities and the habitat of threatened species. These measures have been detailed in this document as well as in the earlier Project Application Report (NSW Roads and Traffic Authority 2006a). Management measures would be addressed in the Flora and Fauna Management Plan for the project. These measures would allow for continuance of biodiversity values for the road corridor. A comprehensive offset package would also be developed in accordance with the RTA's Compensatory Habitat Policy, which would contribute to the maintenance and improvement of biodiversity values.

Whether or not the proposal is likely to reduce the long-term viability of a local population of a species, population or ecological community.

For the majority of species, populations and communities found in the local area, the proposed upgrade is unlikely to reduce their long-term viability as detailed in the Project Application Report (NSW Roads and Traffic Authority 2006a) and in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2. This is due to the process of avoiding and minimising impacts during the route selection and design phases of the project and through the implementation of mitigation measures as outlined in this document. However, the proposed mitigation measures are unlikely to fully ameliorate the impacts on seven species and communities, due largely to the extent of vegetation and habitat clearing and the loss of significant habitat features. The significance of these impacts is discussed in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2. A comprehensive offset package would however be developed in accordance with the RTA's Compensatory Habitat Policy that would contribute to the maintenance and improvement of biodiversity values.

Whether or not the proposal is likely to accelerate the extinction of a species, population or ecological community or place it at risk of extinction.

The proposed upgrade will remove 286.5 hectares of vegetation and habitat within the local area, including endangered ecological communities and habitat for threatened species. However, with the implementation of mitigation measures, it is unlikely that a species, population or community would become extinct, despite there being significant impacts on some species at the local level as outlined in Technical Report 2 – *Supplementary Ecological Assessment* in Volume 2. It is unlikely that the proposed upgrade would accelerate the extinction of a species, population or community.

Whether or not the proposal will adversely affect critical habitat.

Critical Habitat is listed under both the *Threatened Species Conservation Act 1995* and *Environment Protection and Biodiversity Conservation Act 1999* and both the State and Federal Directors-General maintain a register of this habitat. Critical habitat is the whole or any part or parts of an area or areas of land comprising the habitat of an endangered species, an endangered population or an endangered ecological community that is critical to the survival of the species, population or ecological community (NSW National Parks and Wildlife Service 1996).

To date there is no critical habitat declared within Kempsey local government area and no critical habitat is likely to be affected by the proposed upgrade.

11.6 Implications for ecologically sustainable development

This section considers the implications for ecologically sustainable development for the proposed upgrade in terms of biodiversity impacts only. Broader consideration of the implications for ecologically sustainable development to the proposed upgrade and its likely impacts as a whole is provided in Chapter 22 – *Justification and conclusions*.

11.6.1 Precautionary principle

The precautionary principle states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

This principle has been demonstrated in the current project where consideration has been given during the route selection and concept design stage to avoid serious impacts to the environment, including to threatened biodiversity. This process has been proactive rather than reactive. Impacts on threatened species have also been considered for species that were not recorded during survey of the study area.

11.6.2 Intergenerational equity

Intergenerational equity means that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. Impacts to biodiversity have been avoided where possible and minimised to ensure that biodiversity values are not reduced or degraded in the future.

11.6.3 Conservation of biological diversity

The selection of the route and the design of the proposed upgrade have given careful consideration to the conservation of biological diversity as outlined in this chapter and the associated biological impact reports (e.g. NSW Roads and Traffic Authority 2006a). Mitigation measures and compensatory habitat would be implemented and provided so as to conserve biological diversity in the local area.

11.6.4 Improved valuation and pricing of environmental resources

Biodiversity values have been emphasised during the route selection and design process and in many cases have been given a higher profile than other issues such as strategic planning and engineering. Although it is difficult to put a strict value or price on biodiversity values, the cost of the various proposed mitigation measures, including offsets, will provide an indication of value.